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Should Banks Be Worried About Dividend Restrictions?

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Abstract

Countercyclical bank capital requirements have emerged as a popular regulatory tool to help smooth financial cycles. The idea is to reduce capital requirements when exogenous shocks cause aggregate bank capital to decrease so that regulation does not needlessly constrain banks' supply of credit. In the model in this paper, banks are rationally forward-looking and thus ignore short-lived reductions in capital requirements. During a financial crisis, a regulator would want to first impose drastic dividend restrictions to force banks to rebuild capital, but also would want to keep capital requirements low for a sufficiently long time afterwards. However, such a policy is not time-consistent. Once banks are sufficiently re-capitalized, the regulator would be tempted to immediately raise capital requirements all the way to pre-crisis levels. Optimal time-consistent capital regulation requires that bank capital is rebuilt gradually during financial crises. In particular, banks must be able to pay dividends even when bank equity is still significantly below pre-crisis levels.

Topics: Business fluctuations and cycles; Credit and credit aggregates; Credit risk management; Financial stability; Financial system regulation and policies; Lender of last resort
JEL codes: E1, E13, E3, E32, E4, E44

Résumé

Les exigences contracycliques de fonds propres bancaires sont devenues un outil réglementaire courant qui contribue à lisser les cycles financiers. L'objectif est de réduire les exigences de fonds propres quand des chocs exogènes entraînent une baisse du niveau des fonds propres bancaires agrégés pour éviter que la réglementation limite inutilement l'offre de crédit des banques. Dans le modèle du présent document de recherche, les banques ont une optique prospective et rationnelle et, en conséquence, font abstraction des réductions temporaires des exigences de fonds propres. Lors d'une crise financière, un organisme de réglementation souhaiterait tout d'abord imposer des restrictions sévères aux paiements de dividendes pour forcer les banques à reconstituer leurs réserves de fonds propres. Il voudrait aussi maintenir des exigences de fonds propres peu élevées durant une période assez longue par la suite. Cependant, une telle politique n'est pas cohérente dans le temps. Une fois les réserves de fonds propres bancaires reconstituées, l'organisme de réglementation serait tenté de ramener rapidement les exigences de fonds propres aux niveaux d'avant la crise. Pour être optimale et cohérente dans le temps, la réglementation doit exiger que la réserve de fonds propres soit reconstituée graduellement durant les crises financières. Plus particulièrement, les banques doivent être en mesure de payer des dividendes même quand leurs capitaux propres sont encore bien en dessous des niveaux d'avant la crise.

Sujets : Cycles et fluctuations économiques; Crédit et agrégats du crédit; Gestion du risque de crédit; Stabilité financière; Réglementation et politiques relatives au système financier; Fonction de prêteur de dernier ressort
Codes JEL : E1, E13, E3, E32, E4, E44

1 Introduction

Following the global financial crisis of 2007–09 bank regulators have developed a framework of counter-cyclical regulation (BCBS, 2010). The idea is that banks build up more capital during good economic times and then use that capital to absorb losses during bad economic times. Banks' credit supply will be more stable as a result, provided that capital requirements are reduced temporarily during bad economic times. For example, in Spring 2020 bank regulators in many jurisdictions responded to the COVID shock by easing capital requirements.[1] There are two key policy questions. First, what is the desired level of bank capital during good times? Second, *by how much* and *for how long* should the capital requirement be lowered during bad times? This paper, while addressing both questions, raises a novel concern related to the second question.

When regulators lower capital requirements during bad economic times, they face a trade-off between encouraging banks to maintain lending and potentially jeopardizing banks' future soundness. In particular, when banks maintain lending with less capital during bad economic times, they are more vulnerable to a worsening of economic conditions. Accordingly, regulators might take steps to encourage banks to rebuild their capital quickly after an initial period through dividend payout restrictions, in order to limit the time that banks operate with elevated leverage. However, because capital is costly for banks, capital requirements should be expected to be lower for some time in order to have a supporting effect on credit supply.

The analysis in this paper points to a time-inconsistency problem. Tough dividend payout restrictions that quickly restore bank capital ratios reduce the need to keep coun-

[1]Regulators did so by reducing time-varying capital buffers and by 'forbearance' measures in jurisdictions such as United States, the European Union and Canada. Regulators also restricted equity payouts by prohibiting share repurchases and by capping dividends in these jurisdictions. The remainder of this paper uses the term dividends to refer to equity payouts (i.e., the sum of both share repurchases and dividends). A comprehensive list of support measures, including fiscal and monetary-policy support, has been compiled by the International Monetary Fund.

tercyclical capital requirements lowered, ex post. Further, if banks have rebuilt their capital ratios sufficiently through reduced dividend payouts, then requiring banks to retain even higher capital ratios ex post does not decrease credit supply much, but it can significantly increase financial stability.

The policy implication from this paper is that regulators should not restrict banks' capital payouts too aggressively during the period when countercyclical capital requirements have been reduced in response to an adverse shock. In the model explored here, if banks capital ratios are restored very quickly in this way, then regulators ex post are likely to raise required capital promptly to pre-crisis levels. But then any initial decrease in the countercyclical capital requirement has little substantial beneficial impact on lending because it is not credible. In particular, if dividend payout restrictions are suddenly made too tight during a financial crisis, then banks could anticipate a sharp increase in future capital requirements and this could discourage current bank lending. For example, for the case of the United States, the model suggests that capital buffers on top of the the minimum requirement and any capital surcharges for systemically important banks should be fully releasable during a severe financial crisis.

Even a regulator that cannot commit can mitigate sudden bank losses effectively. The reason is that a regulator values its credibility in case of unforeseen bank losses in the future. If there were no future bank losses, then the regulator has no way to implement a time-consistent policy (for example, Schroth, 2016). Van der Ghote (2021) analyses the case of strictly Markov policies, where no commitment is required, in an economy with occasional financial crises. Markov policies can mitigate but not avoid severe financial crises. The extreme cases of full commitment and strictly Markov policies are compared in Schroth (2021). A regulator that has full commitment can avoid severe financial crises. This paper explores the policies that endogenously build some credibility for a regulator that cannot commit and finds that that severe financial crises can still be avoided. Compared to the full commitment case, this comes at the cost of significantly more frequent financial crises of intermediate severity. Intuitively, the regulator builds credibility, which is used to fight the most severe financial crises, by allowing banks to pay dividends even when their equity is still significantly below pre-crisis levels. Limited commitment of the financial regulator implies that while the most severe crises can be avoided, intermediate financial crises still occur with some frequency.

The notion of time-consistency in this paper is different from the one in Bianchi and Mendoza (2018). In their paper borrowers end up borrowing too much which leads to fire-sale dynamics once borrowers become funding constrained (as in Lorenzoni, 2008). In contrast, in this paper, the regulator ends up tightening banks' capital requirements too early after a crisis. This worsens banks' access to market funding and leads to inefficiently scarce credit supply.

2 Model

This section presents a model economy of banks lending to firms and funding themselves with retained earnings (equity) and uninsured deposits (debt). There are two frictions related to banks' funding. On the one hand, banks consider equity a relatively more costly funding source. On the other hand, market monitoring implies that banks have access to debt funding only if their leverage is not too high. Banks' capital structure choices reflect these funding frictions as well as risk on the revenue side. In particular, both exogenous aggregate shocks and the aggregate amount of bank lending affect firms' loan repayments.

The economy features a consumption good and is populated by continuums of mass one each of identical firms, banks, and households, respectively. Firms are short-lived and fund their investment with loans from banks. Only banks can make loans to firms.

Households are endowed with one unit of labor each, which they supply inelastically. They discount future consumption using the subjective discount factor $\beta \in (0, 1)$. There are aggregate productivity shocks $z \in \{z_L, z_H\}$ with $Pr(z = z_L) = \rho$ in each period. Let $z_L < z_H$ and $\rho z_L + (1-\rho) z_H = 1$. The assumption that aggregate productivity shocks are independently and identically distributed ensures that firms' demand for loans depends only on the loan interest rate.

Households trade bank shares among each other, and trade one-period non-contingent bonds with banks. Let $\gamma \in (0, \beta)$. At the beginning of each period, after firms have repaid loans and maturing bonds have been redeemed, a fraction $1 - \gamma/\beta$ of banks exit exogenously. The equity of exiting banks is distributed among a mass $1 - \gamma/\beta$ of new banks. The shares of exiting banks become worthless and shares of new banks are distributed uniformly among households. Note that for an individual household $1 - \gamma/\beta$ is a measure of the cost of bank capital.

Markets:

There are markets for labor, bonds, bank loans and bank shares. Let w be the price of one unit of labor. Let q be the price of one unit of the consumption good to be delivered in the following period in the market for bonds such that $1/q$ is the non-contingent return on bonds. Let R denote the contingent return on bank loans. Finally, let p denote the bank share price including the current dividend. I normalize the supply of bank shares in every period to one. Households are endowed with one bank share initially.

Household problem:

Households choose consumption c, bonds b^h and bank shares s to maximize lifetime utility

$$W_0 = E_0 \left[\sum_{t=0}^{\infty} \beta^t c_t \right],$$

subject to budget constraints

$$c_t + q_{t+1} b_{t+1}^h + p_t \left(s_{t+1} - \gamma/\beta s_t \right) \leq w_t + b_t^h + p_t (1 - \gamma/\beta) + D_t s_{t+1},$$

where D_t are bank dividends and E_t denotes conditional expectation, $t = 0, 1, 2, \ldots$ Households make net bank share purchases of $s_{t+1} - \gamma/\beta s_t$ and receive $1 - \gamma/\beta$ shares of new banks, where γ/β is the fraction of banks that do not exit. The assumption that households are risk-neutral and able to consume negative amounts ensures that their demand for bank bonds and shares is fully elastic when bonds and dividends are discounted at constant factors β and γ, respectively. Specifically, optimal household choices are consistent with the following bond and bank share prices:

$$q_{t+1} = \beta, \tag{1}$$

$$p_t = D_t + \gamma E_t \left[p_{t+1} \right]. \tag{2}$$

Equation (2) implies that households effectively discount bank dividends using the lower discount factor $\gamma < \beta$. Households demand a higher return on bank shares than on bonds because a fraction $1 - \gamma/\beta$ of shares becomes worthless each period while bonds are always redeemed. The bank share price is thus the expected net present value of dividends with γ, rather than $\beta > \gamma$, as the discount factor.

Firm problem:

At the end of each period t a unit measure of firms enters. They each have access to a production technology that turns $k \geq 0$ units of the consumption good in period t and $n \geq 0$ units of labor in period $t + 1$ into $z_{t+1} k^\alpha n^{1-\alpha} + (1 - \delta) k$ units of the consumption good in period $t + 1$ where $\alpha \in (0, 1)$ and where $\delta \in (0, 1)$ is the depreciation rate of physical capital. Firms choose labor after aggregate firm productivity z_{t+1} has been realized. They cannot sell bonds and do not have any internal funds such that they must fund any investment k with loans from banks. Firms choose non-negative investment k to maximize expected profit

$$E_t \left[\max_{n \geq 0} \left\{ z_{t+1} k^{\alpha} n^{1-\alpha} + (1-\delta)k - w_{t+1} n \right\} - R_{t+1} k \right]$$

subject to $\max_{n\geq 0} \left\{ z_{t+1} k^{\alpha} n^{1-\alpha} + (1-\delta)k - w_{t+1} n \right\} - R_{t+1} k \geq 0$ for each z_{t+1}. After production has taken place firms pay wages, repay bank loans, eat any profits and exit.

Bank problem:

Banks choose dividends d, bond issuance b and loans to firms ℓ to maximize shareholder value

$$V_0 = E_0 \left[\sum_{t=0}^{\infty} \gamma^t d_t \right] \tag{3}$$

subject to budget constraints

$$d_t + \ell_{t+1} + b_t \leq R_t \ell_t + q_{t+1} b_{t+1}, \text{ for } t = 1, 2, \ldots, \tag{4}$$

$$d_0 + \ell_1 \leq a_0 + q_1 b_1, \tag{5}$$

a no-default constraint

$$E_t \left[\sum_{\tau=1}^{\infty} \gamma^{\tau} d_{t+\tau} \right] \geq \theta \ell_{t+1}, \tag{6}$$

and dividend non-negativity, $d_t \geq 0$, for given initial bank equity $a_0 > 0$. The no-default constraint (6) requires that banks value expected discounted future dividends more than a fraction $\theta \in (0, 1]$ of current lending. I motivate this constraint by assuming that banks can default, whereby they would lose future dividends, and threaten to hold up payments worth $\theta \ell_{t+1}$ to bank creditors. The no-default constraint (6) ensures that banks do not have an incentive to default and extract $\theta\ell_{t+1}$ from their creditors in exchange for not holding up payments to creditors.[2]

3 Competitive equilibrium

This section defines the competitive equilibrium and a measure of welfare. It then discusses how a pecuniary externality implies that the competitive equilibrium is not constrained-efficient.

Definition 1. *A competitive equilibrium is characterized by (i) bank lending returns $\{R_{t+1}\}$, bond prices $\{q_{t+1}\}$, wages $\{w_{t+1}\}$ and bank share prices $\{p_t\}$, (ii) household choices for bonds and bank stock holdings $\{b^h_{t+1}, \chi_{t+1}\}$ and (iii) bank choices for dividends, bonds and loans $\{D_t, B_{t+1}, K_{t+1}\}$ such that given initial bank equity a_0 and wage w_0,*

1. *household choices are optimal given $\{w_{t+1}\}$, $\{q_{t+1}\}$, $\{p_t\}$ and $\{D_t\}$,*
2. *bank choices are optimal given $\{R_{t+1}\}$ and $\{q_{t+1}\}$,*
3. *the market for bonds clears, $b^h_{t+1} + B_{t+1} = 0$ and $q_{t+1} = \beta$,*
4. *the market for bank loans clears, $R_{t+1} = \alpha z_{t+1} K^{\alpha-1}_{t+1} + 1 - \delta$,*
5. *the market for labor clears, $w_{t+1} = (1-\alpha) z_{t+1} K^{\alpha}_{t+1}$,*
6. *the market for bank shares clears, $\chi_{t+1} = 1$.*

3.1 Welfare measure and pecuniary externality

The welfare criterion in this paper is household welfare. Because households have linear preferences, the initial wage they receive has no effect on equilibrium prices and, in

[2] Another possible motivation for an implicit creditor-imposed limit on bank leverage could be concerns about whether banks pay a nonverifiable monitoring cost as in Holmstrom and Tirole (1997).

particular, no effect on banks' equilibrium choices. Suppose banks have initial equity a_0 and households receive initial wage w_0, then the welfare of households in competitive equilibrium is as follows:

$$W_0(a_0, w_0) = w_0 + D_0 + E_0 \left[\sum_{t=1}^{\infty} \beta^t \left(D_t + z_t(1-\alpha)K_t^{\alpha} \right) \right],$$

where $\{D_t, K_{t+1}\}$ are banks' choices in competitive equilibrium when initial bank equity is a_0. Because the initial wage enters the welfare criterion as a constant, it does not affect the welfare comparisons in this paper. Normalize $w_0 = 0$ for the remainder of the analysis.

Definition 2. *Let $\{D_t, B_{t+1}, K_{t+1}\}$ be banks' choices in the competitive equilibrium with initial bank equity $a_0 = A$. Construct the recursive representation of household welfare in competitive equilibrium, W_{CE}, as follows:*

$$W_{CE}(A) = D + \beta(1-\alpha)K^{\alpha} + \rho\beta W_{CE}(A_L) + (1-\rho)\beta W_{CE}(A_H),$$

with $A_j = z_j \alpha K^{\alpha} + (1-\delta)K - B$ for $j = L, H$, where $D = D_0$, $B = B_1$ and $K = K_1$.

The welfare analysis in this paper focuses on how changes in bank actions can increase household welfare. Household choices are taken as given, for given bank actions.

The competitive equilibrium of this economy is not constrained-efficient because banks' capital structure choices create a pecuniary externality that affects the tightness of market-imposed leverage constraints. Specifically, if a bank anticipates that all other banks have to rely more on debt funding in the future, then it anticipates higher lending margins in the future. The reason is that if all other banks have lower retained earnings in the future, then market monitoring will limit their ability to compete for lending to firms. However, higher future lending margins relax banks' market-imposed leverage constraints today.

Therefore, when all banks have more leverage in the future, they are able to fund more loans with debt today.[3]

4 Constrained-efficient bank regulation

The pecuniary externality illustrated in Section 3.1 matters when adverse exogenous shocks reduce loan repayments enough to substantially reduce banks' equity. When equity is scarce, then an improvement of banks' access to debt funding alleviates a scarcity of lending to firms across the economy.

In practice, a bank regulator that internalizes this pecuniary externality would prefer capital requirements that are countercyclical in the sense of reducing excessive fluctuations in bank lending over time. A sudden decrease of aggregate bank equity today, due to an adverse exogenous shock, would then be followed by a temporary decrease in future capital requirements—for sufficiently long to strengthen banks' access to debt funding today. Both bank equity and the market value of bank equity will be state variables for such a regulator.

However, there is an important time-inconsistency problem. As soon as banks will have retained enough earnings the regulator will prefer that banks retain earnings, even more to guard against possible adverse exogenous shocks in the future. But then any announcement of lower future capital requirements cannot alleviate banks' funding conditions, because it is not credible. The model thus illustrates that countercyclical capital regulation needs to be designed in a way that addresses this inherent time-inconsistency problem.

[3] Note that Schroth (2021) studies this dynamic trade-off and derives policy implications for a financial regulator that can commit to a (state-dependent) path for future capital requirements. The remainder of this paper revisits the same trade-off and derives policy implications for an economy in which financial regulators *cannot* commit. In particular, such a regulator may slash capital requirements in a severe financial crisis but would soon switch its attention to the possibility of future crises and thus be tempted to raise capital requirements back up again quickly.

Definition 3. *The problem of a regulator that wants to maximize household welfare, but that cannot commit to follow through on its announced actions in the future, can be expressed recursively as follows:*

$$W(A, V) = \max_{\{D,B,K,V_L,V_H\}} \{D + \beta(1-\alpha)K^{\alpha} + \beta\rho W(A_L, V_L) + \beta(1-\rho)W(A_H, V_H)\}$$

subject to

$$D + K \leq A + \beta B, \qquad \textit{(bank budget constraint)}$$

$$D \geq 0, \qquad \textit{(dividend non-negativity)}$$

$$\gamma\left[\rho V_L + (1-\rho)V_H\right] \geq \theta K, \qquad \textit{(limited-commitment bank)}$$

$$V_j \geq A_j, \; j = L, H, \qquad \textit{(participation bank)}$$

$$D + \gamma\left[\rho V_L + (1-\rho)V_H\right] \geq V, \qquad \textit{(promise-keeping regulator)}$$

$$W(A_j, V_j) \geq W_{CE}(A_j), \; j = L, H, \qquad \textit{(limited-commitment regulator)}$$

where $A_j = z_j \alpha K^{\alpha} + (1-\delta)K - B$ for $j = L, H$. The function W_{CE} is characterized in Definition 2.

The regulator prefers to keep the promise of V_j for given bank equity A_j as long as constrained-efficient household welfare is higher than welfare in competitive equilibrium. Formally, the regulator has no incentive to deviate from the constrained-efficient allocation characterized in Definition 3 as long as $W(A_j, V_j) \geq W_{CE}(A_j)$ holds for $j = L, H$. These time-consistency constraints ensure credibility of the regulator and help shape the regulator's preferences over banks' capital structures. To see this, let $\beta\chi_j$ for $j = L, H$ denote the associated Lagrange multipliers. Then the first-order condition for banks' bond issuance can be used to express how the regulator would prefer to allocate bank equity over time as follows:

$$\frac{\partial W(A,V)}{\partial A} = \rho\frac{\partial W(A_L,V_L)}{\partial A_L} + (1-\rho)\frac{\partial W(A_H,V_H)}{\partial A_H} + \chi_L\left[\frac{\partial W(A_L,V_L)}{\partial A_L} - \frac{\partial W_{CE}(A_L)}{\partial A_L}\right] + \chi_H\left[\frac{\partial W(A_H,V_H)}{\partial A_H} - \frac{\partial W_{CE}(A_H)}{\partial A_H}\right] \quad (7)$$

Equation (7) shows that in the absence of concerns about time-consistency the regulator would smooth the scarcity of bank equity over time. However, when $\chi_L > 0$ or $\chi_H > 0$, then the regulator would prefer banks to issue more bonds today and make future equity more scarce. The reason is that bank equity is scarcer in a competitive equilibrium compared to the constrained-efficient allocation because a regulator can use its credibility to mitigate any scarcity of bank equity—i.e., the terms $\left[\frac{\partial W(A_j,V_j)}{\partial A_j} - \frac{\partial W_{CE}(A_j)}{\partial A_j}\right]$ are negative for $j = L, H$.[4]

5 Numerical analysis

Section 4 has shown that maintaining elevated leverage following adverse aggregate shocks to bank-loan repayments is a way to alleviate the regulator's time-inconsistency problem. Elevated bank leverage reduces the benefit to the regulator from reneging on its promise of keeping capital requirements low for a while. Therefore, when banks recover from low loan repayments, they can use part of their income to pay dividends rather than to rebuild their equity faster. Paradoxically, such a policy strengthens the reputation of the regulator.

This section solves the model numerically and shows how a macroprudential bank

[4]Intuitively, when $\chi_j > 0$, then V_j is high relative to A_j. But then a high V_j is needed to satisfy the market-imposed equity requirement and thus to sustain lending. Increasing A_j is then not possible without reducing scarce lending (dividends are already zero when the market-imposed equity requirement binds). Suppose, in contrast, that high V_j was required to deliver the promised shareholder value V (and not to support scarce lending). Then increasing A_j would imply lowering dividends today, which would be a more expensive (capital is costly) way of delivering V. Therefore, a regulator would not increase A_j in response to $\chi_j > 0$.

Table 1: Model parameter values

parameter	value	target
β	0.94	return on savings
γ	0.93	financial crisis frequency
δ	0.10	average replacement investment
α	0.35	capital income share
θ	0.10	bank leverage
(z_L, z_H, ρ)	(0.8,1.05,0.2)	bank loss from one shock

regulator would want to vary banks' capital structure over time in response to shocks to bank loan repayments. I first discuss the choices for numerical values of model parameters. Then I compare the second-best allocation with commitment to the constrained-efficient allocation when the regulator cannot commit to future capital requirements and derive implications for optimal dividend restrictions. The computational method is discussed in Appendix A.

5.1 Calibration

Table 1 summarizes the choices of model parameter values used in the numerical analysis. The time period is one year. The choice of consumer discount factor β implies an annual interest rate on household savings of around 6 percent. This rate is between the long-run safe return of 1–3 percent and the long-run risky return of 7 percent as reported in Jordà et al. (2019). The depreciation rate and capital income share are set to 10 percent and 35 percent, respectively. The firm productivity process is normalized to have unit mean and the probability of the low shock realization is set to $\rho = 0.2$. Then z_H is fully determined by ρ and z_L.

The parameter values for θ, z_L, and γ are chosen jointly such that three model moments match their respective targets. The first model moment is bank capital relative to bank lending in normal times during which bank equity and lending are constant as long as realized firm productivity is z_H. I set its target to 12 percent, which is in line with the average ratio of equity capital to total assets of bank holding companies in the United States with assets of $10 billion and over.[5]

The second model moment is the decrease in the capital-to-lending ratio when low firm productivity is realized during normal times. I set its target to 2 percent. This value implies a significant decrease in bank capital from low loan repayment. However, this decrease is smaller than the 4.4 percentage point decline in aggregate regulatory capital ratio generated by the 2018 supervisory bank stress test of the Federal Reserve Board for the case of a severe stress scenario.[6] The model generates bank losses comparable to those considered by regulatory stress tests as the result of multiple adverse shocks. Specifically, a 4.4 percentage point decline in the capital ratio would require around two realizations of low firm productivity and would have a likelihood of around 4 percent.

The third model moment is the fraction of periods during which the "lending gap," defined as the difference between first-best lending K_{FB} and actual bank lending, is at least 5 percent. I set its target to 0.06. Using data from Schularick and Taylor (2012) for the time period 1870–2008, Boissay, Collard, and Smets (2016) report that on average financial crises occur in developed countries once every 42 years and last 2.32 years. Therefore, roughly, a developed economy is expected to spend a fraction $1/42 \cdot 2.32 = 0.055 \approx 0.06$ of years in a financial crisis. In their panel study of more recent financial crises Laeven and Valencia (2018) find that developed countries tend to spend between one and two years in a financial crisis during the time period 1970–2017. Depending on the cutoff for the size of the lending gap used to define a financial crisis in the model economy, the competitive equilibrium spends up to 7 percent of years in a financial crisis (see solid line in Figure 1).

[5]This data is collected by the Federal Reserve System and available for download at the Federal Financial Institutions Examination Council. The model feature of a fixed leverage target that banks aim to achieve during normal times is consistent with empirical evidence in Gropp and Heider (2010) and Begenau, Bigio, Majerovitz, and Vieyra (2020).

[6]Details on the stress test are provided by the Federal Reserve System.

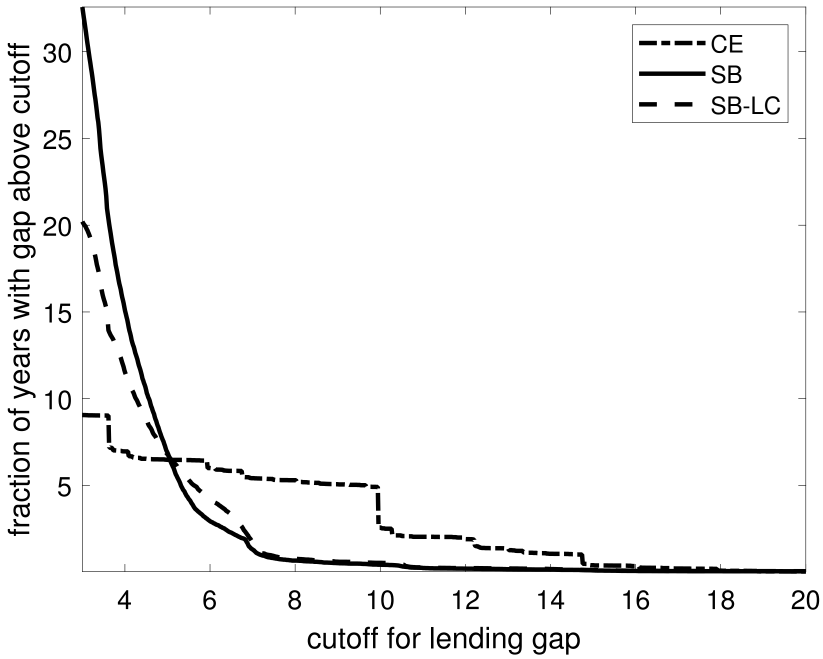


Figure 1: Frequency of low lending in a stochastic steady state (average over $30,000$ simulated periods) in laissez-faire competitive-equilibrium allocation (CE), second-best allocation (SB) and the constrained-efficient allocation when the regulator cannot commit (SB-LC).

The resulting value for θ implies a market-imposed capital requirement of 10 percent in normal times, when bank future profits are zero. Thus, banks hold a 2 percent voluntary capital buffer on top of the market-imposed requirement during normal times. One realization of low firm productivity during normal times wipes out this buffer and brings banks close to becoming funding-constrained. The value for γ implies a cost of equity that is around one percentage point higher than the return on savings. This moderate cost of equity is nevertheless consistent with a plausible frequency of financial crises in the model.

5.2 Second-best and competitive-equilibrium allocations

Figure 1 reveals an important feature of the constrained-efficient allocation when the regulator cannot commit. On the one hand, the regulator is able to avoid severe decreases in lending despite concerns about the credibility of its policies. However, on the other hand, intermediate credit crunches—with lending gaps around 6 percent—occur roughly twice as often compared to the case of full commitment. When the regulator cannot impose tough dividend restrictions on banks following severe losses, then there is a higher risk of a prolonged—although not severe—credit crunch in case there are further losses. Therefore, a regulator that cannot commit can nevertheless build credibility by having a higher risk tolerance. Doing so allows regulators to avoid severe financial crises, just as in the case with full commitment.

This section explores the channels driving this feature and derives policy implications for a regulator that needs credibility to achieve its macroprudential objective. Figure 2 compares the constrained-efficient allocation when the regulator cannot commit with the second-best allocation and the competitive-equilibrium allocation for the following sequence of firm productivity shocks:

$$\{z_H, \ldots, z_H, z_L, z_H, \ldots, z_H, z_L, z_L, z_H, \ldots, z_H, z_L, z_L, z_L, z_L, z_H, \ldots, z_H\}.$$

This sequence produces three impulse responses that illustrate the non-linear effect of shocks to bank balance sheets on bank lending. Following realizations of low firm productivity z_L, enough realizations of high firm productivity z_H occur for the economy to reach normal times during which bank equity and lending are constant as long as realized firm productivity is high.

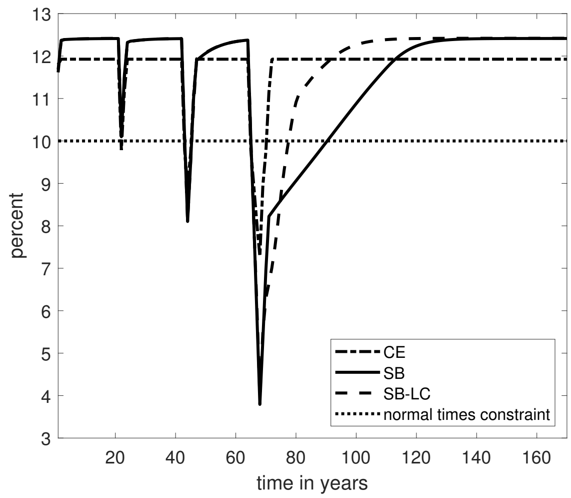
Define aggregate bank equity as $A_t = R_t(z_t)K_t - B_t = z_t \alpha K_t^\alpha + (1-\delta)K_t - B_t$ where K_t denotes aggregate bank lending and B_t denotes aggregate bank bond issuance. Figure 2(a) shows that banks in competitive equilibrium, during normal times, hold a voluntary capital buffer worth 2 percent of normal-times lending on top of the market-imposed capital requirement. One realization of low firm productivity gets absorbed by this buffer and therefore has only a limited effect on bank lending. Banks are not funding-constrained yet and reduce their lending by around 1 percent as a precaution. However, a realization of low firm productivity when this voluntary buffer is used up has a large effect on bank lending, as Figure 2(b) shows. Banks become funding-constrained and are forced to reduce lending by around 10 percent. In contrast, in second best as well as in the constrained-efficient allocation when the regulator cannot commit banks reduce their ending by only around 3 percent when experiencing two consecutive realizations of low firm productivity. The reason is that, during normal times, banks hold additional capital worth 0.5 percent of normal-times lending.

A key difference between the second-best and the constrained-efficient allocation where the regulator cannot commit is dividend policy following severe adverse shocks to loan repayment. Figure 3 shows that this is the time when the regulator's limited commitment constraint binds. To bolster its credibility, the regulator must avoid tough dividend restrictions and allow banks to operate with (even) higher leverage during the most severe financial crises.[7] Note that higher leverage can only be achieved with higher dividend payouts when bank lending is constrained by the market-imposed equity requirement. Figures 2(a) and 2(c) illustrate how the regulator's credibility problem markedly shapes its policy during a severe financial crisis. Although in second best tough dividend restrictions are imposed as long as lending is significantly reduced, a regulator that cannot commit must allow banks to pay dividends in the thick of a crisis.

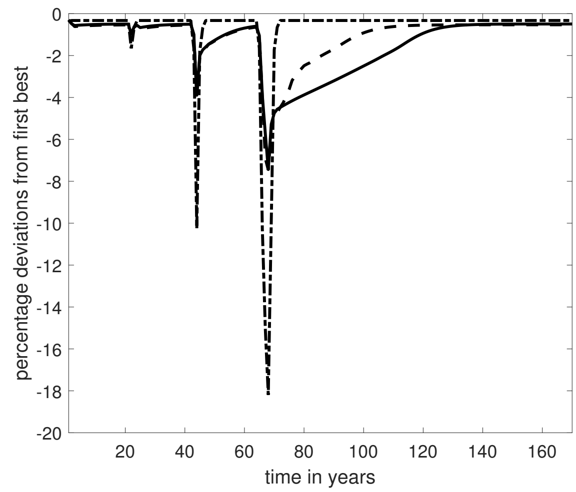
5.3 Credibility of regulator and policy implications

Figure 4 examines a severe financial crisis more closely. It shows that when the regulator cannot commit to future capital requirements, then it allows banks to resume dividend payments substantially earlier during a severe crisis. In fact, banks pay signif-

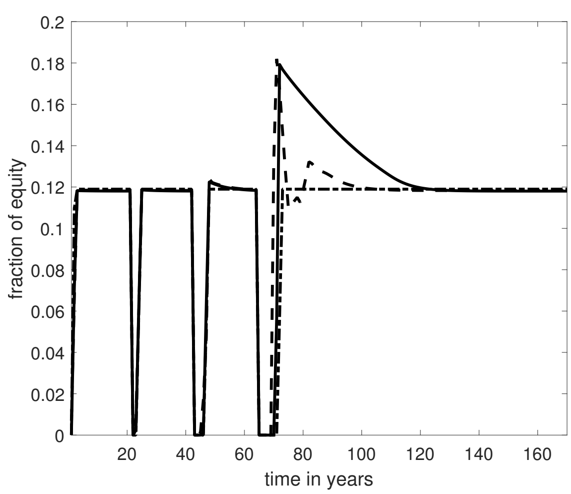
[7] Note that a loss of credibility would mean a lending decrease of 18 percent rather than only around 7 percent (Figure 2(b)).



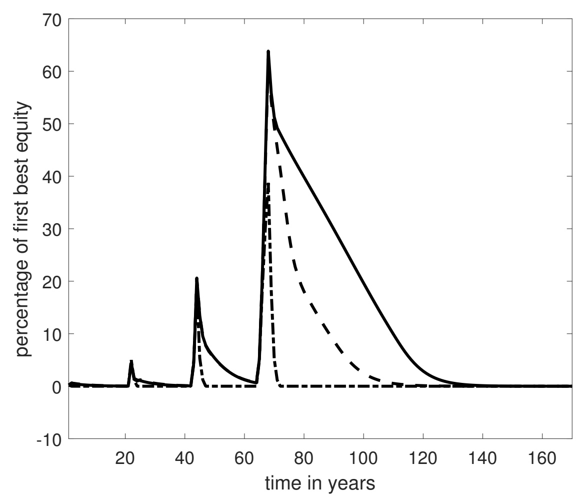
(a) Aggregate bank capital



(b) Aggregate bank lending



(c) Dividends



(d) Future profits

Figure 2: Panel (a) shows bank capital relative to bank lending, $\left[\gamma E_t A_{t+1}/K_{t+1} - 1\right] \cdot 100$, where E_t denotes conditional expectations at time t. Panel (b) shows bank lending relative to first-best lending, $\left[K_{t+1}/K_{FB} - 1\right] \cdot 100$. Panel (c) shows the aggregate bank dividend payout ratio, D_t/A_t. Finally, panel (d) shows bank future profits scaled by first-best lending, $\Pi_t/\beta\theta K_{FB} \cdot 100$.

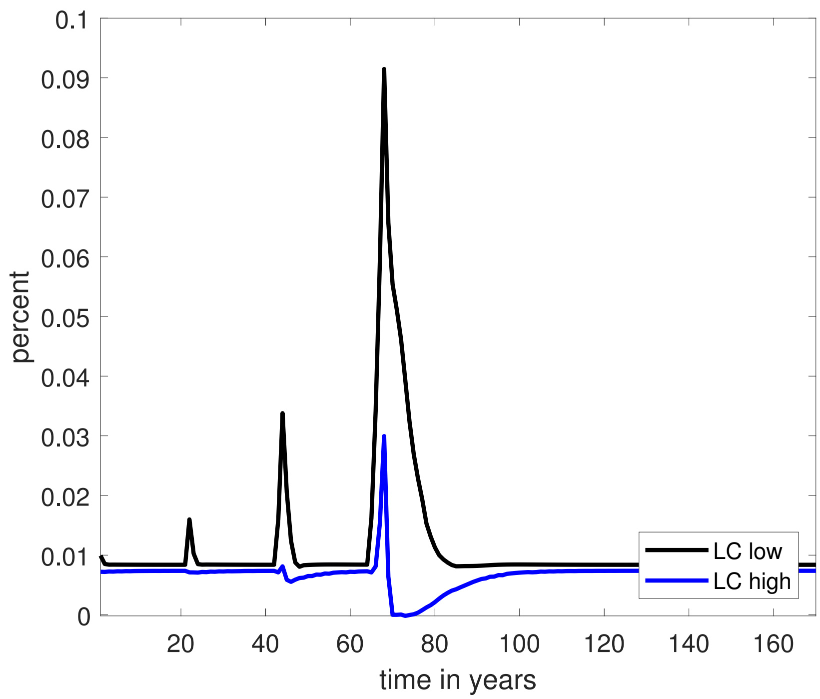


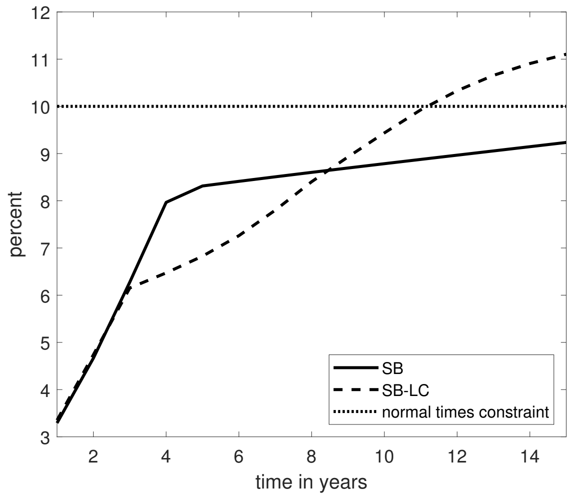
Figure 3: Slack in the regulator's limited-commitment constraint in the constrained-efficient allocation when the regulator cannot commit (SB-LC). Note that the regulator is never tempted to renege on its promises when banks experience low loan repayments (when $z_{t+1} = z_L$, see black line). The reason is that in such an instance, the regulator would want to further reduce capital requirements rather than increase them back to pre-crisis levels.

icant dividends while lending and, especially, bank equity are still significantly below their respective pre-crisis levels. Banks are allowed to pay dividends close to pre-crisis levels even while their equity is about half the pre-crisis level. On the one hand, the regulator that cannot commit can nevertheless avoid the most severe credit crunches. On the other hand, however, bank lending is more susceptible to further adverse shocks to bank loan repayment because of the slower pace at which bank equity is rebuilt.

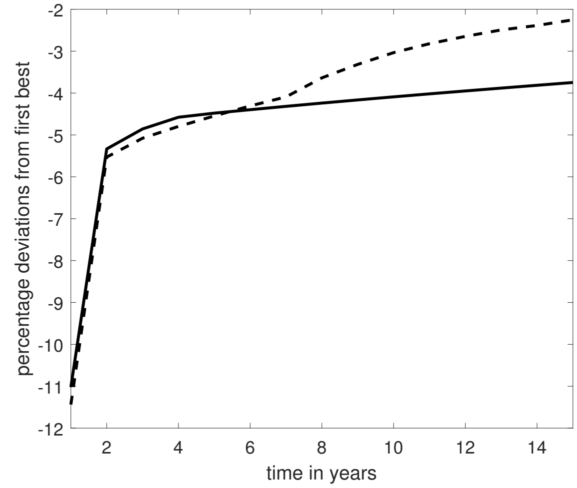
This is exactly the effect of a lack of the regulator's commitment on financial stability illustrated in Figure 1: regulation is still able to avoid severe financial crises but the economy experiences financial crises of intermediate severity much more frequently. However, even a regulator without commitment is doing much better in terms of financial stability compared to the competitive equilibrium without any macroprudential regulation.

The policy implication is that the additional capital buffers introduced in the aftermath of the Global Financial Crisis 2007–09 are likely very beneficial. But to alleviate concerns about the credibility of a buffer release that is meaningful in *duration*, it is important to make sure that the buffer release is as meaningful as possible in terms of *magnitude*. For example, Figure 4 shows that during a severe financial crisis in the United States banks' dividends should not be restricted even if banks breach their capital conservation buffers.[8].

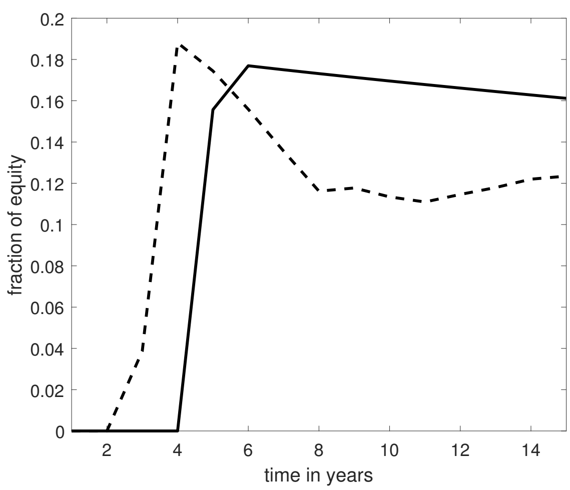
[8]Sam Woods from the Bank of England has argued in a recent speech for combining the various capital buffers into a single releasable buffer. This mirrors the policy implications from the analysis in this paper that calls for making the releasable part of capital buffers as large as possible. Note that with full commitment of the regulator it is optimal to restrict dividends until a substantial part of banks' equity has been rebuilt. In this case there would be no need to make buffers such as the capital conservation buffer releasable (Schroth, 2021)



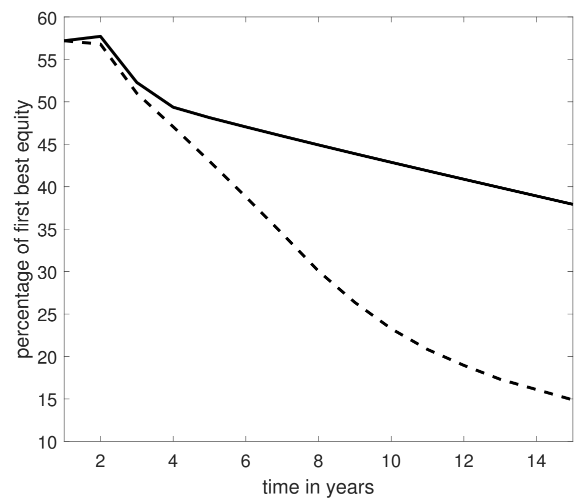
(a) Aggregate bank capital



(b) Aggregate bank lending



(c) Dividends



(d) Future profits

Figure 4: This figure examines closely a financial crisis that is for illustration purposes more severe than those in Figure 2. Panel (a) shows bank capital relative to bank lending, $\left[\gamma E_t A_{t+1}/K_{t+1} - 1\right] \cdot 100$, where E_t denotes conditional expectations at time t. Panel (b) shows bank lending relative to first-best lending, $\left[K_{t+1}/K_{FB} - 1\right] \cdot 100$. Panel (c) shows the aggregate bank dividend payout ratio, D_t/A_t. Finally, panel (d) shows bank future profits scaled by first-best lending, $\Pi_t/\beta\theta K_{FB} \cdot 100$.

6 Conclusion

Macroprudential bank regulation aims to maintain a stable supply of lending and recognizes the importance of the health of the banking sector for achieving this goal.

Therefore, during a severe financial crisis, a financial regulator would want to do two things. First, the regulator would want to restrict banks' dividends to limit the time that banks spend with low equity. Second, the regulator would want to commit to keeping capital requirements reduced for a while to avoid a sharp drop in banks' lending.

But a regulator cannot do these two things simultaneously because of a time-consistency problem. In particular, when banks face tough dividend restrictions, they realize that any promises of temporarily reduced capital requirements are not credible. The reason is that a regulator sees no need to keep capital requirements reduced once banks have rebuilt equity enough to actually bear higher requirements. In other words, banks have good reasons to be concerned about dividend restrictions.

In the absence of a time-consistency problem, the optimal macroprudential policy would resemble a mix of static and time-varying capital buffers. While the former automatically impose dividend restrictions when banks have low equity, the latter can be "released" to support banks' lending activity. However, given that a regulator's promise of reduced future capital requirements needs to be credible to be able to support bank lending, the usefulness of static capital buffers is questioned. The analysis in this paper suggests that the optimal time-consistent policy is a single buffer that is large and fully releasable during severe financial crises.

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A Appendix

The competitive-equilibrium allocation and the second-best allocations—with and without commitment of the regulator—are obtained recursively.

A.1 Competitive-equilibrium allocation

I solve for the competitive-equilibrium allocation using policy function iteration (e.g., Rendahl, 2014) over the multiplier on the bank dividend non-negativity constraint. The endogenous state variable is bank equity. The present value of bank dividends for each level of bank equity is given by a shareholder value function. At each step in the policy function iteration I also use updated policy functions to update the shareholder value function. Only limited iterations on the shareholder value function can be performed at each step of the outer policy function iteration to achieve convergence of the latter (dampening). Policy function convergence then implies shareholder value function convergence.

A.2 Second-best allocation

I solve for the second-best allocation without commitment of the financial regulator using standard value function iteration over household lifetime utility W. Specifically, this allocation solves the dynamic program presented in Definition 3 for states $(A, V) \in \mathfrak{R} \subset \mathbb{R}^2$.[9] Also impose the transversality condition V_L, $V_H \leq M$, with $M < \infty$ large enough such that the transversality condition never binds. The set $\mathfrak{R}$ is the limit of the sequence of sets $\{\mathfrak{R}_n\}$ where $\mathfrak{R}_{n+1}$ is defined as the set of pairs $\left(A_j(A, V), V_j(A, V)\right)$ that are consistent with the Bellman equation in Definition 3 for $j = L, H$ for each $(A, V) \in \mathfrak{R}_n$. Let $\mathfrak{R}_0 = \{(K_{FB}, 0)\}$. The second-best allocation with full commitment of the financial regulator is solved the same way except that the time-consistency constraints are dropped from the dynamic program in Definition 3.

[9] Note that the second-best allocation without commitment could be interpreted in the context of dynamic risk sharing—between a regulator, on behalf of households, and banks—under two-sided limited commitment similar to Thomas and Worrall (1988) and Kocherlakota (1996). Promising a bank shareholder value becomes a deliberate choice, and the value promised to banks at a given point in time becomes an endogenous state variable. However, in contrast to Thomas and Worrall (1988) and Kocherlakota (1996), there are no direct transfers possible toward the agents facing the commitment problem. It is assumed that dividends are non-negative and bonds non-contingent.