Optimal Capital Regulation*

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This paper studies a dynamic stochastic production economy where financial intermediation matters. In the model, not all bank funding is secured such that the ability of a bank to obtain funding depends not only on its collateral but also on its long-term viability. As a consequence, the tightness of implicit leverage constraints imposed by market discipline depends on banks' future prospects. The paper shows that macro-prudential concerns, which aim at insulating the economy from shocks to banks, naturally lead to regulatory actions which explicitly influence banks' access to external funding. Specifically, macro-prudential regulation should require banks to hold additional capital buffers in normal times, while at the same time committing to raising banks' future prospects temporarily following crises in order to relax market-imposed leverage constraints during crisis times.

JEL: E13, E32, E44

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1 Introduction

Financial crises are considered to be costly and generally lead to policy interventions (Laeven and Valencia, 2013). Theoretical work finds that interventions can improve welfare significantly due to the pivotal role that financial intermediaries play (Schroth, 2012; Philippon and Schnabl, 2013; Sandri and Valencia, 2013). However, theoretical work also stresses the importance of ex-ante measures, such as capital buffers, which reduce the reliance on ex-post policy intervention (Lorenzoni, 2008; Martinez-Miera and Suarez, 2012; Begenau, 2014; Clerc et al., 2014). The literature which studies ex-post intervention and ex-ante measures in a unified framework typically assumes that financial intermediaries rely exclusively on collateralized lending (Jeanne and Korinek, 2013). In practice, however, financial intermediaries rely more on non-secured funding, via issuing bonds and commercial paper, than on secured funding (citation). It is therefore important to take into account the willingness of market participants to provide non-secured funding to financial intermediaries during financial crisis times. This raises the question of how regulation should balance ex-ante and ex-post tools in order to avoid, or mitigate, severe credit crises which arise when intermediaries suddenly lose access to market funding?

To answer this question the paper develops a small-scale DSGE model where the presence of financial intermediaries introduces strong non-linearities (He and Krishnamurthy, 2012; Brunnermeier and Sannikov, 2014). The paper then studies the problem of a constrained regulator that takes as given the structure of markets as well as intermediary (bank) moral hazard but internalizes the effect of regulation on market prices and on banks' access to funding. Such a regulator would choose 'constrained-efficient' capital requirements which can be decomposed into a mix of implementable policies such as capital buffers, conservation buffers, capital relief, or recapitalization.

In the model, banks engage in risk management (loan-loss provisioning) such that they lose access to market finance only occasionally. But when they do lose access then the flow of credit is severely disrupted throughout the economy. The contribution of the paper is to characterize constrained-efficient regulation in an economy where banks rely on non-secured market finance and where market participants worry about long-term bank viability. A regulator temporarily raises banks' future prospects following times where bank lending is constrained due to limited access to market finance. Such an ex-post action increases the long-term viability of banks and supports their access to market funding during crisis times. At the same time a regulator imposes additional ex-ante capital buffers which reduce the need to rely on varying bank future prospects ex-post too much in a way that would create excessive economic distortions. Regulation thus trades off requiring banks to hold more costly capital ex-ante against distortionary increases in bank future prospects whenever bank capital is low ex-post.[1]

2 Model

This section describes an infinite horizon economy in discrete time with time periods $t = 0, 1, 2, \ldots$. There are random i.i.d. aggregate fluctuations $z \in Z = \{z_L, z_H\} \subset \mathbb{R}^2_{++}$, where $Pr(z = z_L) = \rho$. There is a consumption good. There is a measure one of identical intermediaries, a measure one of identical households, and, in every period t, a measure one of identical short-lived firms. Households are endowed with one

[1] I assume that bank capital is costly. If bank capital would not be costly then the regulator would require banks to fund themselves with equity and retained earnings (Admati et al., 2010).

unit of labor each which they supply inelastically. Firms have access to a production technology which turns k units of the consumption good in period t and l units of labor in period $t+1$ into $F(k,l) = zk^{\alpha}l^{1-\alpha} + (1-\delta)k$ units of the consumption good in period $t+1$ where aggregate productivity z is realized at the beginning of period $t+1$, before l is chosen, and where $\delta \in (0,1)$ is a depreciation rate. Spot markets for labor, contingent intermediary loans, and non-contingent one-period bonds open in every period. In every period t, the wage w_t clears the labor market, the returns on loans $(R_{t+1}(z))_{z\in Z}$ clear the market for intermediary lending, and it is assumed that a constant risk-free world-interest rate implies a price for bonds that is fixed at $\beta \in (0,1)$.

Firms:

A firm that is born at the end of period t produces in period $t+1$ and maximizes its expected profit subject to solvency in each state of the world. It is assumed that each firm must borrow from an intermediary to finance its investment in period t, i.e. firms cannot borrow at the risk-free rate and do not have any internal funds. Due to constant returns to scale, firm profits will be exactly zero in every state. The wage and return on intermediary lending in an equilibrium are given by

$$w_t = (1-\alpha)z_t K^{\alpha}, \tag{1}$$

$$R_t(z_t) = \alpha z_t K_t^{\alpha-1} + 1 - \delta, \tag{2}$$

where K_t denotes the aggregate amount invested in period $t-1$, $z_t \in Z$, and where the aggregate labor supply is $L_t = 1$.

Households:

Households are risk-neutral, value consumption, but do not value leisure.

Intermediaries:

Intermediaries are risk neutral, value dividends, and lend to firms. It is assumed that intermediaries are more impatient than the capital market in the sense that the intermediary discount factor satisfies $\gamma < \beta$. However, intermediaries will generally not set dividends as high as possible since the timing of intermediary dividends determines an intermediary's incentive to engage in moral hazard, which in turn affects intermediary's access to external finance. Intermediaries use equity (retained earnings) and external finance to fund non-negative lending to firms $\{k_{t+1}\}_{t=0,1,2,\ldots}$ as well as non-negative dividends $\{d_t\}_{t=0,1,2,\ldots}$. Intermediary creditors (e.g. households) are willing to provide external finance to an intermediary as long as the intermediary values the future dividends it expects to enjoy more than the fraction $\theta \in (0,1)$ of its lending that it could misappropriate (moral hazard). This is captured by the following no-default condition which needs to be satisfied in every period $t = 0, 1, 2, \ldots$ in which the intermediary wishes to make use of external finance.

$$E_t \left[\sum_{s=1}^{\infty} \gamma^s d_{t+s} \right] \geq \theta k_{t+1} \tag{3}$$

Note that equation (3) will be satisfied as well when the intermediary uses only equity finance such that it will be imposed throughout without loss of generality. In every period $t = 0, 1, 2, \ldots$, intermediaries face budget constraints of the form

$$d_t + k_{t+1} + \beta b_{t+1} \leq R_t(z_t) k_t + b_t, \tag{4}$$

where b_{t+1} denotes an intermediary's purchase of one-period non-contingent and risk-free bonds. Let $V_t = d_t + E_t\left[\sum_{s=1}^{\infty} \gamma^s d_{t+s}\right]$ denote intermediary value at time t.

2.1 Definition and analysis of competitive equilibrium

Let $s^t \in Z^t$ denote a history of aggregate shocks for each $t = 0, 1, 2, \ldots$. The following definition characterizes a competitive equilibrium in terms of intermediary actions only since household and firm demand and supply are perfectly elastic given the defined equilibrium prices.

Definition 1. *A competitive equilibrium is defined as lending returns $\{R_{t+1}(s^{t+1})\}_{t=0,1,2,\ldots}$, wages $\{w_t(s^t)\}_{t=1,2,\ldots}$, as well as intermediary actions $\{d_t(s^t), b_{t+1}(s^{t+1}), k_{t+1}(s^{t+1})\}_{t=0,1,2,\ldots}$ such that (i) intermediary actions maximize the value of the intermediary subject to equations* (3) *and* (4) *and dividend non-negativity, and (ii) lending returns satisfy $R_{t+1}(s^{t+1}) = z_{t+1}\alpha k_{t+1}^{\alpha-1}(s^{t+1}) + 1 - \delta$ and wages satisfy $w_t(s^t) = z_t(1-\alpha)k_t^{\alpha}(s^t)$.*

Consider the problem of an intermediary that chooses lending and debt in order to maximize its value at date zero, $V_0 = d_0 + E_0\left[\sum_{t=1}^{\infty} \gamma^t d_t\right]$, subject to equations (3) and (4) and dividend non-negativity. Let $\psi_t(s^t)$ be the multiplier on equation (3) in period t, when $k_{t+1}(s^t)$ is chosen. It determines the change in the value of the intermediary's internal funds (equity) when the intermediary loses access to external finance. Let the value of internal funds be $\lambda_t(s^t)$, i.e. the multiplier on equation (4). Then the first-order condition for $k_{t+1}(s^t)$ can be written as

$$\theta\psi_t(s^t) = \gamma E_t\left[\lambda_{t+1}(s^{t+1})\left(R_{t+1}(s^{t+1}) - \frac{1}{\beta}\right)\right]. \tag{5}$$

Equation (5) says that intermediaries are profitable, after adjusting their income for its riskiness, only at times where they lose access to external finance. The reason is that intermediaries are competitive and would immediately compete away any risk-adjusted profit margin if their creditors would allow them to increase leverage. The assumption that intermediaries are more impatient than other participants in the bond market, i.e. $\gamma < \beta$, implies that equation (3) will occasionally bind. To see this note that the first-order condition for intermediary bond holdings yields

$$\lambda_t(s^t) = \frac{\gamma}{\beta} E_t \left[\lambda_{t+1}(s^{t+1}) \right], \tag{6}$$

which implies that the value of internal funds increases on average. Then the first-order condition for dividends shows that, unless dividends are ’always’ zero which does not occur in an equilibrium, there is no upper bound on the number of instances where equation (3) binds, since

$$\lambda_t(s^t) = 1 + \mu_t(s^t) + \sum_{\tau=0}^{t-1} \psi_\tau(s^\tau), \tag{7}$$

where s^τ denote sub-histories of s^t and $\mu_t(s^t)$ denotes the multiplier on $d_t(s^t) \geq 0$. To summarize, each intermediary is aware that low realizations of the aggregate shock lower internal funds of all other intermediaries and increase the probability that other intermediaries lose access to external funds in the current or some future period. For this reason, each intermediary risk-weights lending income and extends lending only up to the point where their risk-adjusted profitability drops to zero.[2] Intermediaries thus engage in loan-loss provisioning due to a last-bank standing effect (Perotti and Suarez, 2002).

[2]The bond market is incomplete exogenously in this paper. Lorenzoni (2008) and Rampini and Viswanathan (2010, 2012) show how contracting frictions limit intermediary risk management even if a complete set of contingent securities is potentially available.

2.1.1 Deterministic steady state

Suppose $z_L = z_H = 1$ such that the economy does not experience any stochastic fluctuations. Define First-Best lending as

$$K_{FB} = \left[\frac{\alpha\beta}{1-\beta(1-\delta)}\right]^{\frac{1}{1-\alpha}}. \tag{8}$$

Note that $\mu_t = 0$ in a steady state of the competitive equilibrium. It follows from equations (6) and (7) that $\psi_t = \frac{\beta-\gamma}{\gamma}\lambda_t$ in a steady state. Note that intermediaries are always borrowing constrained due to their relative impatience. The amount of steady state lending in a competitive equilibrium follows from equation (5) as

$$K_{CE} = \left[\frac{\alpha\beta}{1-\beta(1-\delta)+\theta\frac{\beta-\gamma}{\gamma}}\right]^{\frac{1}{1-\alpha}}. \tag{9}$$

It can be seen from equations (8) and (9) that intermediaries provide less than the First-Best amount of lending in steady state.

2.2 Intermediary no-default condition and capital requirements

This section discusses how equation (3) is related to intermediary capital requirements (e.g. BCBS, 2010). Let A_t denote intermediary equity and let Π_t denote the value of an intermediary's charter net of equity, then

$$A_t = R_t(z^t)k_t + b_t, \tag{10}$$

$$\Pi_t = \sum_{\tau=1}^{\infty}\gamma^{\tau}E_t\left[\left(R_{t+\tau}(z_{t+\tau}) - \frac{1}{\gamma}\right)k_{t+\tau}\right] + \sum_{\tau=1}^{\infty}\gamma^{\tau}E_t\left[\frac{\gamma-\beta}{\gamma}b_{t+\tau}\right]. \tag{11}$$

Note that the first term in Π_t is the present value of pure profits where the intermediary's own discount factor is used rather than the bond market discount factor. Since $\gamma < \beta$ this term is lower compared to the case where intermediary profits are discounted using bond prices. The second term reflects the fact that usage of external finance, $b_{t+\tau} < 0$, is a way for the intermediary to increase its value. That is, there is a benefit from front-loading dividends, and back-loading debt repayments, due to impatience. Using equation (4), the value of an intermediary can then be expressed as $V_t = A_t + \Pi_t$. The no-default condition given by equation (5) can then be reformulated as

$$E_t A_{t+1} \geq \frac{\theta}{\gamma} k_{t+1} - E_t \Pi_{t+1}. \tag{12}$$

With intermediary capital defined as expected equity, equation (12) gives a capital requirement that depends on the expected present value of intermediary future profits. These capital requirements are 'micro-prudential' in the sense that their purpose is to guarantee the solvency of the intermediary only. For example, if the value of the intermediary's charter does not exceed its equity then permissible leverage is given by $\frac{\gamma}{\theta}$. If the intermediary is expected to have a charter value that is higher than its equity then it is allowed to have higher leverage, as the intermediary future profits serve as 'skin in the game'.

It is important to note that 'micro-prudential' capital requirements are very low in this economy such that intermediaries often hold capital (equity) well above the requirement stipulated by equation (12), implying that equation (12) will bind only occasionally. The reason is that intermediaries seek to protect their charter value, that is they risk-weight interest income in order to avoid low equity (and binding capital requirements) in states where the return on lending is high (i.e. they engage in loan loss provisioning). In that sense, market-imposed capital requirements already induce prudent behavior to some extent. The following section asks whether this extent is sufficient or whether additional macro-prudential capital regulation is necessary.[3]

3 Optimal Capital Regulation

The capital requirement given by equation (12) gives rise to a pecuniary externality, in the sense of Greenwald and Stiglitz (1986), which implies that an exclusive reliance on market monitoring of intermediaries may lead to inefficiencies in this economy. The reason is that future asset prices, i.e. future lending returns $\{R_{t+1+\tau}(z_{t+1+\tau})\}_{\tau\geq 1}$, are entering equation (12) through expected future profits $E_t\left[\Pi_{t+1}\right]$ which implies that a constrained-social planner can affect capital requirements and thus permissible intermediary leverage by affecting these future asset prices (Schroth, 2012). Due to this pecuniary externality, a constrained social planner can potentially do a better job at dynamically stabilizing aggregate lending in the economy and thus improve upon self-interested (competitive) individual provisioning by financial intermediaries.

Definition 2. *Optimal capital regulation is defined as intermediary lending that obtains in a constrained efficient allocation.*

Since bank capital is costly, due to banks' relative impatience, it is necessary to

[3] Micro-prudential capital regulation is not concerned with intermediary leverage beyond the objective of ensuring intermediary solvency. Macro-prudential, or counter-cyclical, capital regulation, on the other hand, may have the objective of reducing leverage ex ante in order to avoid low levels of lending ex post, while allowing for particularly high leverage ex post at times where lending is particularly low ex post.

impose bank participation constraints in periods $t = 1, 2, \ldots,$

$$E_t \left[\sum_{\tau=0}^{\infty} \gamma^\tau d_{t+\tau} \right] \geq R_t(z_t) k_t + b_t. \tag{13}$$

Condition (13) ensures that banks prefer continuing being a bank to liquidating their assets. Note that the bank participation constraint can be written as $V_t \geq A_t$ which is equivalent to $\Pi_t \geq 0$. Condition (13) requires that the future profits that banks expect to earn are non-negative. To see why it might be binding in a constraint-efficient allocation consider the case where bank lending is First Best and bank debt is zero such that the first term in Π_t is negative while the second is zero. A constrained-efficient allocation will thus allow for bank leverage or bank rents or both in order to discourage banks to liquidate themselves.

Definition 3. *The constrained-efficient allocation is given by sequences of dividends* $\{d_t\}_{t \geq 0}$ *and intermediary lending* $\{K_{t+1}\}_{t \geq 0}$ *such that social welfare*

$$\mathcal{W} = d_0 + \sum_{t=1}^{\infty} \beta^t E_0 \left[d_t + w_t \right],$$

is maximized subject to equations (1) *to* (4) *and* (13) *as well as dividend non-negativity* $d_t \geq 0$. *Note that dividends are discounted using* β *rather than* γ *when calculating social welfare.*

In a constrained-efficient allocation equation (3) can be relaxed by increasing future profits $E_t \left[\Pi_{t+1} \right]$. While an increase in future intermediary profits mitigates a severe credit crunch it also creates socially costly distortions in future intermediary lending.

3.1 Analysis of the constrained-efficient allocation

Before continuing to the numerical part of the paper, first-order conditions are discussed that the constrained-efficient allocation must satisfy. Let again ψ_t be the multiplier on the intermediary no-default condition (3), λ_t be the multiplier on the intermediary budget constraint equation (4), η_t be the multiplier on the participation condition (13), and μ_t the multiplier on dividend non-negativity. The following equation (14) shows that the constrained-efficient allocation may feature an excess risk premium on intermediary lending even if intermediaries have further access to external finance (i.e. even if (3) does not bind).[4]

$$\theta\psi_t + \beta E_t\left[(\lambda_{t+1} - \eta_{t+1} - 1)\,\alpha(1-\alpha)z_{t+1}K_{t+1}{}^{\alpha-1}\right] = \beta E_t\left[(\lambda_{t+1} - \eta_{t+1})\left(R_{t+1} - \frac{1}{\beta}\right)\right]. \tag{14}$$

Excess returns enjoyed by intermediaries depend on the next-period's value of internal intermediary funds λ_{t+1}. The multiplier λ_{t+1} is non-decreasing on average as equation (15) shows.

$$\lambda_t = E_t\left[\lambda_{t+1} - \eta_{t+1}\right]. \tag{15}$$

The first-order condition on dividends, equation (16), that the constrained-efficient allocation must satisfy reveals that λ_t increases whenever equation (3) or equation (13) binds and then decays over time for given multipliers $\{\mu_{t+\tau}\}_{\tau\geq 0}$ as long as equa-

[4] Equation (16) below shows that

$$\lambda_t(s^t) - \eta_t(s^t) = 1 + \mu_t(s^t) + \sum_{\tau=1}^{t}\left(\frac{\gamma}{\beta}\right)^{\tau}\left[\psi_{t-\tau}(s^{t-\tau}) + \eta_{t-\tau}(s^{t-\tau})\right] \geq 1$$

for all $t = 0, 1, 2, \ldots$

tions (3) and (13) do not bind again.

$$\lambda_t(s^t) = 1 + \mu_t(s^t) + \sum_{\tau=1}^{t} \left(\frac{\gamma}{\beta}\right)^{\tau} \left[\psi_{t-\tau}(s^{t-\tau}) + \eta_{t-\tau}(s^{t-\tau})\right] + \eta_t(s^t). \tag{16}$$

The intuition is as follows. When the no-default condition (3) binds lending is severely reduced in the economy and lending returns shoot up. As a result, the value of intermediary internal funds increases and this increase is long-lived by equation (16). This in turn leads to to higher excess returns via equation (14) over a number of periods, increasing expected intermediary future profits immediately. The result is that equation (3) is being relaxed such that lending returns shoot up by less, at the social cost of somewhat higher lending returns over a number of future periods. That is, in a constrained-efficient allocation, the scarcity of intermediary lending is smoothed out over time.

3.1.1 Deterministic steady state

In a deterministic steady state, where $\mu_t = 0$, it follows from equations (15) and (16) that $\psi_t = \frac{\beta-\gamma}{\gamma}(\lambda_t - 1)$ in a steady state. Note that intermediaries are always borrowing constrained due to their relative impatience. Let $\lambda = \lim_{t\to\infty} \lambda_t$ which exists since $\{\lambda_t\}_{t=0,1,2,...}$ is monotonic by equation (15). The amount of steady state lending in a constrained-efficient allocation follows from equation (14) as

$$K_{SB} = \left[\frac{\beta\alpha\left(1-(1-\alpha)\frac{\lambda-1}{\lambda}\right)}{1-\beta(1-\delta)+\theta\frac{\beta-\gamma}{\gamma}\frac{\lambda-1}{\lambda}}\right]^{\frac{1}{1-\alpha}}. \tag{17}$$

parameter	value	target
β	0.95	risk-free interest rate
γ	0.94	crisis frequency
δ	0.12	average replacement investment
α	0.35	capital income share
θ	0.10	average bank leverage
(z_L, z_H, ρ)	(0.8,1.05,0.2)	several large crises

Table 1: Model parameter values

It can be seen from equations (8) and (17) that intermediaries provide less than the First-Best amount of lending in a steady state of the constrained-efficient allocation.[5] It can also be seen from equation (17) that equation (13) does not bind in steady state such that λ is finite.[6]

4 Numerical analysis

This section puts the theory developed in sections 2 and 3 to use. The current version of the paper focuses on exploring the qualitative aspects of the theory and features a preliminary calibration. Table 1 summarizes the choices of model parameter values used in this section.

[5]When dividends are discounted using γ rather than β then steady state lending in a constrained-efficient allocation is given by

$$\left[\frac{\beta\alpha\left(1-(1-\alpha)\frac{\lambda-1}{\lambda}\right)}{1-\beta(1-\delta)+\theta\frac{\beta-\gamma}{\gamma}}\right]^{\frac{1}{1-\alpha}} \leq K_{CE}.$$

[6]To see this suppose that λ is not finite such that $\frac{\lambda-1}{\lambda} \equiv \lim_t \frac{\lambda_t-1}{\lambda_t} = 1$. But then steady state lending is equal to the monopolistic amount

$$K_M = \left[\frac{\alpha^2\beta}{1-\beta(1-\delta)+\theta\frac{\beta-\gamma}{\gamma}}\right]^{\frac{1}{1-\alpha}}.$$

It follows that $V_t \geq A_t$ such that $\eta_t = 0$ in steady state. But then λ is finite, a contradiction.

In section 3 it was shown that when the intermediary no-default condition binds in a constrained-efficient allocation then lending returns are increased for some time. Elevated lending returns increase intermediary future profits and relax the no-default condition. The economic impact of a credit crunch, during which intermediaries are forced to reduce lending due to insufficient access to external finance, is therefore mitigated. However, granting future profits to intermediaries creates economic distortions such that a constrained-efficient allocation would also require intermediaries to hold more equity on average. The idea is to limit usage of an increase in future profits to the most severe credit crunches. As a result, intermediaries increase their loan loss provisioning and can withstand more adverse shocks before the economy enters a credit crunch. On the rare occasions where the economy does enter a credit crunch, despite higher provisioning, lending is stabilized by increasing intermediary future profits.

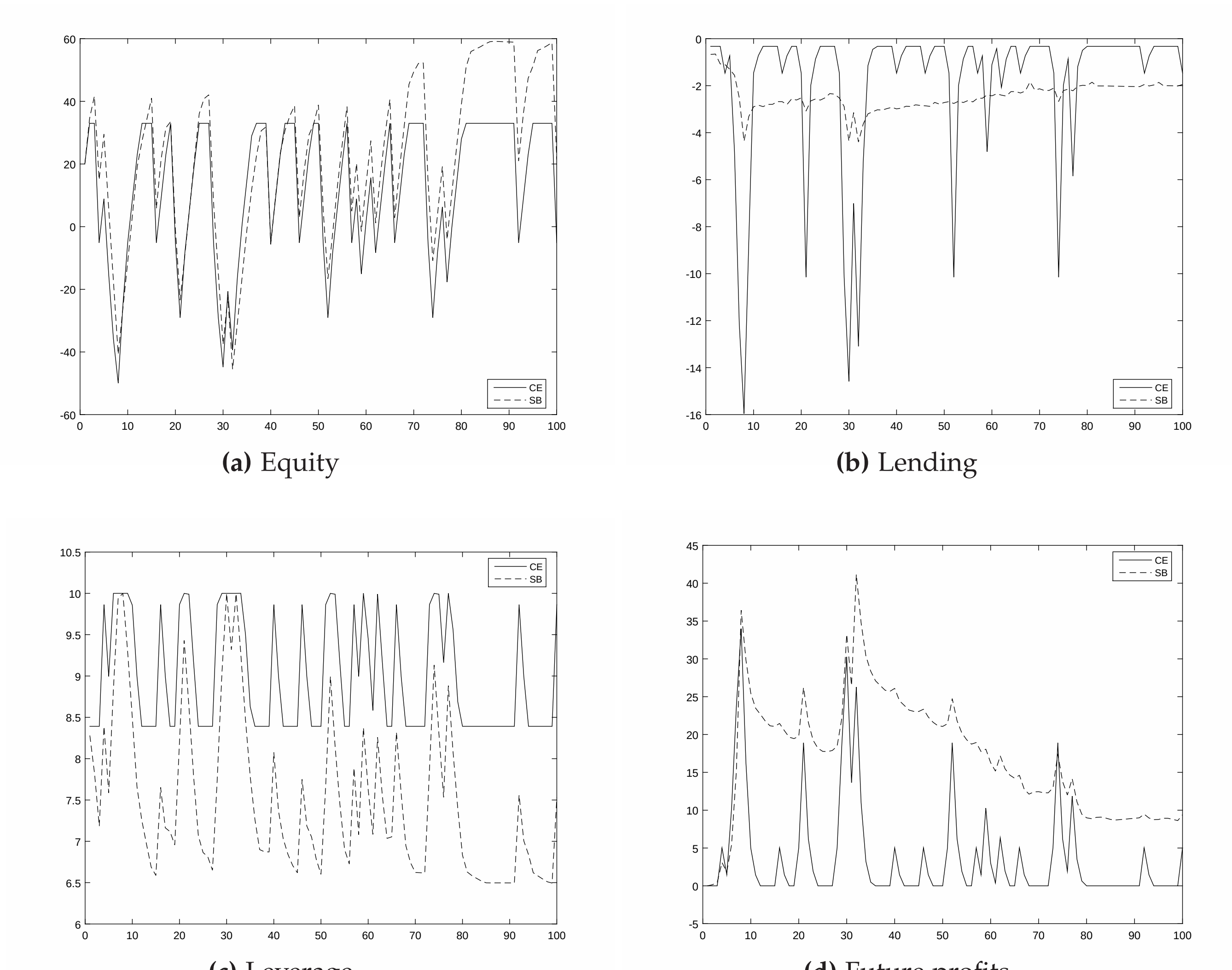
Figure 1 compares the constrained-efficient allocation (SB) to the competitive equilibrium (CE) for a particular sequence of shocks. Equation (3) limits leverage, defined as lending relative to intermediary value, which can be seen by rewriting the equation as follows.

$$\frac{k_{t+1}}{\gamma E_t[V_{t+1}]} \leq \frac{1}{\theta}$$

Figure 1c shows that this leverage constraint is slack most of the time in both CE and SB (the dotted line in figure 1c indicates $1/\theta = 10$). This implies that intermediaries have substantial loan loss provisions in CE. However, SB involves even higher equity which gives intermediaries additional 'capital buffers' to withstand most shocks to their balance sheet. In fact, series of shocks that lead to a medium sized credit crunch in CE, with reductions in lending about ten percent, do not lead to any significant reduction in lending in SB. Relatively small shocks to intermediary balance sheets are absorbed entirely by capital buffers in SB. However, due to intermediary impatience capital buffers are costly as they require higher average future profits, and lower lending in SB, in order to satisfy the intermediary participation constraint (13).

There are two large credit crunches in CE where lending drops by more than ten percent. The corresponding sequences of adverse shocks to intermediary balance sheets are severe enough to deplete capital buffers in SB and generate a credit crunch in SB as well. However, the drop in lending is much smaller in SB. The reason is that, in addition to the capital buffer, there is an increase in intermediary future profits in SB which increases the access to external finance for the intermediary, reducing the pressure to deleverage, during a credit crunch. Note that future profits are not necessarily higher in SB compared to CE in the impact period of a credit crunch. However, increased future profits during a credit crunch in CE come from currently very low lending and currently very high lending returns while in SB high future profits come from somewhat lower lending and somewhat higher lending returns in future periods. In SB the scarcity of intermediary lending is distributed over many periods which greatly reduces the magnitude of the credit crunch in SB compared to CE and lowers the overall economic cost.

It is worthwhile to point out the strong non-linearities present in the model. Instances where the leverage constraint is almost binding are associated with at most a small reduction in lending while lending decreases considerably when the constraint binds tight. As a result, in SB, capital buffers are often depleted and lending returns are elevated.



(a) Equity

(b) Lending

(c) Leverage

(d) Future profits

Figure 1: The competitive equilibrium (solid line) and the constrained-efficient allocation (dashed line) are each simulated for 100 periods. For this particular draw of shocks there are multiple credit crunches in competitive equilibrium including one large one.

5 Conclusion

Financial intermediaries may lose access to external finance at some times. This can create a socially costly credit crunch in the economy where intermediaries are forced to reduce their lending activity. This paper studies constrained-efficient capital regulation that aims at preventing and mitigating such credit crunches. The constrained-efficient allocation takes into account all possible macro-prudential concerns and reveals to necessary regulatory tools. First, additional capital buffers should be imposed ex ante. Due to the strong non-linearities present in the model such buffers should be always activated. Second, capital requirements should be reduced ex-post during severe credit crunches. Intermediary default at increased levels of leverage is avoided by granting higher future profits to intermediaries. A macro-prudential regulator would affect intermediary profitability dynamically in order to smooth out the scarcity of intermediary lending over financial cycles.

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