研究ノート

A Note on Macroprudential Capital Buffers

SATO Yoshiaki

マクロ・プルーデンスの視点に立った資本バッファーに関する研究ノート

佐藤 嘉晃

Abstract

This note provides an alternative explanation for the effect of capital requirements for banks on the economy that is shown by Iacoviello [Financial business cycles, Review of Economic Dynamics 18, pp.140-163, (2015)]. The contribution of this note is to show that a capital requirement regime that requires banks to set aside extra capital for future expected losses significantly moderates a credit crunch in a period of financial stress.

Keywords

Dynamic general equilibrium, Financial intermediaries, Capital requirements

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I. Introduction

This note provides an alternative explanation for the effect of capital requirements for banks on the economy that is shown by Iacoviello (2015)[1]. Iacoviello (2015) argues that in a period of financial stress, banks reduce loans to the production sector in order to meet capital requirements, which leads to a fall in output[1]. This explanation implies that the relaxation of capital requirements during a period of financial stress could moderate tightening of credit and a subsequent downturn, i.e., the relaxation of capital requirements acts as macroprudential policy (see, e.g., Angelini et al., 2014, Rubio and Carrasco-Gallego, 2016, and Clancy and Merola, 2017)[2-4]. Here this note shows the case where a capital requirement regime works as macroprudential policy.

There is lengthy theoretical literature that analyzes capital requirements for banks as macroprudential policy (e.g., Gertler et al., 2012, Schroth, 2021)[5,6]. The contribution of this note to the literature is to show that a capital requirement regime that requires banks to set aside extra capital for future expected losses significantly moderates a credit crunch in a period of financial stress.

II. Model

1. Model overview

The macroeconomic framework builds on Iacoviello (2005) and Iacoviello (2015)[1,7]. Time is discrete, and let $t = 1,2,\cdots$ denotes time. Consider a closed economy that features four sectors: household sector, production sector, financial sector, and government sector. The production sector is made up of wholesale-goods producing firms, retail-goods producing firms (which is referred to as retail firms), and final-goods producing firms.

2. Household sector

Each household consumes, saves, holds real estate, and works. Let $c_{H,t}$ be consumption of a representative household at time t, $h_{H,t}$ be the quantity of real estate that the household acquires, and n_t be labor supply. Then a preference of the household is given by

$$\mathcal{U}_H = \sum_{t=1}^{\infty} \beta_H^{t-1} \left[(1-\eta) \cdot \ln\left(c_{H,t} - \eta c_{H,t-1}\right) + j \cdot \ln h_{H,t} + \tau \cdot \ln(1-n_t) \right],$$

with $0 < \beta_H < 1$, $0 < \eta < 1$, $j > 0$, and $\tau > 0$.

Let D_t be the quantity of deposits that pay the gross return R_t from time $t-1$ to t,

W_t be the wage rate, Q_t be the price of real estate, and P_t be the price index of a single type of final good. The flow-of-funds constraint of the household is given by

$$P_t c_{H,t} + D_t + Q_t\left(h_{H,t} - h_{H,t-1}\right) = R_{H,t-1} D_{t-1} + W_t n_t + P_t \varepsilon_t\,, \tag{1}$$

where ε_t denotes a redistribution shock that transfers wealth from a financial intermediary to the household. Following Iacoviello (2015), the shock is meant to provide capital losses on financial intermediaries[1).

The optimal consumption path for the household has to satisfy

$$\frac{1-\eta}{c_{H,t} - \eta c_{H,t-1}} = \beta_H \cdot \frac{R_{H,t}}{1+\pi_{t+1}} \cdot \frac{1-\eta}{c_{H,t+1} - \eta c_{H,t}}, \tag{2}$$

where $\pi_{t+1} \equiv (P_{t+1} - P_t)/P_t$. Optimal labor supply has to satisfy

$$\frac{\tau}{1-n_t} = w_t \cdot \frac{1-\eta}{c_{H,t} - \eta c_{H,t-1}}, \qquad w_t \equiv \frac{Q_t}{P_t}. \tag{3}$$

Finally, optimal holdings of real estate have to satisfy

$$\frac{j}{h_{H,t}} + \beta_H \cdot q_{t+1} \cdot \frac{1-\eta}{c_{H,t+1} - \eta c_{H,t}} = q_t \cdot \frac{1-\eta}{c_{H,t} - \eta c_{H,t-1}}, \qquad q_t \equiv \frac{Q_t}{P_t}. \tag{4}$$

3. Production sector

1) Entrepreneurs

Each entrepreneur manages a wholesale-goods producing firm. Each wholesale-goods producing firm produces output by means of physical capital, real estate, and labor services. Then, wholesale-goods producing firms sell their output to retail firms. Wholesale-goods producing firms obtain funds from financial intermediaries.

Let $y_{W,t}$ denote output of a representative wholesale-goods producing firm, A_t denote total factor productivity, k_t denote physical capital, and $h_{E,t}$ denote the quantity of real estate that the wholesale-goods producing firm holds. Then, production technology of the wholesale-goods producing firm is given by

$$y_{W,t} = A_t k_{t-1}^{\alpha} h_{E,t-1}^{\nu} n_t^{1-\alpha-\nu}. \tag{5}$$

Let $P_{W,t}$ be the price of wholesale goods, and L_t be the value of funds that the wholesale-goods producing firm obtains from a financial intermediary. Then, residual income of the wholesale-goods producing firm $c_{E,t}$ is given by

$$P_t c_{E,t} = P_{w,t} y_{W,t} + L_t - P_t[k_t - (1-\delta)k_{t-1}] - Q_t \Delta h_{E,t} - R_{E,t} L_{t-1} - W_t n_t - P_t ac_{E,t}, \qquad (6)$$

with

$$\Delta h_{E,t} \equiv h_{E,t} - h_{E,t-1}, \qquad ac_{E,t} \equiv \frac{\phi_E}{2} \cdot \frac{(l_t - l_{t-1})^2}{\bar{l}}, \qquad l_t \equiv \frac{L_t}{P_t}.$$

Following Iacoviello (2015), the term $ac_{E,t}$ is a loan-adjustment cost, in which l_{t-1} is external to the wholesale-goods producing firm[1].

Each wholesale-goods producing firm is subject to a borrowing constraint, which is given by

$$L_t \le m_H \left(\frac{Q_{t+1}}{R_{E,t+1}} h_{E,t} \right) - m_N W_t n_t, \qquad (7)$$

where $0 < m_H < 1$ is the loan-to-value ratio, and $m_N > 0$ implies the fraction m_N of wage must be paid in advance (see, Iacoviello (2015))[1].

The optimal choice of production and borrowing for the wholesale-goods producing firm maximizes a convex function of the residual income $c_{E,t}$:

$$\mathcal{U}_E = \sum_{t=1}^{\infty} \beta_E^{t-1} \ln c_{E,t}.$$

Let $\lambda_{E,t}$ be the Lagrangian multiplier of the borrowing constraint (7) denominated by the term $\beta_E^{t-1}/c_{E,t}$. Then, any interior optimum $l_t, h_{E,t}, n_t$ and k_t have to satisfy the respective first-order conditions:

$$1 - \phi_E \cdot \frac{l_t - l_{t-1}}{\bar{l}} = \lambda_{E,t} + \beta_E \cdot \frac{R_{E,t+1}}{1 + \pi_{t+1}} \frac{c_{E,t}}{c_{E,t+1}}, \qquad (8)$$

$$q_t - \lambda_{E,t} m_H \frac{q_{t+1}}{R_{E,t+1}} (1 + \pi_{t+1}) = \beta_E \left(\nu \frac{P_{w,t+1}}{P_{t+1}} \frac{y_{W,t+1}}{h_{E,t}} + q_{t+1} \right) \frac{c_{E,t}}{c_{E,t+1}}, \qquad (9)$$

$$(1 - \alpha - \nu) \frac{P_{w,t}}{P_t} y_{W,t} = (1 + \lambda_{E,t} m_N) w_t n_t, \qquad (10)$$

$$\frac{1}{c_{E,t}} = \beta_E \frac{1}{c_{E,t+1}} \left[\alpha \frac{P_{w,t+1}}{P_{t+1}} \frac{y_{W,t+1}}{k_t} + 1 - \delta \right]. \qquad (11)$$

2) Retail firms

Retail firms buy wholesale goods at the price $P_{W,t}$, and produce retail goods using the wholesale goods as sole input.

Let $y_t(z)$ be the quantity of output sold by retail firm z, and $P_t(z)$ be the nominal price. Each retailer faces a demand function:

$$y_t(z) = \left(\frac{P_t(z)}{P_t}\right)^{-\psi} y_t,$$

where y_t denotes the total amount of a single type of final good.

Each retail firm chooses a sale price taking the price of wholesale goods and the demand function as given. Each retail firm can change the price in a given period only with probability $1 - \theta$. Let $P_t^*(z)$ denote the sale price set by retail firm z, which can change the price at time t, and $y_t^*(z)$ be the demand given that sale price. Then, retail firm z chooses the sale price to maximize the expected discounted profits, which is given by

$$\sum_{k=0}^{\infty} \frac{\theta^k}{\prod_{i=1}^{k} R_{H,t+i-1}} [P_t^*(z) - P_{W,t+k}] y_{t+k}^*(z).$$

The first-order condition for the optimal sale price $p_{o,t} \equiv P_{o,t}/P_t$ is given by

$$p_{o,t} = \frac{\psi}{\psi - 1} \frac{X_{1,t}}{X_{2,t}} \tag{12}$$

with

$$X_{1,t} \equiv p_{W,t} y_t + \theta \Lambda_{t,t+1} \left(\frac{P_{t+1}}{P_t}\right)^{\psi} X_{1,t+1}, \tag{13}$$

$$X_{2,t} \equiv y_t + \theta \Lambda_{t,t+1} \left(\frac{P_{t+1}}{P_t}\right)^{\psi-1} X_{2,t+1}, \tag{14}$$

$$\Lambda_{t,t+1} \equiv \beta_H \cdot \frac{u_{C,t+1}}{u_{C,t}}, \qquad u_{C,t} \equiv \frac{1-\eta}{c_{H,t} - \eta c_{H,t-1}}.$$

3) Final-goods producing firms

Retail goods are bundled into a single type of final good by a group of final-goods producing firms. The final-goods production technology is given by

$$y_t = \left[\int_0^1 y_t(z)^{\frac{\psi-1}{\psi}} dz\right]^{\frac{\psi}{\psi-1}}.$$

The corresponding price index is given by

$$P_t = \left[\int_0^1 P_t(z)^{1-\psi} dz\right]^{\frac{1}{1-\psi}}.$$

4. Financial sector

There is a continuum of identical bankers of measure unity. Each banker manages a financial intermediary. Financial intermediaries raise deposits from households, and provide funds to entrepreneurs.

Let Cap_t be the amount of capital that a representative financial intermediary has at time t (which is referred to as bank capital). Balance sheet condition of the intermediary is given by

$$L_t = D_t + Cap_t. \tag{15}$$

Residual income of the financial intermediary is given by

$$P_t c_{B,t} = R_{E,t} L_{t-1} - R_{H,t-1} D_{t-1} - Cap_t - P_t ac_{B,t} - P_t \varepsilon_t, \tag{16}$$

with

$$ac_{B,t} = \frac{\phi_B}{2} \frac{(l_t - l_{t-1})^2}{\bar{l}}.$$

The term $ac_{B,t}$ is a loan-adjustment cost, in which l_{t-1} is external to the intermediary. As noted above, the redistribution shock ε_t transfers wealth from the intermediary to a household.

Financial intermediaries are subject to capital requirements:

$$\frac{Cap_t - \sigma\varepsilon_{t+1}}{L_t} \geq 1 - \gamma, \tag{17}$$

with $\sigma \geq 0$, and $0 < \gamma < 1$. The right-hand side of Eq. (17) denotes a regulatory capital requirement ratio. In a regime that the financial regulatory authority sets $\sigma > 0$, financial intermediaries are required to set aside extra capital at time t for expected future shock ε_{t+1}. In this note, the regime is referred to as capital buffer requirements.

The optimal choice of deposits and loans for the financial intermediary maximizes a convex function of the residual income, which is given by

$$\mathcal{U}_B = \sum_{t=1}^{\infty} \beta_B^{t-1} \ln c_{B,t}.$$

The first-order condition for deposits is given by

$$1 - \lambda_{B,t} = \beta_B \frac{R_{H,t}}{1+\pi_{t+1}} \frac{c_{B,t}}{c_{B,t+1}}, \tag{18}$$

where $\lambda_{B,t}$ is the Lagrangian multiplier for capital requirements (17), which is denominated by the term $\beta_B^{t-1}/c_{B,t}$. The first-order condition for loans is given by

$$1 + \phi_B \frac{l_{E,t} - l_{E,t-1}}{\bar{l}_E} - \gamma \lambda_{B,t} = \beta_B \frac{c_{B,t}}{c_{B,t+1}} \frac{R_{E,t+1}}{1+\pi_{t+1}}. \tag{19}$$

5. Government sector

Following Iacoviello (2005), monetary policy is characterized by a simple Taylor rule with interest-rate smoothing:

$$R_{H,t} = \left(R_{H,t-1}\right)^{r_R} \left[(1+\pi_{t-1})^{1+r_\pi} \left(\frac{y_{t-1}}{\bar{y}}\right)^{r_Y} \bar{R}_H\right]^{1-r_R}, \tag{20}$$

where $\bar{y}$ is the steady-state value of output y_t, and $\bar{R}_H$ is the steady-state value of the policy rate $R_{H,t}$[7].

6. Aggregation and market clearing

Given that the fraction θ of retail firms do not change the price of their goods in period t, the price index evolves according to

$$P_t^{1-\psi} = (1-\theta) P_{o,t}^{1-\psi} + \theta P_{t-1}^{1-\psi}. \tag{21}$$

Market clearing condition for real estate is given by

$$h_{H,t} + h_{E,t} = 1. \tag{22}$$

7. Equilibrium

Definition 1. The equilibrium is defined as a sequence of 11 endogenous quantities $\{c_{H,t}, c_{E,t}, c_{B,t}, h_{H,t}, h_{E,t}, n_t, y_t, d_t, l_t, k_t, cap_t\}_{t=1}^{\infty}$ and seven prices

$\{R_{H,t}, R_{E,t}, w_t, p_{W,t}, p_{o,t}, \pi_t, q_t\}_{t=1}^{\infty}$ which satisfy equations (1)-(22) together with a sequence of endogenous variables $\{\lambda_{E,t}, \lambda_{B,t}, X_{1,t}, X_{2,t}\}_{t=1}^{\infty}$ for given initial conditions and a sequence of exogenous shocks $\{A_t, \varepsilon_t\}_{t=1}^{\infty}$ [Note 1].

III. Model analysis

1. Calibration

The time period is a quarter. There are 20 parameters that we need to assign values. Table 1 lists the parameter values. The parameter values are from Iacoviello (2005) and Iacoviello (2015) except the parameter of capital buffer requirements $\sigma = 1$[1,7].

2. Experiment: counterfactual analysis

Figure 1 shows the impulse response of the equilibrium to a redistribution shock: the solid line shows the response of the model economy. For comparison, the dashed line illustrates the response of the same model, but with the capital buffer requirements removed (i.e., the parameter $\sigma = 0$). A sequence of the shock is as follows: first, at time $t = 1$, it is expected that a redistribution shock is likely to hit the economy in $t = 2$. The expected size of the shock is 2 percent (i.e., $\varepsilon_2 = 0.02$). Then, the shock is realized at $t = 2$. The size of the shock is picked to hit the following two targets: 20 percent decline from trend in credit supply to the production sector; and 2 percent decline from trend in output (see Iacoviello (2015))[1]. Exogenous total factor productivity A_t is fixed to unity ($A_t = 1$ for all t).

Within the model economy, the redistribution shock produces a decline in aggregate bank capital in the financial sector. A decline in capital of financial intermediaries limits the amount of funds that they can intermediate, and then they reduce credit supply to the production sector. This leads to a contraction in the aggregate demand for real estate, which in turn leads to a fall in real estate prices. Then, a fall in real estate prices depresses the value of collateral of borrowers, and consequently, the drop in credit supply is enhanced. As a result, both aggregate output and household consumption drop.

As Figure 1 shows, the capital buffer requirements significantly moderate the credit crunch and the contraction. The reason is that the regulatory-required extra capital that each financial intermediary set aside in time $t = 1$ acts as a buffer against the shock at $t = 2$. Then, the extra capital provides a sufficient effect of preventing a sharp drop in aggregate bank capital.

Table 1. Parameter values

Parameters	Values	
Household sector		
η	0.46	External habits in consumption
β_H	0.9925	Discount factor
τ	2	Weight on leisure
j	0.075	Weight on real estate
Production sector		
α	0.35	Physical capital share
δ	0.035	Physical capital depreciation rate
ϕ_E	0.25	Loan adjustment cost
ν	0.04	Real estate share
m_H	0.9	Loan-to-value ratio
m_N	1	Labor cost payments
β_E	0.94	Discount factor of entrepreneur
ψ	21	Elasticity of substitution
θ	0.75	Probability of keeping price fixed
Financial sector		
ϕ_B	0.07	Loan adjustment cost
β_B	0.945	Discount factor of banker
Government sector		
$1-\gamma$	0.1	Capital requirement ratio
σ	1	Capital buffer requirements
r_π	0.27	Taylor rule
r_R	0.73	Interest-rate smoothing
r_y	0.13	Taylor rule

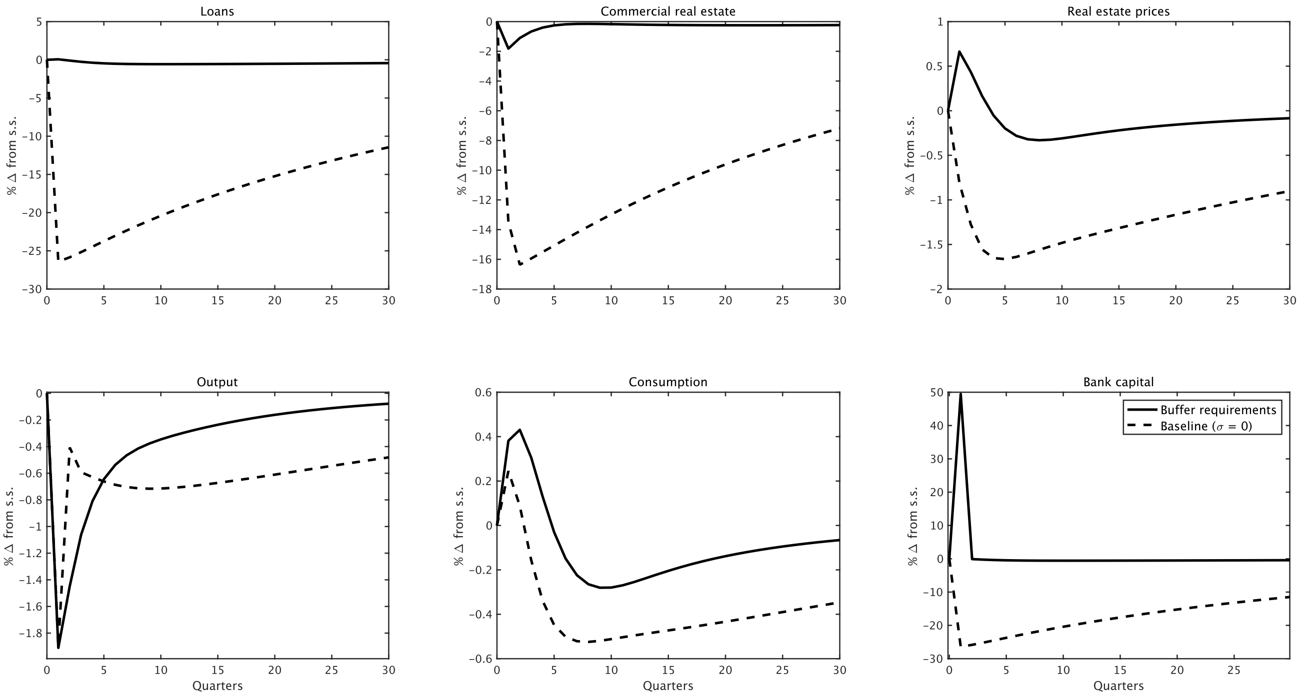

Figure 1. Response to a redistribution shock

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Notes

Note 1 Here, $cap_t \equiv Cap_t/P_t$ and $d_t \equiv D_t/P_t$.

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