Abstract

In this paper, we investigate the effect of bank capital adequacy on the economic boom-bust cycles. To investigate this effect, we use a Dynamic Stochastic General Equilibrium (DSGE) model with a news shock. We perform the simulation three type of shocks: a monetary shock, capital price shock with no news shock, and capital price shock with news shock. In terms of the effect of bank capital adequacy, in both the simulation of simple capital price shock, we investigate the countercyclicality of the Basel III type. In particular, for the economic boom-bust cycle, the Basel III framework implies that it mitigates the increase in output in periods of boom and the decrease in output in period of bust depending on the elasticity of output growth.

1. Introduction

An economic downturn implies the need for higher capital requirements. Repullo and Suarez (2004, 2007), for example, propose a dynamic equilibrium model of bank lending behavior to verify the pro-cyclicality of capital adequacy requirements and evaluate the effects of the minimum capital requirements under Basel I and Basel II[1].

This problem of the pro-cyclicality of bank requirements became remarkable during the 2007 Lehman shock. Therefore, formulating regulation to relieve this degree of pro-cyclicality was required, lending to the announcement of Basel III[2]. Based on the foregoing, this study adopts a DSGE model to investigate the relationship between bank capital adequacy and the boom-bust cycle in the recent financial crisis.

The introduction of the DSGE model into the financial sector has accelerated since the financial crisis, especially for analyzing financial market imperfections. The financial accelerator model proposed by Bernanke et al. (1999), based on Carlstrom and Fuerst (1997), was seminal in this respect[3]. However, while their model describes the default probability of entrepreneurs, it is difficult to analyze the relationship between the financial conditions of financial intermediaries and the business cycle because it does not specialize in financial intermediaries such as banks. Further, this model cannot analyze the relationship between a fluctuation in prices and entrepreneurs' debt since

---

[1] Capital adequacy requirements changed in March 2007 under Basel II, by allowing banks to choose between using a standardized approach and an internal ratings-based approach. The latter is more risk sensitive, since borrowers' risk is reflected more precisely when using the bank's own internal ratings. Further, the internal ratings-based approach depends on the probability of default, which varies with the business cycle. de Walque et al. (2010) investigate the effects of liquidity injection by financial supervision, using the dynamic stochastic general equilibrium (DSGE) model with Basel I and Basel II.

[2] Basel III was agreed upon by the members of the Basel Committee on Banking Supervision in 2010-2011.

[3] To verify whether the volatility of asset prices increases the magnitude of macro-economic variables through financial contracts, Bernanke et al. (1999) develop a DSGE model with price rigidity.

financial contracts are real. Similarly, Meh and Moran (2010) analyze the specialization of the banking sector, particularly the relationship between bank capital and the business cycle, in order to verify the efficiency of the bank capital channel after the formulation of monetary policy[4]. However, more recent financial DSGE models have been based on Iacoviello's (2005) credit constraint model with collateral value. Iacoviello (2005) expands Kiyotaki and Moore (1997) by defining the collateral constraint as that when the financial contracts are carried out with loans determined by the nominal expected asset value. With this model, it is thus possible to verify Fischer's debt deflation[5].

Recently, the DSGE model has been introduced into the banking sector for banks operating under monopolistic competition to inspect interest rate rigidity, i.e. the distortion of the interest rate pass through[6]. In particular, by modeling the pass through from the policy rate, which is determined in the interbank market by the loan and deposit rates, studies have examined how financial institutions respond to monetary and technology shocks. For instance, Gerali et al. (2010) introduce a deposit and loan bank under monopolistic competition and examine the transmission mechanism of monetary and technology shocks.

In macroeconomics, it is recognized that changes in expectations about the future may be important for economic fluctuations. In particular, capital accumulation caused by the optimistic expectations of future demand increases may result in recession when these expectations are not realized. This mechanism is referred to as the Pigou cycle (Beaudry and Portier (2004, 2006))[7].

In the DSGE model presented in this paper, the bank faces a quadratic cost of capital accumulation, which is calculated according to the risk weight of loans granted to entrepreneurs based on loan size. In addition, a part of the counter-cyclical buffer is set depending on the deviation from the steady state of output, while we introduce a news shock into the boom-bust cycle (Beaudry and Portier (2004)).

2. The Model

2.1 Households

Households have the following expected utility:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left[\ln\left(C_t^h - \iota_h C_{t-1}^h\right) - \frac{N_t^{1+\eta}}{1+\eta} \right] \tag{1}$$

[4] For bank capital models, see den Heuvel (2008), Zhang (2010), Dib (2010), Gerali et al. (2010), Agenor et al. (2012), Angeloni et al. (2012), and Angeloni and Faia (2013).

[5] For DSGE models with the collateral constraint, see Aoki et al. (2004), Gertler et al. (2007), Christensen and Dib (2008), Iacoviello and Neri (2010), Lombard and McAdam (2012), and Iacoviello (2015).

[6] De Bandt and Davis (2000) and Claessens and Leaven (2004) suggest that banks may operate under monopolistic competition. Berger et al. (2003) connect market concentration and market power with interest rate setting by banks. Mandelman (2006), using panel data on 124 countries, implies that a cyclical variation in bank mark-up is associated with variation in the concentration of internal-section.

[7] Jaimovich and Rebelo (2009), Denhaan and Kalternbrunner (2007), Kobayashi et al. (2007), and Christiano et al. (2008) also examine expectation shocks. In addition, Barsky and Sims (2011), Kurman and Otrock (2013), and Barsky et al. (2014) show that a positive news shock for TFP generates a sharp and long decline in inflation and a slow persistent increase in the real economy.

where, β_h is the households' discount factor. Households maximize their utility (1) subject to the following budget constraint:

$$C_t^h + D_t = \frac{w_t N_t}{X_t^w} + \frac{R_{t-1}}{\pi_t} D_{t-1} + Div_t \tag{2}$$

Thus, they allocate their income among deposits D_t, which pay gross interest rate R_t, and consumption C_t^h. w_t is real wage earnings and X_t^w is the wage mark-up introduced later. In addition, Div_t are lump-sum profit from the final goods producer and from labor unions, and π_t is the inflation rate in the consumption goods sector.

The first-order conditions with respect to C_t^h, N_t, and D_t are as follows.

$$\lambda_t^h = \frac{1}{C_t^h - \iota_h C_{t-1}^h} - \beta_h \mathbb{E}_t \left\{ \frac{\iota_h}{C_{t+1}^h - \iota_h C_t^h} \right\} \tag{3}$$

$$N_t^\eta = \lambda_t^h \frac{w_t}{X_t^w} \tag{4}$$

$$\lambda_t^h = \beta_h \mathbb{E}_t \left\{ \frac{\lambda_{t+1}^h R_t}{\pi_{t+1}} \right\} \tag{5}$$

where, λ_t^h is the Lagrange multiplier for households' budget constraint.

2.2 Entrepreneurs

In our model, there exist an infinity of entrepreneurs of unit mass. They hire labor and use capital to produce intermediate goods Y_t. Further, they care only about their own consumption C_t^e and have the following expected utility function:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \ln(C_t^e - \iota_e C_{t-1}^e) \tag{6}$$

where, ι_e measures the degree of consumption habits

They face the following constraint:

$$\frac{Y_t}{X_t} + L_t = C_t^e + w_t N_t + q_t (K_t - (1 - \delta_k) K_{t-1}) + \frac{R_{t-1}^L}{\pi_t} L_{t-1} \tag{7}$$

where, X_t is the mark-up of final goods over intermediate goods, K_t is capital in the consumption goods sector with price q_t, and L_t is real borrowing at nominal gross rate R_t^L. Moreover, δ_k is the depreciation rate of capital used in the consumption goods sector.

We suppose that entrepreneurs maximize their utility (6) subject to the budget constraint (7) and the following production technology:

$$Y_t = A_t K_{t-1}^\alpha N_t^{1-\alpha} \tag{8}$$

where, A_t is productivity in the consumption goods sector.

Entrepreneurs' borrowing is constrained by the value of their collateral (Iacoviello, 2005). In our model, only collateral for entrepreneurs is physical capital. Thus, entrepreneurs' borrowing constraint is

$$R_t^L L_t \leq m \mathbb{E}_t \{ \pi_{t+1} q_{t+1} (1 - \delta_k) K_t \} \tag{9}$$

where, m is the steady state loan-to-value (LTV) ratio.

In addition, entrepreneurs' net worth is given by

$$NW_t = \frac{Y_t}{X_t} - C_t^e - w_t N_t + q_t (1 - \delta_k) K_{t-1} - \frac{R_{t-1}^L}{\pi_t} L_{t-1} \tag{10}$$

The first order conditions are as follows:

$$\lambda_{1,t}^e = \frac{1}{C_t^e - \iota_e C_{t-1}^e} - \beta_e \mathbb{E}_t \left\{ \frac{\iota_e}{C_{t+1}^e - \iota_e C_t^e} \right\} \tag{11}$$

$$N_t = \frac{(1-\alpha)Y_t}{X_t w_t} \tag{12}$$

$$\lambda_{1,t}^e q_t = \beta_e \alpha \mathbb{E}_t \left\{ \frac{\lambda_{1,t+1}^e Y_{t+1}}{X_{t+1} K_t} \right\} + \beta_e \mathbb{E}_t \{ \lambda_{1,t+1}^e (1 - \delta_k) q_{t+1} \}$$
$$+ \lambda_{2,t}^e m \mathbb{E}_t \{ \pi_{t+1} q_{t+1} (1 - \delta_k) \} \tag{13}$$

where, $\lambda_{1,t}^e$ is the Lagrange multiplier for entrepreneurs' budget constraint and $\lambda_{2,t}^e$ is the Lagrange multiplier for their collateral constraint.

2.3 Nominal Rigidities

We suppose that the price and wage rigidities in our model are in line with those shown by Bernanke et al. (1999), Iacoviello (2005), and Iacoviello and Neri (2010). In the consumption goods sector, the final goods producer purchases intermediate goods Y_t from entrepreneurs at price P_t^w in a competitive market, differentiates the goods at no cost, and sells them at mark-up $X_t \equiv P_t / P_t^w$ over marginal cost. The wage setting is analogous to the price setting by defining mark-up $X_t \equiv W_t / W_t^w$. Thus, the log-linearized Phillips curve for price is

$$\hat{\pi}_t = \beta_h \mathbb{E}_t \{ \hat{\pi}_{t+1} \} - \frac{(1-\theta)(1-\beta_h \theta)}{\theta} \hat{X}_t \tag{14}$$

On the contrary, in the case of the wage setting, the Phillips curve is specified by a rate of change in the nominal wage. Therefore, the log-linearized Phillips curve for wages is as follows:

$$\hat{\omega}_t = \beta_h \mathbb{E}_t \{ \hat{\omega}_{t+1} \} - \frac{(1-\theta_w)(1-\beta_h \theta_w)}{\theta_w} \hat{X}_t^w \tag{15}$$

where, $\hat{\omega}_t \equiv \Delta \hat{w}_t + \Delta \hat{\pi}_t$. Moreover, $(1-\theta)$ and $(1-\theta_w)$ are the proportions of the agents set prices and wages optimally, respectively.

2.4 Capital Goods Producer

The specification of the capital goods producer is identical to that in the standard New Keynesian DSGE model, for which capital is an important component. The capital goods producer produces capital, which is purchased by entrepreneurs, and sells its capital and final goods I_t purchased from the final goods producer in order to produce new capital K_{t+1}, which is sold at the end of period t. The law of motion of this capitals in this economy is

$$K_{t+1} = (1 - \delta_k) K_t + I_t - \frac{\chi_k}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 I_t \tag{16}$$

where, χ_k is a parameter measuring the costs of adjusting investment. These equations means that they invest the depreciated part, but face the quadratic adjustment cost function when investing. The capital goods producer chooses investment I_t to maximize its profits. Thus,

$$\max_{I_t} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \Lambda_t \left\{ q_t \left[I_t - \frac{\chi_k}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 I_t \right] - I_t \right\}$$

The optimal condition is as follows:

$$\frac{1}{q_t} = 1 - \chi_k \left(\frac{I_t}{I_{t-1}} - 1 \right) \frac{I_t}{I_{t-1}} + \beta_h \chi_k \mathbb{E}_t \left[\left(\frac{I_t}{I_{t-1}} - 1 \right) \left(\frac{I_{t+1}}{I_t} \right)^2 \frac{q_{t+1}}{q_t} \frac{\Lambda_{t+1}}{\Lambda_t} \right] \tag{17}$$

2.5 Monetary Policy

The central bank sets the interbank rate according to the log-linearized Taylor rule as follows:

$$\hat{R}_t = (1 - \rho_r)\left[(1 + \rho_\pi)\hat{\pi}_t + \rho_y \hat{Y}_t \right] + \rho_r \hat{R}_{t-1} + \epsilon_t^r \tag{18}$$

where, $\hat{R}_t$ is the log-linearized interbank rate (for simplicity, we assume that this is the deposit rate). Further, $\hat{Y}_t$ is the log-linearized output growth rate and $\hat{\pi}_t$ is the inflation rate. Thus, the interbank rate is set in response to the inflation and output growth rates.

3. Banking Sector

We suppose a simple banking sector[8]. Perfectly competitive banks receive deposits D_t from households at interest rate R_t. On the contrary, banks provide loans L_t at interest rate R_t^L to entrepreneurs. When deciding on deposits and loans, banks face a quadratic adjustment cost related to bank leverage. This cost captures the capital requirement pressures on banks. In addition, we suppose that the bank weights risk in response to the default probability of entrepreneurs as in the case of Basel II. Further, we introduce a measurement of risk-weight that depends on the countercyclical buffer that responds to credit/GDP growth. This represents the case of Basel III.

Banks maximize the profit as follows:

$$\max_{L_t} R_t^L L_t - R_t D_t - \frac{\chi_b}{2} \left(\frac{K_t^b}{\varpi_t L_t} - \nu_b \right)^2 K_t^b$$

subject to the balance sheet identity:

$$L_t = D_t + K_t^b$$

Further, in line with Agénor et al. (2012), we define the risk-weight as follows:

$$\frac{\varpi_t}{\varpi} = \left(\frac{\varpi_{t-1}}{\varpi} \right)^{\vartheta_\varpi} \left(\frac{R_t^L L_t}{NW_t} \xi_L \right)^{\tau_1} \left(\frac{L_t}{K_t^b} \xi_K \right)^{\tau_2} \left(\frac{Y_t}{Y} \right)^{\tau_3} \tag{19}$$

where, τ_1, τ_2, $\tau_3 \geq 0$, $\xi_L = NW/(R^L L)$, and $\xi_K = K^b/L$. In addition, ϑ_ϖ is the autoregressive parameter.

Equation (19) shows the risk associated with entrepreneurs' loans to net worth and the bank capital ratio. The second term of this equation captures the idiosyncratic risk for entrepreneurs. In addition, the term (Y_t/Y) captures the systemic risk.

Basel III requires that the ratio of Common equity Tier I to risk-weighted assets be higher than

---

[8] In recent banking models, to introduce interest rate rigidity the banking sector is segmented into three parts: wholesale banks, retail deposit branches, and retail loan branches (e.g. Gerali et al., 2010; Dib, 2010). Retail branches collect savings from patient households and place them in the money market. Wholesale banks receive money from retail deposit branches and take bank capital. Retail loan branches receive money from wholesale banks and lend to impatient households and entrepreneurs.

4.5% plus a conservation buffer is introduced to restrain reinvested earnings and the appropriate accumulation of the buffer, which is added to the minimum standards in the stress period.

The countercyclical buffer is introduced to protect the banking sector from future losses owing to the increase in the risk of the whole system. Each country's authorities refer to the appropriate indexes while watching the deviation of total credit to GDP from its trend as a common reference index.

According to Gerali et al. (2010), the law of motion of bank capital is given by

$$K_t^b = (1 - \delta_b)K_{t-1}^b + \phi_B \Pi_{t-1}^B \tag{20}$$

where, δ_b is the depreciation rate of bank capital and $(1 - \phi_B)$ captures the bank dividend policy, which is assumed be the exogenous variable. Thus, banks can only accumulate their net worth by using internal earnings.

Since banks maximize profit subject to their balance sheet identity, the first order condition with respect to loans is as follows:

$$R_t^L = R_t - \chi_b (1 + \tau_1 + \tau_2 + \tau_3)\varpi_t \left(\frac{K_t^b}{\varpi_t L_t} - \nu_b\right)\left(\frac{K_t^b}{\varpi_t L_t}\right)^2 \tag{21}$$

By using the balance sheet identity, we can obtain the overall profit at the end of period t. Following Gerali et al. (2010), the profit is as follows:

$$\Pi_t^B = (R_t^L - R_t)L_t + R_t K_t^b - \frac{\chi_b}{2}\left(\frac{K_t^b}{\varpi_t L_t} - \nu_b\right)^2 K_t^b \tag{22}$$

4. Equilibrium and the News Shock

The goods market clearing condition is as follows:

$$Y_t = C_t^h + C_t^e + I_t \tag{23}$$

where, we ignore government spending in the demand term. Moreover, the labor market equals full labor supply. Thus, the labor market clearing condition is as follows:

$$\left(\frac{\lambda_t^h w_t}{X_t^w}\right)^{1/\eta} = \frac{(1 - \alpha)Y_t}{X_t w_t} \tag{24}$$

Next, we consider the news shock. In our model, we introduce the news shocks into the capital price. Here, consider the stationary capital price shock process, which follows:

$$\ln u_t^q = \rho_q \ln u_{t-1}^q + \epsilon_t^q \tag{25}$$

Consider innovation ϵ_t^q. We split this innovation into two components: an unanticipated component $\epsilon_{o,t}^q$ and an anticipated component $\epsilon_{news,t}^q$. This process is given as follows:

$$\epsilon_t^q = \epsilon_{o,t}^q + \epsilon_{news,t}^q \tag{26}$$

where, $\epsilon_{news,t}^q \equiv \sum_{z=1}^{Z} \epsilon_{z,t-z}^q$ and $\epsilon_{z,t-z}^q$ is the z-period ahead news about the capital price received by agents in period $t - z$. As described by Kahn and Tsoukalas (2012), Z represents the longest horizon over which shocks are anticipated by agents.

5. Calibration

The parameters and steady state values are summarized in Table 1. We follow Iacoviello (2005)

and Iacoviello and Neri (2010) to calibrate the parameters. The discount factors of households and entrepreneurs are 0.995 and 0.975., respectively. We set the inverse of Frisch's elasticity η as 1.5, while the habit parameter for households and entrepreneurs is set as 0.7. In addition, we set the LTV ratio as 0.85 following to Iacoviello and Neri (2010). The capital share in production function α is set to 0.36 and the depreciation rate of physical capital δ_k is set to 0.025. The adjustment cost parameter of capital investment χ_k is given by 3.25. These parameter values are standards.

Next, we consider the parameters for the banking sector. We set the depreciation rate of bank capital δ_b to 0.02 and the proportion of reinvested bank profit ϕ_B to 0.85. The adjustment cost parameter of bank capital accumulation is set to 3.25. We divide the risk weight parameters into two cases. First, we think about the case of the Basel II framework. Since Basel II adopts a risk sensitive calculation, we set only τ_1 and τ_2 to 0.01 and 0.01, respectively, and τ_3 to 0. Because $\tau_3 > 0$ is the elasticity of the deviation of economic growth from its steady state (i.e. the countercyclical term), we set it to 0.01 to investigate the effect of Basel III. Finally, the autoregressive parameter in the risk weight ϑ_{ϖ} is set to 0.8.

Table 1. Parameters and steady state values

β_h	Households' discount rate	0.995	ϑ_{ϖ}	Parameter of the AR(1) process	0.8
β_e	Entrepreneurs' discount rate	0.975	τ_1	Elasticity of the LTV ratio	0.01
δ_k	Depreciation rate of capital	0.025	τ_2	Elasticity of the loan-to-capital ratio	0.01
δ_b	Depreciation rate of bank capital	0.02	τ_3	Elasticity of the output growth	0.01
η	Inverse of Frisch's elasticity	1.5	ϕ_B	Proportion of reinvested bank profit	0.85
m	LTV ratio	0.85	ρ_r	Taylor rule parameter (lagged interest rate)	0.78
α	Capital share	0.36	ρ_π	Taylor rule parameter (inflation rate)	0.27
θ	Impossibility of price re-optimization	0.75	ρ_y	Taylor rule parameter (output growth)	0.1
ν_b	Steady state capital-to-loan ratio	0.1	X	Steady state mark-up in the goods market	1.13

For wage and price rigidity, we set the parameters of θ_w and θ to 0.7 and 0.75 following to Iacoviello (2005) and Iacoviello and Neri (2010)[9]. The Taylor rule parameters are set as follows. The parameter for lagged interest rate ρ_r is 0.78, the parameter for inflation rate ρ_π is 0.27, and the parameter for output growth is 0.1. The autoregressive parameter in the capital price shock process is set to 0.85.

The other steady state values needed for the simulation are calculated with the parameters and steady state values.

6. Simulation

In this section, we perform a simulation of a monetary shock and a capital price shock. We simulate a monetary shock to check the model movement, by investigating a 1% positive shock in the policy interest rate. In addition, we simulate a capital price shock with a news shock and no news shock. We also distinguish between Basel II and Basel III. The parameter implying this difference is τ_3, which controls the countercyclical buffer.

---

[9] Iacoviello and Neri (2010) use Bayesian estimations for the wage and price rigidity parameters.

6.1 Monetary Shock

In this subsection, we simulate a 1% positive shock in the policy interest rate and check the model movement. The result is shown in Figure 1.

Figure 1 shows the impulse response function of output. The response of output to a negative demand shock is to decrease. The difference in bank capital adequacy is that Basel II is more countercyclical, whereas Basel III may provide a soft landing[10].
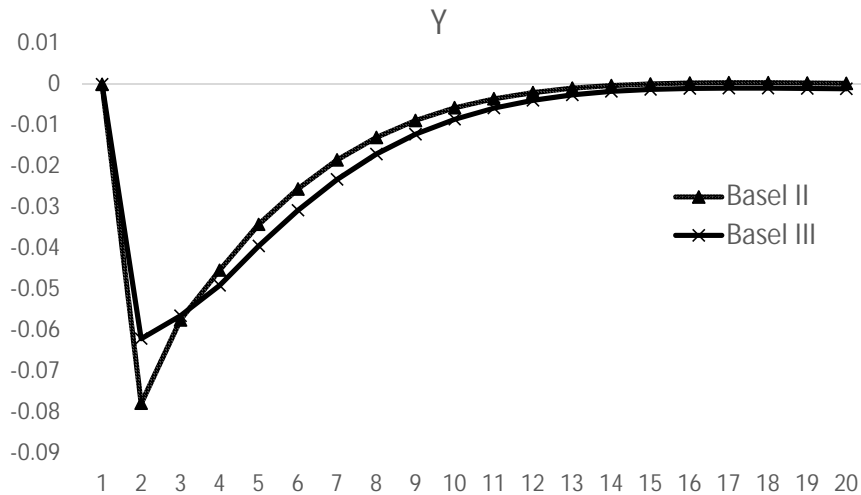

Figure 1. The effect of a monetary shock

6.2 Capital Price Shock

6.2.1 No news shock

First, we investigate the effect of the capital price shock without a news shock on output. The simulation shows how output changes when the capital price increases by 10%. As shown in Figure 2, when the capital price rises by 10%, the collateral constraint of entrepreneurs is relaxed. Thus, the money able to be borrowed may increase. On the contrary, in the Basel II system, since risk weight ϖ depends on the capital price and its effect is negative, the bank can increase loans. That is, credit supply increases and therefore, investment also rises. As a result, investment and output increase.

Next, we consider the Basel III framework, which additionally includes the countercyclical buffer. The calculation of risk weight in Basel II is more sensitive to the ratio of loans to entrepreneurs' net worth and the ratio of loans to bank capital. Therefore, the risk weight has a positive response to a positive capital price shock. However, the calculation of risk weight in Basel III also responds to differences in output from its steady state. Thus, the risk weight responds to the output term in a positive direction. As described in Figure 2, Basel III is thus countercyclical.

---

[10] However, impatient households are not included in this simple model, and Basel III may be more countercyclical (See Fukuda, 2015).
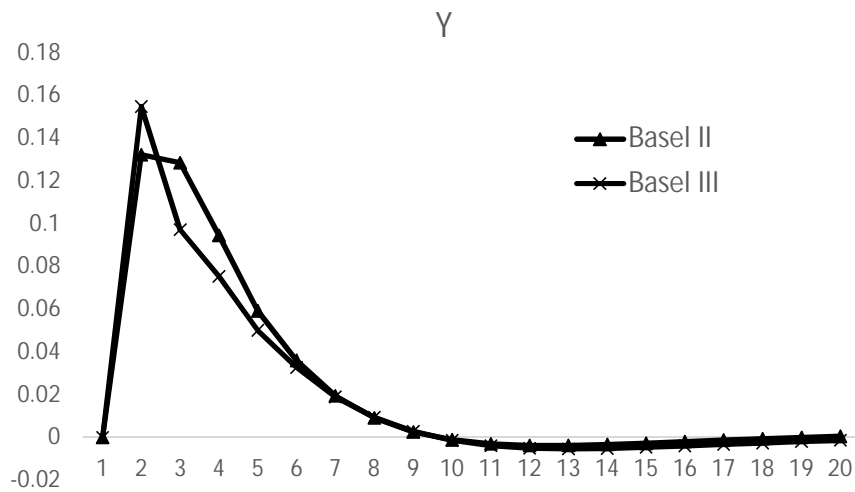
Figure 2. The effect of a positive capital price shock

Next, we consider the Basel III framework, which additionally includes the countercyclical buffer. The calculation of risk weight in Basel II is more sensitive to the ratio of loans to entrepreneurs' net worth and the ratio of loans to bank capital. Therefore, the risk weight has a positive response to a positive capital price shock. However, the calculation of risk weight in Basel III also responds to differences in output from its steady state. Thus, the risk weight responds to the output term in a positive direction. As described in Figure 2, Basel III is thus countercyclical.

6.2.2 News shock

Finally, we investigate the effect of the bank capital adequacy ratio on the capital price shock with a news shock. We rewrite (26) as follows:

$$\epsilon_t^q = \epsilon_{0,t}^q + \epsilon_{1,t-1}^q + \epsilon_{2,t-2}^q + \epsilon_{3,t-3}^q + \epsilon_{4,t-4}^q$$

where, $\epsilon_{0,t}^q$ is an unanticipated component and $\sum_{z=1}^4 \epsilon_{zt-z}^q$ is an anticipated component, which represent news about period t that arrives four periods ahead.
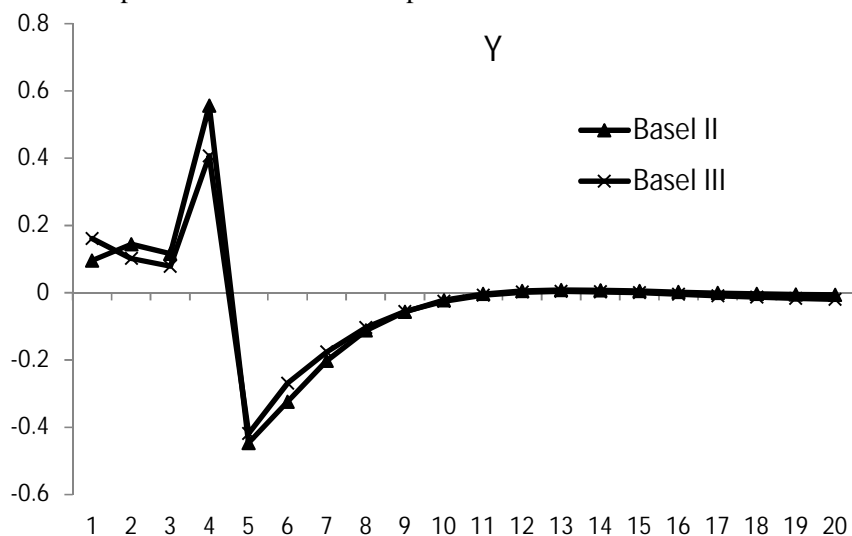

Figure 3. The capital price shock with a news shock

As shown in Figure 3, since the expectation error of the capital price emerges in period 4, there is a boom-bust cycle. This simulation shows that expectation errors occurs in four periods. The capital price crashes and the economic boom-bust cycle occurs. The mechanism in the same in the simulation of the capital price shock without a news shock. The difference is that Basel III shows fewer boom and recession periods than the Basel II framework. Figure 3 thus confirms that Basel III has countercyclicality.

7. Conclusion

This study used a DSGE model with a news shock to investigate the effect of bank capital adequacy on the economic boom-bust cycles. Bank capital adequacy is supposed to be of the Basel II type (i.e. risk-sensitive) and of the Basel III type, which includes a countercyclical buffer. Moreover, for economic boom-bust cycles, we suppose the Pigou cycle in line with Beaudry and Portier (2005).

The economy is driven by three type of shocks: a monetary shock, capital price shock with no news shock, and capital price shock with a news shock. We analyze the monetary shock to check the movement of our model. Since a positive monetary shock decreases output, our model movement is standard. The capital price shock with no news shock is simply a positive capital price shock in period 1. Because the positive capital price shock increases the loanable volume for entrepreneurs, its shock increases business investment. Third experiment is the capital price shock with a news shock. The news shock occurs in period 4. That is, although ones expects the capital price to rise in period 4, this expectation is actually an error. This expectation error thus drives the economic boom-bust cycle.

In terms of the effect of bank capital adequacy, in both the simulations of simple capital price shocks, we investigate the countercyclicality of the Basel III type. In particular, for the economic boom-bust cycle, the Basel III framework implies that it mitigates the increase in output in periods of boom and the decrease in output in periods of bust depending on the elasticity of output growth.

References
[1] Agénor, P., K. Alper, and I. Pereira da Silva (2012), "Capital requirements and business cycles with credit market imperfection," *Journal of Macroeconomics*, 34, pp.678-705.
[2] Angeloni, I. and E. Faia (2013), "Capital regulation and monetary policy with fragile banks," *Journal of Monetary Economics*, 60, pp.311-324.
[3] Aoki, K., J. Proudman, and G. Vlieghe (2004), "House prices, consumption, and monetary policy: a financial accelerator approach," *Journal of Financial Intermediation*, 13, pp.414-435.
[4] Barsky, R. and E. Sims (2011) "News shocks and business cycles," *Journal of Monetary Economics*, 58, pp.273-289.
[5] Beaudry, P. and F. Portier (2004), "An exploration into Pigou's theory of cycles," *Journal of Monetary Economics*, 51, pp.1183-1216.
[6] Beaudry, P. and F, Portier (2006), "News, stock prices and economic fluctuations," *American Economic Review*, 96, pp.1293-1307.
[7] Berger, A. and G. Udell (1992), "Some evidence on the empirical significance of credit rationing," *Journal of Political Economy*, 100, pp.1047-1077.

[8]   Bernanke, B., M. Gertler, and S. Gilchrist (1999), "The financial accelerator in a quantitative business cycle framework," In Taylor, J. and M. Woodford (eds), *Handbook of Macroeconomics*, pp.1341-1393, Elsevier.

[9]   Calvo, G. (1983), "Staggered price in a utility-maximizing framework," *Journal of Monetary Economics*, 12, pp.383-398.

[10] Carlstorm, C. and T. Fuerst (1997), "Agency costs, net worth, and business fluctuations: a computatable general equilibrium analysis," *American Economic Review*, 87, pp.893-910.

[11] Christensen, I. and A. Dib (2008), "The financial accelerator in an estimated New Keynesian model," *Review of Economic Dynamics*, 11, pp.155-178.

[12] Christiano, L., C. Ilut, R. Motto, and M. Rostagno (2008), "Monetary policy and stock market boom-bust cycles," *Working Paper Series*, 955, European Central Bank.

[13] Denhaan, W. and G. Kaltenbrunner (2007), "Anticipated growth and business cycles in matching models," *Mimeo*, London Business School.

[14] De Walque, G., O. Pierrad, and A. Rouabah (2010), "Financial (in)stability, supervision and liquidity injection: a dynamic general equilibrium approach," *Economic Journal*, 120, pp.1234-1261.

[15] Dib, A. (2010), "Banks, credit market frictions, and business cycles," Bank of Canada, *Working Paper* 2010-23.

[16] Fujiwara, I., Y. Hirose, and M. Shintani (2011), "Can news be a major source of aggregate fluctuation? A Bayesian DSGE approach," *Journal of Money, Credit and Banking*, 43, pp.1-29.

[17] Fukuda, S. (2015), "The role of bank capital requirements in the propagation of monetary policy," *Economics and Finance Review*, 4, pp.51-60.

[18] Gerali, A., S. Neri, L. Sessa, and F. Signoretti (2010), "Credit and banking in a DSGE model of the euro area," *Journal of Money, Credit and Banking*, 42, pp.107-141.

[19] Gertler, M. and P. Karadi (2011), "A model of unconventional monetary policy," *Journal of Monetary Economics*, 58, pp.17-34.

[20] Gertler, M. and N. Kiyotaki (2012), "Financial intermediation and credit policy in the business cycle analysis," In Friedman, B. and F. Hahn (eds), *Handbook of Monetary Economics*, 3, pp.547-599, Elsevier.

[21] Iacoviello, M. (2005), "House prices, borrowing constraints and monetary policy in the business cycle," *American Economic Review*, 95, pp.739-764.

[22] Iacoviello, M. (2015), "Financial business cycle," *Review of Economic Dynamics*, 18, pp.140-163.

[23] Iacoviello, M. and S. Neri (2010), "Housing market spillover: evidence from an estimated DSGE models," *American Economic Journal: Macroeconomics*, 2, pp.124-164.

[24] Jaimovich, N. and S. Revelo (2009), "Can news about the future drive the business cycle?," *American Economic Review*, 99, pp.1097-1118.

[25] Kahn, H. and J. Tsoukalas (2012), "The quantitative importance of news shocks in estimated DSGE model," *Journal of Money, Credit and Banking*, 44, pp.1535-1561.

[26] Kiley, M. and J. Sim (2014), "Bank capital and the macroeconomy: Policy consideration," *Journal of Economic Dynamics and Control*, 43, pp.75-198.

[27] Kiyotaki, N. and J. Moore (1997), "Credit cycles," *Journal of Political Economy*, 105, pp.211-248.

[28] Kobayashi, K., T. Nakajima, and M. Inaba (2007), "Collateral constraint and news-driven cycles," *Discussion Paper* 07013, Research Institute of Economy, Trade and Industy (RIETI).

[29] Mandelman, F. (2006), "Business cycle: A role for imperfect competition in the banking system," Federal Reserve Bank of Atlanta *Working Paper*, 2006-21.

[30] Meh, C. and K. Moran (2004), "Bank capital, agency costs, and monetary policy," Bank of Canada, *Working Paper* 2004-06.

[31] Meh, C. and K. Moran (2010), "The role of bank capital in the propagation of shocks," *Journal of Economic Dynamics and Control*, 34, pp.555-576.

[32] Repullo, R. and J. Suarez (2004), "Loan pricing under Basel capital requirements," *Journal of Financial Intermediation*, 13, pp.496-521.

[33] Repullo, R. and J. Suarez (2007), "The procyclical effects of Basel II," CEPR *Discussion Paper* 6862.

[34] Roger, S. and J. Vlcek (2011), "Macroeconomic costs of higher bank capital and liquidity requirements," IMF *Working Papers*.

[35] Schmitt-Grohe, S. and M. Uribe (2008), "What's news in business cycle," *Working Paper* 14215, National Bureau of Economic Research.