ISSN 1975-5163
WORKING PAPER No.336

May
2008

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* The author thanks Hyung-Kwon Jeong, Byoung Hark Yoo, Kyuil Chung and other seminar participants at the Bank of Korea for their helpful comments.

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Do Capital Adequacy Requirements Really Matter?

This paper investigates how the bank capital adequacy requirements affect economic fluctuations. It is widely claimed that when bank loans are bounded by bank capital, as the Basel Accord stipulates, economic fluctuations are amplified. However, since banks would hold capital even without the regulation and thereby the amplifying effect must already exist, it is unclear how much additional amplification effect the regulation itself creates. This paper answers this question. Following the literature the bank loan and the bank capital are modeled from dual layers of information asymmetry and incorporated into an otherwise standard New Keynesian model. With reasonable parameter values for Korean economy, I find that the capital adequacy requirements add little to the economic fluctuations beyond what already caused by the information asymmetry. It is true even when the regulation is sensitive to the business cycle. If the bank re-capitalization by outside funds is allowed, the amplifying effect may even become smaller. This implies that the monetary policy framework does not need to be altered in response to the adoption of the Basel II capital regulation.

Keywords: Capital adequacy requirement, Procyclicality, Information asymmetry, Basel accord

JEL Classification: E44; E52; G20

1 Introduction

The role of the banking sector in the business cycle is one of the widely studied subjects. Bernanke and Gertler (1989), for example, analyze how a financial friction caused by information asymmetry amplify economic fluctuations. If borrowers are bounded by the information problem, they need to pledge their own net worth into the project when they borrow. In this way, a shock such as a monetary policy shock affects economic activities not only through the changes in relative prices but also through borrower's net worth. This logic can be extended to the argument that the regulation on the bank capital amplifies the initial shock to create larger economic fluctuations. When banks are required to hold capital, the net worth of bankers, shocks are amplified and sometimes protracted. Blum and Hellwig (1995) are the among the first who argue this. Cecchetti and Li (2005) extend their model and argue that the amplifying effect of bank capital, 'procyclicality of bank capital', can be countered by an active monetary policy. Van den Heuvel (2006), Meh and Moran (2004), and Aikman and Paustian (2006) explicitly incorporate asymmetric information as the source of the existence of bank capital, and analyze the implication of the bank capital to monetary transmission channels and economic fluctuations. Although most of the works on this issue do not distinguish the role of the (voluntarily held) bank capital and the bank capital adequacy requirement, there is a fine line between the two. One of the contributions of this paper is that it shows that there is little difference between the two in terms of monetary policy transmission mechanism.

Starting the first quarter of 2008, commercial banks in Korea are to adopt the Basel II capital regulation. The Basel II Pillar I implements a risk adjusted capital charge. This raises a concern that the new regulation would make economic fluctuations even larger than it has been under the Basel

I. So, if this is true, it should be not only important for bank supervisors, but also it should raise a concern for central bankers as to whether the monetary policy framework needs to be altered in response to the changes in transmission mechanisms of monetary policy. If the role of the bank capital in amplifying economic fluctuation is due to the regulation, then the adoption of the Basel II would in fact add more fluctuation to the economy, therefore the framework of monetary policy should be changed accordingly. On the other hand, if the the role of the bank capital is mostly from the information asymmetry, then the change of the regulation has little impact. As a result the monetary policy framework does not need to be changed.

Despite the attention on the role of the bank capital in the literature, there has not been much discussion of the above distinction. Recent studies are focused more on the comparison of the required capital under the Basel II with that under the Basel I. The most of the studies find that the required capital under the Basel II is larger than under the Basel I. Kashyap and Stein (2004), for example, argue, based on their simulation, that the bank capital needed under the Basel II is larger than under the Basel I, and therefore the cyclicality of the bank capital can be interpreted as a large cyclicality in the business cycle as well. Also many other empirical studies confirm that the bank capital matters in a similar vein. However, empirical findings are not universal on this point. Illing and Paulin (2004) perform a simulation on Canadian banks and find that the cyclical implication of the Basel II may depend on how the supplement capital behaves. This is one of the points this paper takes.

In this paper I investigate the degree to which capital adequacy requirement amplifies economic fluctuations, and whether monetary policy should react to the amplified economic fluctuation due to capital adequacy requirement. To this end, I follow the tradition in the literature by explicitly

modeling a banking sector from information asymmetry between borrowers (entrepreneurs) and lenders (banks). Also bank capital is modeled from another layer of information asymmetry between banks and depositors.[1]

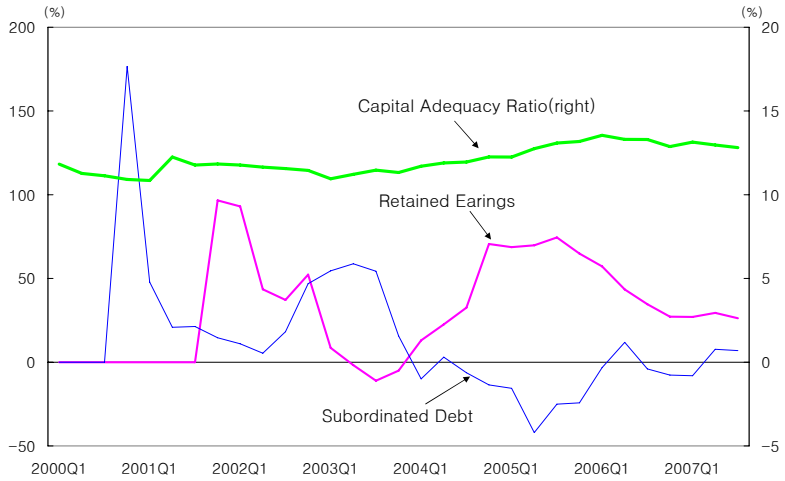
The results show that even though the existence of bank capital does amplify economic fluctuations, the amplification effect is mostly attributable to bank capital holding due to information asymmetry. That is, the amplification effect from the capital adequacy requirement above and beyond that from information asymmetry is small. Moreover, if banks can flexibly change the speed of bank capital accumulation from their profits, then the amplification effect gets smaller. This result can be further extended to the case when banks can freely borrow from outside for recapitalization.

The assumptions about varying speed of bank capital accumulations and banks' borrowing from outside are well supported by the data for Korean Economy. Figures 1 and 2 show the changes in components of the bank capital, such as retained earnings and subordinated debts, are relatively easily adjusted. Since 2000, capital adequacy ratio has been well stabilized around 12%. However, retained earnings (Tier 1 capital) and subordinated debts (Tier 2) capital show a distinct negative correlation. Especially, the subordinated debt co-moves with risk weighted assets, which implies that banks adjust the subordinated debts first when they need to change the level of the bank capital, followed by the changes in retained earnings in the opposite direction. This implies that banks manage the level of subordinated debts together with the level of retained earnings to meet the capital requirement in such a way that the one is a complement to the other. This aspect is implemented later in the model as a variable consumption rate for bankers.

Although bank loans and bank capital play important roles in this line

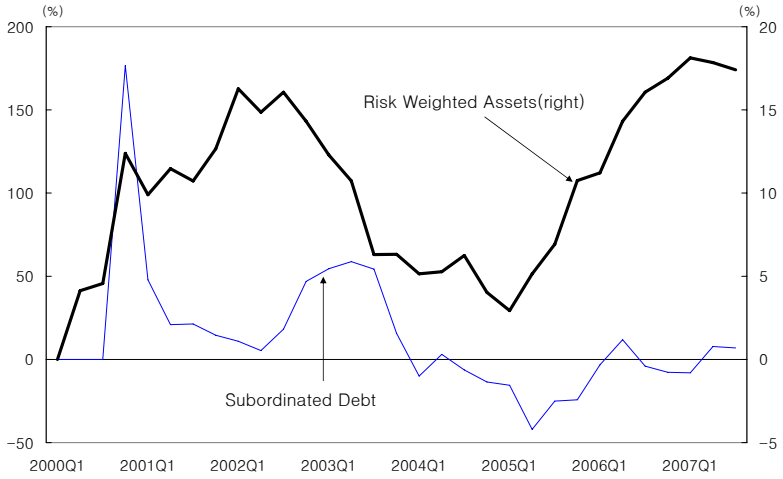
[1]See Holmstrom and Tirole (1998), Carlstrom and Fuerst (1997) and Carlstrom and Fuerst (2001), Chen (2001) and most recently Aikman and Paustian (2006).

Figure 1: Retained Earnings and Subordinated Debts



of research, including this paper, empirical results regarding the lending channel are mixed. Let's take a look at Figure 3. The loans to enterprises, especially loans for equipment, do not co-move with investment. In addition, as Figure 4 shows, the correlation between bank capital and SME loans are not as conspicuous as it should. That is, when a bank is constrained by its capital, it seems natural to assume that it cuts back SME loans more than other type of loans, in the spirit of Kashyap and Stein (1993). They argue that the effect of contractionary monetary policy on small banks, which cannot easily substitute CDs for deposits, is larger, and the SME loans decrease more than other type of loans. However, this does not necessarily mean that firms do not depend on bank loans for the investment financing, and there is no bank lending channel of monetary policy. Instead it simply suggests the difficulties in identifying the links between bank lending and economic activities.

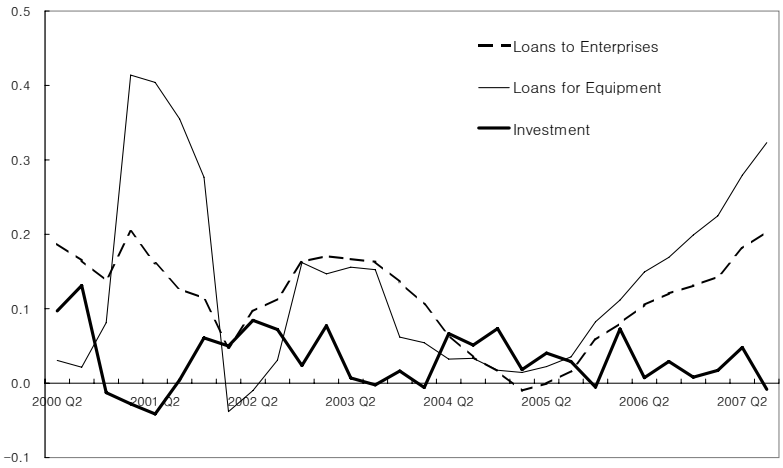
Figure 2: Risk Weighted Assets and Subordinated Debts



This paper is organized as follows. First, I present a baseline model with asymmetric information between non-bank firms and banks. Due to the fact that entrepreneurs may enjoy private benefits by shirking at the expense of lower probability of successful production, banks ask entrepreneurs to put their net worth into production. This alone would amplify the economic fluctuation through changing entrepreneur's net worth. In order to model bank capital, bankers' net worth, the introduction of another layer of information symmetry is needed. Banks too may shirk and enjoy the private benefits. This too calls for bankers to hold their net worth. Together with entrepreneurs net worth, this create the procyclicality of bank capital. That is, when the economy expands, both entrepreneur's net worth and bankers' net worth increase, since they are the accumulated profits for entrepreneurs and bankers, respectively.

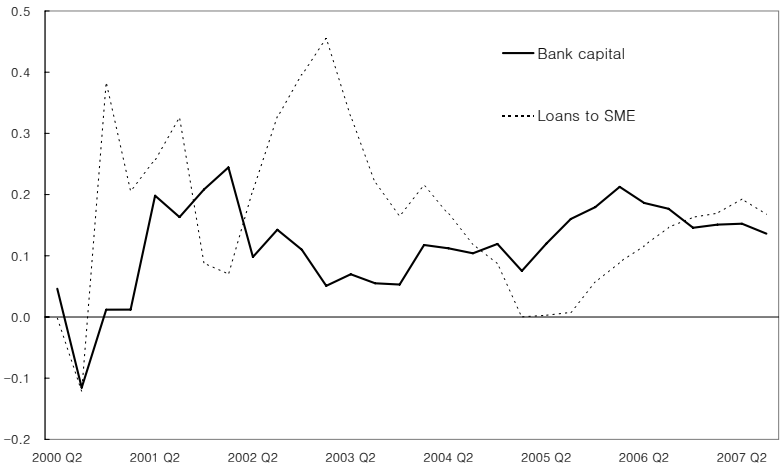
Using this model as a benchmark, I analyze other variations of the model.

Figure 3: Bank Loans



I first compare the baseline model with a symmetric information model to show the magnitude of the amplification. Next I modify the model that incorporates Basel I requirement, which requires banks to hold minimum amount of capital proportional to loans, and compare this with the baseline model to show how large the additional fluctuations this requirement creates. In modeling this, I allow bankers' consumption ratio, the ratio of consumption to their net worth, to vary. This is only sensible way to model for banks to maintain the capital above the level that they would without the requirement. They would first cut back their consumption to meet the requirement. Next I further modify the model to incorporate Basel II, which requires banks to hold minimum capital according to the risks of borrowers (Pillar I). Since the model is linear, I assume that CAR ratio is proportional to output, which acts as a proxy to macroeconomic risks. This assumption can be justified because the argument that the Basel II would exacerbate

Figure 4: Bank Capital and SME Loans



the procyclicality stems from the very assumption that the CAR ratio IS procyclical, which, by definition, the ratio increases when output increases. The last modification to the model is the inclusion of the possibility that banks can be recapitalized from external funds. This assumption is a bit at odds with the assumption that there exists an information asymmetry between bankers and depositors. This can be justified from the observation that under the normal circumstances banks usually do not have any difficulties in recapitalization up to a certain amount. Even under a severe credit crunch, unless banks are totally replete with capital, they can be recapitalized either through financial markets or through some other arrangements. I conclude with a caveat and a direction for further research.

2 Baseline Model

I first introduce a baseline model without the capital adequacy requirement (CAR henceforth). Then I introduce the CAR and compare the degree of procyclicality with and without the CAR. The introduction of the CAR takes 3 different forms. The first, the CAR is binding, but bankers can adjust their consumption level. The second, the CAR is binding, bankers can adjust their consumption level, and they can borrow from outside. The third, the CAR is binding, but bankers can adjust their consumption level, and the CAR is sensitive to business cycle. The last feature gives a flavor of the Basel II Pillar I.

This economy consists of 3 agents: households who demand consumption goods and provide labor; entrepreneur who operates non-bank firms that produce intermediate goods using capital goods; bankers who make loans to entrepreneurs and take deposits from households. In addition to these three agents, there are final goods sector, and capital goods sector, and the central bank.

2.1 Household

There are an infinite number of households, who live forever. They are assumed identical so that we can analyze the behavior of a representative household.

$$\begin{aligned} \text{Max} \quad & E_0 \sum_{t=0}^{\infty} \beta^t [\frac{(c_t^H)^{1-\sigma}}{1-\sigma} - \frac{n_t^{1+\theta}}{1+\theta}], \\ \text{s.t.} \quad & c_t^H + \frac{D_t}{P_t} \leq \frac{W_t}{P_t} n_t + R_t^n \frac{D_{t-1}}{P_t} + \frac{\Pi_t}{P_t} + \frac{T_t}{P_t}. \end{aligned}$$

c_t^H denotes consumption, n_t denotes labor, D_t denotes bank deposit, and

Π_t and T_t denote lump sum transfer from monopolistic non-bank firms and government respectively. R_t^n is the nominal interest rate on deposit. β, σ, χ_n, and θ are parameters. As can be seen, there is only one saving vehicle for the household, that is, deposit. We abstract from money demand of the representative household since money demand does not play any role except being adjusted passively by the level of nominal interest rate set by the central bank.

The first order conditions of the utility maximization of this representative household are as follows.

$$(c_t^H)^{-\sigma} = \beta R_t^D E_t[(c_{t+1}^H)^{-\sigma}], \quad (1)$$

$$n_t^\theta = (c_t^H)^{-\sigma}\omega_t, \quad (2)$$

where $R_t^D \equiv R_t^N \frac{P_{t-1}}{P_t}$, and $\omega_t \equiv \frac{W_t}{P_t}$.

2.2 Non-bank Firms

There are three tiers of non-bank firms: final good producers, wholesalers, and intermediate good producers. Entrepreneurs own intermediate good producing firms. Intermediate goods are identical and produced using capital owned by entrepreneurs, and wholesalers transform the intermediate goods into differentiated wholesale goods so that each wholesaler has monopolistic power. This assumption, together with the sticky price assumption, will lead to the New Keynesian Phillips curve. The final goods are aggregated from individual (differentiated) wholesale goods as follows.

$$y_t = (\int_0^1 y_t(i)^{\frac{\epsilon-1}{\epsilon}})^{\frac{\epsilon}{\epsilon-1}}, \quad (3)$$

where y_t is the final good, $y_t(i)$ is differentiated wholesale good index with i, the measure of which is assumed to be 1. ϵ is an elasticity of substitution among wholesale goods. The final goods market is perfectly competitive. Wholesale goods are produced using intermediate goods and labor with Cobb-Duglas technology.

$$y_t(i) \quad = z_t m_t(i)^{\alpha} n_t(i)^{1-\alpha} \quad , \tag{4}$$

where z_t is a macroeconomic technology shock, $m_t(i)$ is the intermediate goods input by i th wholesaler, and $n_t(i)$ is the labor input by i th wholesaler. It is assumed that intermediate goods and labor are identical, respectively.

$m_t(i)$ is produced by a linear technology with only input, and capital. However, there is a probability, denoted by $1-p$, that the production may fail. The intermediate goods production function on average is

$$m_t(i) \quad = \quad rpk_t(i), \tag{5}$$

where r is the return rate, and $k_t(i)$ is the capital input.

Following Calvo (1983), we can derive the following Phillips Curve from profit maximization of wholesalers.

$$\pi_t \quad = \quad \beta E_t \pi_{t+1} + \kappa \psi_t, \tag{6}$$

where π_t is inflation, κ is a parameter, and ψ_t is real marginal cost.

Under the perfectly competitive factor market, factor demands are as

follows.[2]

$$n_t = \frac{\psi_t}{\omega_t} y_t, \tag{7}$$

$$m_t = \frac{\psi_t}{\nu_t} y_t, \tag{8}$$

where ν_t is the price of intermediate goods.

Capital goods are produced with final goods and existing capital, so the following relations can be derived.[3]

$$nk_t = \mu i_t^{\phi} [(1-\delta)k_{t-1}]^{1-\phi}, \tag{9}$$

$$k_t = (1-\delta)k_{t-1} + nk_t, \tag{10}$$

$$q_t = (\mu\phi)^{-1} i_t^{\phi-1} [(1-\delta)k_{t-1}]^{1-\phi}, \tag{11}$$

where μ, $\phi$and δ are parameters, nk_t is new capital, and q_t is the price of capital goods.

Entrepreneurs are assumed to be risk neutral and are faced with a fixed rate of mortality, π^e, to ensure that they always need outside financing. At the beginning of a period, they are notified whether they live or die. If they live, they postpone their consumption and put all of their net worth, denoted by w_t, in capital. If they die, they consume all of their net worth and exit. Without this assumption they may accumulate enough net worth to finance the total value of capital on their own. Also if they live, they are endowed with a fixed amount, e_t^e. This is to ensure that they can jump

[2]I abbreviate index i, since each firm is face with an identical optimization problem.

[3]I assume that there is no compensation for the existing capital, so the price of capital equals the marginal product of the final consumption good used. So the inclusion of existing capital in the capital production function can be better thought of as some type of 'learning by doing' at work, not as existing capital being rented from entrepreneurs for free.

start even if they failed in production in the previous period.

$$w_t = (1-\pi^e)p_H[r\nu_t + (1-\delta)q_t - f_{t-1}]k_{t-1} + e^e_t, \quad (12)$$

$$c^e_t = \pi^e p_H[r\nu_t + (1-\delta)q_t - f_{t-1}]k_{t-1}, \quad (13)$$

where c^e_t denotes entrepreneur's consumption, f_t denotes the amount that firms pledge to repay for the loans, and p_H is the probability of successful production of intermediate goods when entrepreneurs do not shirk. Details of the information asymmetry and the loan arrangement are explained in the next section.

2.3 Banks

Usual macroeconomic models abstract from a banking sector as if banks are nothing special except in simply handing over funds from savers to borrowers. However, in the banking literature, the existence of banks has been explained in the context of information asymmetry, so this paper adopts this tradition. It is needless to say that modeling banking sector explicitly is crucial in this paper since the purpose of this paper is to analyze how the CAR amplifies (or not) economic fluctuation. In order to model bank capital explicitly, I build a model on Chen (2001) and Aikman and Paustian (2006), whose models are again built on Carlstrom and Fuerst (2001), and Holmstrom and Tirole (1998).

Banks are faced with information asymmetry because firms may shirk and enjoy a fixed amount of private benefit, B, which lowers the probability of success in producing the intermediate goods from p_H to p_L. This change in the probability is denoted by Δp. When the production fails, there is no return to either the firms or the banks. Banks can retrieve the principal and

interests only when the production succeeds. Since there is no way for banks to directly stop firms from shirking, the only way to prevent shirking is to keep the maximum amount that firms pledge to repay when the production succeeds, f_t, to such a level that firms would choose not to shirk. That is

$$\begin{aligned} p_H E_t[\nu_{t+1} r + (1-\delta) q_{t+1} - f_t] &\geq p_L E_t[\nu_{t+1} r + (1-\delta) q_{t+1} - f_t] + B, & (14) \\ f_t &= E_t[\nu_{t+1} r + (1-\delta) q_{t+1}] - \frac{B}{\Delta p}. & (15) \end{aligned}$$

If the amount that firms pledge, the left hand side, is greater than the expected return, the right hand side, firms would rather shirk than work hard and share the return with banks. The first term on the right hand side is the total expected return from the production, and the second term is the (negative) marginal private benefit of shirking. So knowing all this, banks would not extend loans to the firm. As is assumed in the previous section, firms cannot finance by themselves the total amount of funds needed to purchase the capital, so entrepreneur's own net worth is needed. That is, the total value of input, $q_t k_t$, should be financed partly by loans and partly by entrepreneur's own net worth.

$$q_t k_t = l_t + w_t, \quad (16)$$

where w_t denotes the net worth of entrepreneurs.

Bank capital is introduced from another layer of information asymmetry. Let's assume that if banks monitor firms with a fixed cost per unit capital, c, then the private benefit of firms when they shirk, is reduced from B to b. That is, when banks monitor, the total amount that firms can pledge (borrow) increases, since the monitoring by the bankers would make shirking

less attractive. ($f'_t > f_t$)

$$f'_t = E_t[\nu_{t+1} r + (1-\delta) q_{t+1}] - \frac{b}{\Delta p}. \tag{17}$$

However, depositors do not know if banks themselves shirk and not monitor the firms in order to save the monitoring costs. Thus, in order for the bankers to be incentive compatible, the share of bankers from the repayment from firms, R_t^B, cannot be lower than a level that the cost of monitoring equals the benefit of monitoring. That is, if banks promise to take too little from what they are repaid for the loans to the firms, they may shirk and not monitor. If so, the depositors would not deposit their money in the first place. That is, since entrepreneurs now realize that there is no monitoring, they find themselves to have pledged too much, as much as $f_t^B - f_t$. So it is better for them to shirk and enjoy B at the cost of lower probability of successful production.

$$R_t^B = \frac{c}{\Delta p f_t}. \tag{18}$$

The last incentive compatibility condition is that the interest rate on the deposit equals average return from the deposits. One thing to note here is that in equilibrium no one shirks, so the return of the production is on average p_H times the total amount that the firms pledge for the loans minus banker's share. In order for this relationship to hold, there needs an additional assumption that deposits are pooled so that the depositors are not faced with idiosyncratic risks.

$$R_t^D = \frac{p_H(1-R_t^B)f_t k_t}{d_t}. \tag{19}$$

With these assumptions, loans are financed by deposits and banker's own net worth.

$$l_t = a_t + d_t. \tag{20}$$

Bankers too are assumed to be risk neutral and face a fixed rate of mortality, π^B, to ensure that they always need outside financing. At the beginning of a period, they are notified whether they live or die. If they live, they postpone their consumption and put all of their net worth in loans. If they die, they consume all of their net worth and exit. Without this assumption they may accumulate enough net worth to finance the total amount of loans on their own. In addition, if they live, they are endowed with a fixed amount, e_t^B, to ensure that they can jump start even when they are not repaid for the loans made in the previous period.

$$a_t = (1-\pi^B)[p_H f_{t-1} - r_{t-1}^d d_{t-1}]k_{t-1} + e_t^B, \tag{21}$$

$$c_t^B = \pi^B[p_H f_{t-1} - r_{t-1}^d d_{t-1}]k_{t-1}, \tag{22}$$

where c_t^B denotes entrepreneur's consumption.

2.4 Central bank

The central bank sets the nominal interest rate by the following Taylor type rule.

$$\frac{R_t^N}{Rss} = (\frac{R_t^N}{Rss})^{\rho_r}(\frac{\pi_t}{\pi ss})^{(1-\rho_r)\rho_\pi}(\frac{y_t}{yss})^{(1-\rho_r)\rho_y}exp^{u_t}, \quad (23)$$

where $\cdot ss$ denotes the steady state value of the variable, ρ_r, ρ_π,ρ_y are parameters[4], u_t is a monetary policy shock.

2.5 Equilibrium

The equilibrium of this model is $\{c_t^H, \omega_t, \psi_t, \nu_t, \omega_t, \pi_t, n_t, m_t, i_t, nk_t, q_t, w_t, c_t^e, f_t, k_t, r_t^B, d_t, l_t, a_t, c_t^B, R_t^N, y_t, R_t^D\}_{t=0}^{\infty}$ that satisfies Equations (1), (2), (4), (5), (6), (7), (8), (9), (10), (11), (12), (13), (17), (16), (18), (19), (20), (21), (22), (23), and the following equations with given initial values.

$$y_t + e_t^e + e_t^B = c_t^H + c_t^e + c_t^B + i_t + c, \quad (24)$$

$$R_t^D = R_t^N/\pi_t. \quad (25)$$

3 Calibration

The model is calibrated to fit the Korean economy. I assume the curvature parameter of household utility function to be 1, that is $\sigma = 1$, and $\theta = 1$. Discount factor β is assumed to be 0.99, and depreciation rate δ is 0.025. $1 - \alpha$ is assumed 0.35 to reflect labor income share. $\kappa = 0.09$ to reflect the usual estimate of prices stickiness, 0.75, which implies roughly resetting the prices once every 4 quarters. $\epsilon = 6$ reflects roughly 20% of markup. Capital production curvature parameter, ϕ, is 0.90, estimated by Kang (2007). μ is calibrated as 0.2 to fit the GDP to Capital ratio, $\frac{y_t}{q_t k_t}$, which is roughly 5 from GDP and National Wealth data. I assume r to be 20. However, it does not

[4]Usual assumption about the uniqueness and stability of an equilibrium, or Blanchard and Kahn (1980) condition applies.

affect any dynamics except the steady state price of intermediate goods ν. I assume $p_H = 0.99$, and $p_L = 0.69$. The latter probability is not observable in reality, so it may pose a problem. This value, however, does not change the results, so I picked the value for the sake of computational convenience. π^e, and π^B are calibrated as 0.80 and 0.85, respectively, to match the dividend to earning ratios from the Financial Statement Analysis data. ρ^r, ρ^π, and ρ^y are assumed 0.5, 1.5, and 0.5 respectively as a benchmark. b is calibrated to fit the equity to wealth to be roughly 1, and c is calibrated as 0.03 to match the expenditure to asset ratio for banks, which is roughly 10%.

4 Model Extension and Simulation

In order to produce the impulse responses of endogenous variables to exogenous shocks, the model is log-linearized and the equilibrium values are calculated using Klein (2000)'s QZ method. Although it is well known that log-linearization may impair the welfare implication of the model, since the focus of this paper is on model dynamics, log-linearization does not create any unwanted biases to the results. The steady state of the baseline model is in the Appendix. Before I proceed with the baseline model with asymmetric information problem, I present no asymmetric information case for a comparison.

4.1 No Information Asymmetry

When the economy has no asymmetric information problem, the savings are channeled to investment without any help of the banking sector. This means that the return of savings by the households, R_t^D, should be the same as the marginal product value of capital, that is,

$$R_t^D = \frac{1}{q_t} E_t[r p_H \nu_{t+1} + (1-\delta) q_{t+1}]. \quad (26)$$

So the symmetric information equilibrium is defined as $\{c_t^H, \omega_t, \psi_t, \nu_t, \omega_t, \pi_t, n_t, m_t, i_t, nk_t, q_t, k_t, R_t^N, y_t, R_t^D\}_{t=0}^{\infty}$ that satisfies Equations (1), (2), (4), (5), (6), (7), (8), (9), (10), (11), (26), (23), (24), (25). Here I assume that the consumption of entrepreneurs and banker, $c^e$and c^B are exactly the same as their respective endowments, $e^e$and e^B. From the symmetric information assumption, it is clear that $b = c = 0$.

4.2 Basel I: Fixed Capital to Loan Ratio

Now banks are no longer left to hold capital as they need, banks are required to hold a certain minimum level of capital. The requirement stipulates that banks hold capital proportional to the amount of loans. In order to make this exercise meaningful, the required ratio must be higher than what it would be without the requirement. Now banks need to accumulate capital more than they otherwise would, so I modify the model to allow banks to change consumption ratio, π^B, in response to shocks while keeping the required ratio. That is, the bank capital accumulation equation, (21) and banker's consumption function, (22) need to be modified as follows.

$$a_t = (1-\pi_t^B)[p_H f_{t-1} - r_{t-1}^d d_{t-1}]k_{t-1} + e_t^B, \quad (27)$$

$$c_t^B = \pi_t^B [p_H f_{t-1} - r_{t-1}^d d_{t-1}]k_{t-1}. \quad (28)$$

And the equation for the CAR requirement needs to be added. This equation pins down the equilibrium level of π_t^B.

$$a_t = 0.035 l_t. \tag{29}$$

Although the actual CAR ratio is 8%, too high a ratio would make the consumption ratio for bankers $\pi_t^B > 1$ under our calibrated parameters, which implies banks need to borrow. So, I assume CAR ratio to be 3.5%, the level which keeps π_t^B below 1. Since this exercise is not to replicate the data, but to measure the relative magnitude of the effects, as long as the CAR ratio is higher than the capital to asset ratio under no regulation, the results are not affected by the absolute level of CAR ratio.

4.3 Basel II: Variable Capital to Loan Ratio

The most important aspect of Basel II compared to Basel I is that the CAR is no longer a fixed ratio to the total amount of loans, 8%. Instead, the loans are weighted by risks. This feature is suggested in the Basel II capital requirement (Pillar I) as a counter-measure to recent practices called capital arbitrage. Since the CAR ratio is calculated irrespective of the risks of the borrowers under the Basel I, banks has an incentive to merge the risks using derivatives such as CDO's in order to avoid the capital charge. However, many raised a concern that this risk weighted capital requirement would exacerbate the procyclicality of CAR, since in a recession, when overall risks are higher, bank loans would be more constrained by the capital requirement. Therefore the activities of firms that depend their finance on bank loans would be further dampened.

Since the model is solved using linearization around the steady state, the risk, in the usual sense in terms of second order moments, cannot be incorporated into the model. So, instead I assume that the CAR ratio is

proportional to the output, which still reflects the core idea of the argument that the CAR ratio becomes pro-cyclical under Basel II. The followings are the equations needed to modified.

$$a_t = \theta_t l_t, \tag{30}$$

$$\theta_t = -\phi^B y_t, \tag{31}$$

where θ_t is the CAR ratio and ϕ^B is the sensitivity parameter, which I assume 0.5. According to the FSS (2007), a simulation for the required capital under Basel II, the sensitivity of the required capital to macro variables, and the sensitivity of the required capital to risk factors are much less than 0.5. However, in order to give the maximum benefit of the doubt, I assume a relatively large value for the sensitivity parameter. Here Equation (30) pins down π_t^B as before, and Equation (31) pins down θ_t.

4.4 Basel I: Fixed Capital to Loan Ratio with Recapitalization

So far I modified the model to analyze the Basel I and Basel II capital requirements. Here I modified the model to include the possibility that banks can borrow from outside. This may seem at odds with the assumption that banks are faced with another layer of information asymmetry, which is the source of the existence of bank capital in the first place. However, as I discuss earlier, this modification can be justified from the observation that banks usually do not have any difficulties in recapitalization up to a certain amount. Of course, when a bank suffers a significant loss and is depleted of its capital, it would be not easy to be recapitalized. In a period of credit crunch, not only non-bank firms, but also banks themselves will experience

a shortage of funds. Nevertheless, this does not mean that it is always hard for the banks to be recapitalized. Figures 1 and 2 clearly show this point. While the CAR ratio remains stable and well above the required level (8%), the subordinated debts are highly correlated with the risk weighted assets. This implies that it is the subordinated debts that are to be adjusted first when needed. So, with a qualification that this model only concerns about a relatively normal circumstances, I go on to assume that banks can borrow, when needed, from outside for recapitalization.

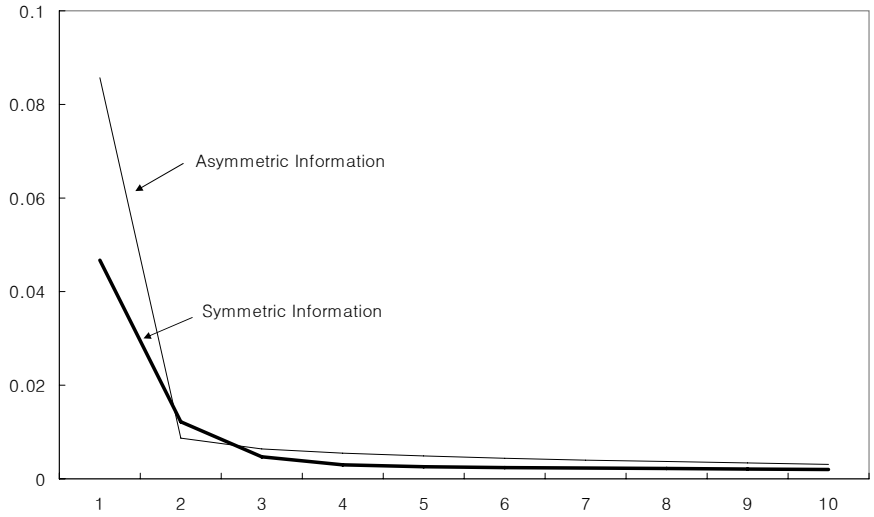
In this case, the equations are modified as follows.

$$
\begin{aligned}
a_t &= (1-\pi_t^B)[p_H f_{t-1} - r_{t-1}^d d_{t-1}]k_{t-1} + e_t^B + \hat{a}_t, && (32)\\
c_t^B &= 0, && (33)\\
a_t &= 0.06 l_t && (34)\\
y_t + e_t^e + e_t^B &= c_t^H + c_t^e + c_t^B + i_t + \hat{a}_t + c, && (35)
\end{aligned}
$$

where $\hat{a}_t$ denotes the borrowed capital.

Thus, this modification implies that when banks run out of their own net worth for the required CAR ratio they borrow from outside. I abstract from the decision making process of outside recapitalization or the pricing of this outside funds. It is as if households support the bank without any remuneration. However, it can be easily re-interpreted as the government or the non-bank firms with an incentive to invest in the banking sector support the banks. However it may be interpreted, within the confinement of the purpose of this paper, comparison of the role of the bank capital can be proceeded. Here I assume the CAR ratio to be 6%, which is still lower than the actual ratio, but high enough so that consumption ratio for bankers, $1-\pi_t^B$ becomes 0, and thereby outside funding is needed.

Figure 5: Impulse Response of Output to Unexpected 25bp Interest Rate Cut

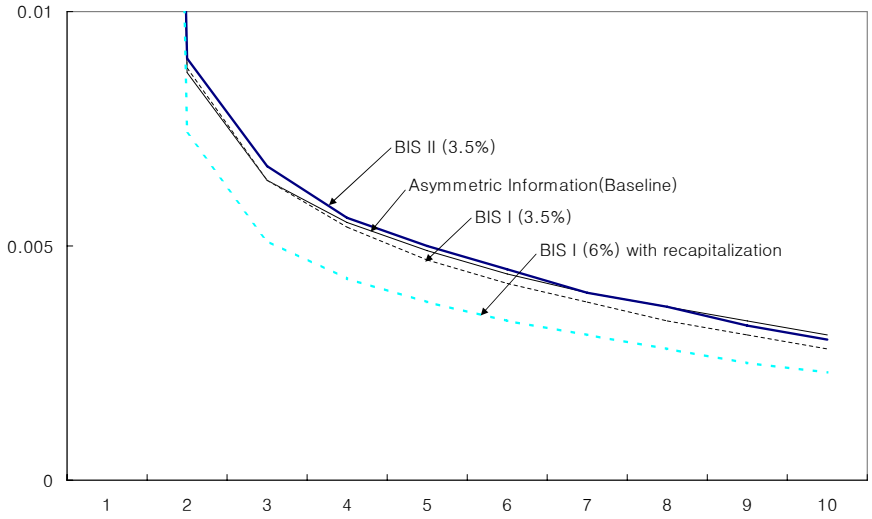


4.5 Comparison of the Models

First, let's consider a monetary policy shock. As expected, the impact of unexpected interest rate cut is much larger compared to the symmetric information case (see Figure 5). The intuition is straightforward. Since entrepreneurs are financially constrained due to information asymmetry, whenever the information problem is lessened, shocks create a second round effect on top of its direct impact through net-worth of entrepreneurs and bankers. That is, when interest rate is lowered, the aggregate demand increases along with factor demands including intermediate goods. This leads to the higher price of the intermediate goods, so the return and the net worth of entrepreneurs increase. This allows entrepreneurs to be able to pledge more while satisfying incentive compatibility condition. The net worth of the banks also increases and therefore total amount of loans increases.

Next, Figure 6 reports the responses of output to an unexpected 25bp interest rate cut. Although Basel I and Basel II do in fact amplify the shocks further compared to the baseline model, the additional effects are minimal.

Figure 6: Impulse Response of Output to Unexpected 25bp Interest Rate Cut



Especially it is noteworthy that the Basel II does not amplify the economic fluctuation any further than the effects already at work under Basel I.

It is quite intuitive that the amplifying effect is reduced when bankers can change their consumption rate in response to a shock. When the central bank cuts the interest rate unexpectedly, aggregate demands including capital demands increase. This in turn raises the demand for loans. If banks are to maintain fixed consumption ratio, they increase their net worth in proportion to the increase in their share from the successful production. Increased net worth allows bankers to provide more loans to firms, which would in turn increase output further. Now, banks can adjust their consumption ratio out of their net worth. Thus when the bankers' net worth increase above the level required by the CAR, banks would increase their consumption. This implies that bankers do not supply as much loans as they would with fixed consumption ratio. Therefore output does not increase as much.

This intuition can be carried over to the case when banks are recapi-

Figure 7: Impulse Response of Loans to Unexpected 25bp Interest Rate Cut

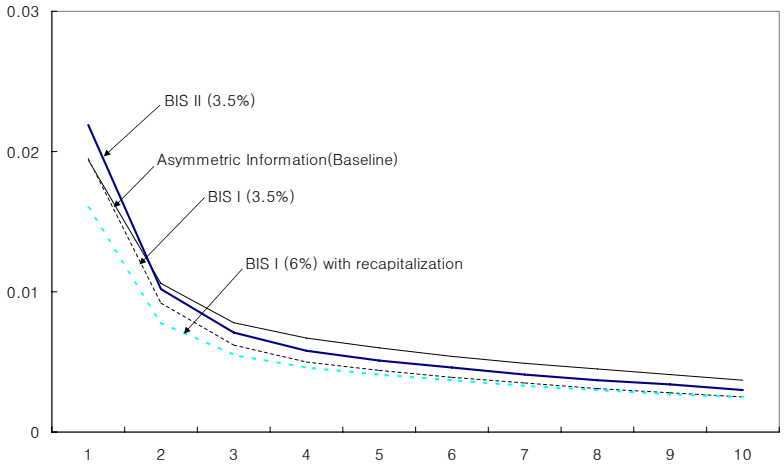
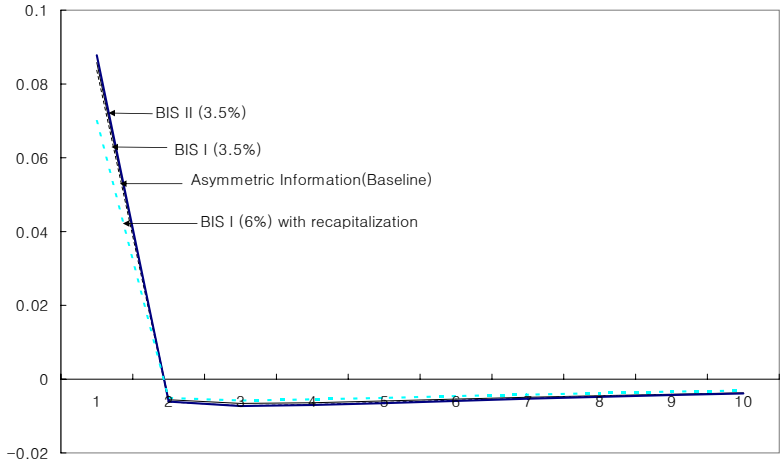


Figure 8: Impulse Response of Asset Price to Unexpected 25bp Interest Rate Cut



talized with borrowed funds. Note, however, that if bankers can borrow from outside, the output fluctuations are dampened. This is due to the assumption that bankers can borrow the funds at the market price of funds. As can be seen from Equation (32), the price of this external funds is the shadow price of income. This is as odds with the assumption of asymmetric information. However, since it is assumed that deposits are pooled to earn the market interest rate, it is not too unrealistic to assume that bank capital too can be somehow pooled and earn market return for equity. In this model a risk premium is nonexistent so the return for deposits should be the same as the return for equity.

It is in line with the conventional wisdom that the Basel II regulation does add to the procyclicality of bank capital. However, the reason that the additional effect is so small is that any added effects due to the new regulation are absorbed by the variable consumption ratio for bankers.

The response of loans and the asset price are similar to the response of output. (See Figures 7 and 8)

5 Conclusions

The introduction of the Basel II capital adequacy requirement raises many questions including if and how the regulation would affect the transmission of monetary policy. One of the concerns is that the new regulation, which is believed to be sensitive to the business cycle, may amplify the business cycle even further than the old Basel I regulation does. In order to address this concern I combine two very standard modeling strategies. The banking sector exits due to the information asymmetry and monetary policy is effective due to sticky prices. With this model as a baseline, different regulatory frameworks are compared. The result shows that what matters is the

information asymmetry not the regulation. Thus the new regulation would add little, if any, to the existing effect of amplifying business cycle under the old regulation. This is somewhat against the conventional wisdom that the Basel II would create a larger procyclicality than the Basel I. However, what the conventional wisdom misses is the fact that the bank capital can be adjusted from internal or external funding sources. If this possibility is allowed, the additional amplifying effect is mitigated.

In this paper bank capital is endogenized in such a way that there is no shirking by both entrepreneurs and bankers in equilibrium . In reality, however, banks always try to avoid capital charge. That is, the capital adequacy requirements, as much as other regulatory measures, exist due to the fact that banks (want to) hold less than socially optimal level of capital. This may be because the deposit insurance, which is established to prevent bank run, give bankers an incentive to hold less capital than they otherwise would. This is a non-trivial element not to be ignored. It will be very interesting to see how the inclusion of the deposit insurance, as a factor that affects bankers decision on capital holding, would change the results of this paper.

In addition, some of the ad-hoc elements of this paper should be refined in the future research. First, the decision making process of bank recapitalization should be modeled in a more coherent way. Second, since the model is linear, it is unable to answer questions such as how risks affect the behaviors of entrepreneurs and bankers. In order to investigate the macro implication of the Basel II coherently, the risk should be modeled explicitly. And last, more empirical studies beyond matching the steady state are needed.

Appendix: Steady state for the baseline model

$$
\begin{aligned}
R^D &= \frac{1}{\beta}, && (36)\\
R_t^N &= \frac{1}{\beta}, && (37)\\
\psi &= \frac{\epsilon-1}{\epsilon}, && (38)\\
\frac{i}{k} &= [\frac{\delta}{(1-\delta)^{1-\phi}}]^{\frac{1}{\phi}}, && (39)\\
q &= \frac{1}{\mu\phi}(1-\delta)^{1-\phi}(\frac{i}{k})^{1-\phi}, && (40)\\
\frac{w}{k} &= \pi^e p_H \frac{b}{\Delta p} + \frac{e^e}{k}, && (41)\\
\frac{a}{k} &= \pi^B p_H \frac{c}{\Delta p} + \frac{e^B}{k}, && (42)\\
\frac{d}{k} &= q - \frac{w}{k} - \frac{a}{k} + c, && (43)\\
f &= \frac{1}{p_H}(R^D \frac{d}{k}) + \frac{c}{\Delta p}, && (44)\\
\frac{l}{k} &= \frac{a}{k} + \frac{d}{k} - c, && (45)\\
\nu &= \frac{1}{r}(f - (1-\delta)q + \frac{b}{\Delta p}), && (46)\\
\frac{c^e}{k} &= (1-\pi^e)p_H \frac{b}{\Delta p}, && (47)\\
\frac{c^B}{k} &= (1-\pi^B)p_H \frac{c}{\Delta p}, && (48)\\
\frac{k}{n} &= \frac{1}{rp_H}(\frac{\nu}{\alpha\psi})^{\frac{1}{\alpha-1}}, && (49)\\
\frac{y}{k} &= (rp_H)^{\alpha}(\frac{k}{n})^{\alpha-1}, && (50)\\
R^B &= \frac{c}{\Delta p f}, && (51)\\
\frac{c^H}{k} &= \frac{y}{k} + \frac{e^e}{k} + \frac{e^B}{k} - \frac{c^e}{k} - \frac{c^B}{k} - \frac{i}{k} - c. && (52)
\end{aligned}
$$

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< Abstract in Korean >

김준한*

은행자기자본규제는 은행자기자본을 대출의 일정비율 이상으로 유지토록 함으로써 대출의 부실화가 은행 건전성 저하로 이어지는 것을 방지하기 위하여 도입되었다. 그러나 동 규제가 경기의 변동성을 확대할 가능성이 있으며, 특히 최근 도입된 Basel II의 경우 이러한 현상이 더욱 심화될 것이라는 주장도 일부에서 제기되고 있다. 본고에서는 은행자기자본의 존재가 통화정책의 파급경로에 미치는 영향을 분석함으로써 은행자기자본규제와 경기변동성 간의 관계를 살펴보았다.

분석결과 기존제도(Basel I)하에서는 규제가 없는 경우에 비하여 콜금리가 생산에 미치는 영향이 다소 확대되었으나 그 확대폭은 미미한 것으로 나타났으며 금년 중 시행되는 Basel II의 경우에도 동 영향이 Basel I의 경우에 비하여 소폭 확대되는 데 그쳤다. 이는 은행자기자본의 경기변동성 확대효과가 규제대상 자기자본의 경우 뿐만아니라 은행이 자발적으로 보유하는 자기자본의 경우에도 거의 동일하게 나타나기 때문이다.

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