Macroeconomic Stabilization Effect of Countercyclical Macroprudential Policy: A DSGE Approach

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Abstract

This paper builds a new Keynesian DSGE model with price rigidity to investigate the effect of countercyclical credit regulation policy on macroeconomic volatilities. To do so, a risk-loving behavior of the financial intermediaries is introduced which creates the procyclical credit supplies, and two types of macroprudential policies which can directly control for the financial procyclicality by requiring the higher capital-asset ratio of banks and limiting the loan-to-asset ratio of borrowers. As a result, high level of the macroprudential policies along with the conventional type of monetary policy can improve the social welfare, which is estimated as a quadratic welfare loss function of macroeconomic variances, when there are positive housing market shock or positive monetary shock. But the stabilization effect is not clear when there is a positive productivity shock. This result can be interpreted that the countercyclical financial regulation can be effective as a macroeconomic stabilization policy against some financial shocks, when it is mixed with the conventional monetary policy.

Keywords: Macroprudential Policy; Monetary Policy; Business Cycles; Financial Stabilization; Countercyclical Capital Buffer.

JEL Classification Numbers: E32, E44, E58

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1 Introduction

Motivation and Main Findings **?** Aftermath of 2008 global financial crisis have not only induced prolonged economic recovery(so-called a debate on "secular stagnation"), but also provided a chance to invent new economic policies to prevent another systemic financial crisis. One of the newly introduced policy is a countercyclical capital buffer(CCyB, hereafter), one of the macroprudential policies which were adopted by Basel III in 2016. The main purpose of CCyB is to protect banking industry from a systemic risk, by enforcing each bank to stack up higher capital-asset ratio, and thus alleviate procyclicality of banking industry that has been pointed out as a main causality of the recent global financial crisis.

The bank's procyclicality problem has been main issue among the banking regulators in recent years after the 2008 crisis, but it has been also rapidly growing part of discussion in the related academic literature, such as central banking or financial stabilization. CCyB has been drawn an interest from many scholars in those fields for its unique characteristic in policy focus and mechanism, which separates itself from the conventional monetary policies. While CCyB detects the procyclical patterns of banking industry as a whole in a country by observing Credit-to-GDP gap as a main indicator, and controls for the credit-to-asset ratio to control the overall credit level in the economy to fix the possible procyclical behavior of the banking industry, it also can possibly affect on real business cycles through so-called "credit channel," which would make changes in credit availability and asset values of economic agents. Interactions between monetary policy and macroprudential policy has been another important part of discussion in the literature, because for the credit channel effect, the CCyB can alter the trade-off between faced by monetary policy authority. As **?** empirically pointed out, the interactions between conventional monetary policy and the new type macroprudential policy attains more serious attention when credit expansion(expansionary financial cycle) and economic recession(contractionary business cycle) coincidentally happen. In this special economic event, central bank's dilemma on financial and economic stabilization can be deepened without consideration of CCyB or the other countercyclical capital requirement policy.

In this regard, this paper builds a New Keynesian Dynamic Stochastic General Equilibrium(DSGE, hereafter) model to answer the following research questions. First, is there any stabilization effect of the special type of macroprudential policy, CCyB in this case, along with Loan-to-Value(LTV, hereafter) regulation on total available loan values, on financial cycles as well as business cycles when different types of exogenous shocks come to the economy? Second, is there any welfare-improving effect of the possible combination of these two policies? To find an answer, a risk-loving behavior of the financial intermediaries is introduced in the model which creates the procyclical credit supplies from that side, and three types of macroprudential policies which can directly control for the financial supplies and demands by curbing the capital-asset ratio of banks or loan-to-asset ratio of borrowers. As a result, high level of the macroprudential policies with the conventional type of monetary policy can improve the social welfare, which is estimated as a quadratic form of macroeconomic variances, when there are positive housing market shock or positive monetary shock, but the stabilization effect is not clear when there is a positive productivity shock. This result can be interpreted that the countercyclical financial regulation can be effective as a stabilization policy, when it is mixed with the conventional monetary policy.

Statistical Sketch In this paper, I use South Korean macroeconomic and financial data for the empirical part of the analysis for two reasons. First, historically, credit-to-GDP gap, the main(official) indicator for CCyB activation, has been functioning as a good early warning indicator for economic crises. As shown in Figure 1[1], there have been three times of significant economic crises in South Korea - 1998, 2003, and 2008 - and credit-to-GDP gap was rapidly increased at the beginning stage of each crisis. This was the combined result of excessive credit expansion and sudden GDP growth decrease at the same time. The historical performance of the variable draws one interesting question: if CCyB were to be activated before these three economic crises, would the macroeconomic conditions be better off? Second, South Korean credit-to-GDP gap after 2009 suggests there have been de-coupling trend between credit growth and GDP growth in this country. From 1993 to 2008, the correlation coefficient between credit growth rate and GDP growth rate in South Korea is -0.09, but after 2008 to the 3rd quarter in 2018, the correlation coefficient is increased

[1]All quarterly data sources are obtained from the homepage of the Bank of Korea. GDP data is collected from seasonally adjusted, current priced national expenditures. National credit is defined by sum of securities, loans, and government loans in non-financial corporations and households and NPISHs sectors, following the definition of Bank of International Settlements.

to -0.33. Despite it is still ambiguous to determine a clear path of the relationship, it is safer to say that the directions of two variables has tended to be more in opposite ways after 2009. In this macroeconomic circumstance, the dilemma a central bank encounters gets more serious. Overall credit-to-GDP ratio has been the biggest level in every quarter since 2014, but the growth rate of the variable has been slower than the previous before-crisis time, which keeps the gap level at very low level around zero. The policy mix discussion could be helpful to solve the complexity of this puzzle.

Structure of the Paper The remaining of the paper is organized as follows. Section 2 briefly discusses about the past related literature. Section 3 explains the model in detail, and section 4 shows some preliminary simulation results with very rough parameterization. Section 5 concludes.

2 Literature Review

After Basel III introduced some countercyclical financial regulation rules in 2016, here have been rich volume of literature on the related academic issues. This paper relies on three aspects of the macroprudential policy issue: macroeconomic effects of the countercyclical type of banking regulation, interactions between inflation-targeting monetary policy and countercyclical type macroprudential policy, and the relation between the two policies and housing market volatilities.

First, searching an optimal level of countercyclical macroprudential policy has gathered more interests in macroeconomic stabilization policy discussion, since 2008 global financial crisis called the alarm of the another systemic risk possibility which would be caused by the procyclical behavior of the banking industry. Once the problem is tried to be solved in a DSGE fashion, a limited collateral constraint is a usual form for the financial friction. **?** introduces credit and banking sectors in a DSGE model with collateralized loans issued by banks, and discovers that banks' capital-to-asset ratio can make an impact on loan margins under interest rates stickiness conditions. This financial environment can attenuate the effect of monetary policy, according to the paper. Another work to seek for the optimal capital requirement in the Euro area is **?**, which argues that the Basel III type higher capital requirement would benefit both borrowers and savers in some degree. **?** finds the optimal time-consistent(state-contingent) macroprudential debt tax in which a collateral constraint is introduced in its DSGE model as a pecuniary externality.

Another important issue related to this paper is an interaction between monetary and macroprudential policy makers. This part of the literature has been rapidly developing since **?** introduced a kind of financial regulation on banking sector as an "unconvential" monetary policy. A dynamic game between these two policy authorities and in which each part seeks its own optimal policy rule is a usual form for the governance issue in a DSGE model. **?** carefully builds a DSGE model with countercyclical banks' capital regulation and sees the combined effect with the inflation-targeting monetary policy. Some papers agree with the argument of **?**, which points out that the combined effect with loan-to-value ratio regulation or direct capital regulation has a merit on stabilizing economic volatility. **?** is one of the efforts to find the similar result empirically, and so is **?** in its seminal theoretical approach. **?** argues that if there exists a moral hazard problem in a financing investment process, the conventional monetary policy is not enough to fully stabilize the economy. Rather, the policy mix can attenuate the trade-off faced by the policy makers. **?** picks a leverage tax as a countercyclical macroprudential policy to show how the policy mix can improve macroeconomic welfare in DSGE analysis.

The last important aspect of the paper is the effect of housing market volatility on the macroeconomic dynamics and the interaction with the macroprudential policies. Because of the statistical evidence from the South Korean economy, which points out that relatively large portion of the economy's financial asset is heavily relied on the housing market, the paper seriously considers the housing goods consumption in the model and assumes that the part of the consumption should be financed by the financial intermediation, which can possibly affected by collateral constraints and banks' capital requirement. **?** is a seminal work on housing price dynamics and its impact on macroeconomic fluctuations. The paper captures the reality of the co-movement between land prices and business investment, which is pointed out as a main driver for the macroeconomic volatilities. Another canonical theoretical paper on housing market and monetary policy in a DSGE fashoin is **?**, which consider a collateral effect of the household's debt to finance the housing consumption as a potential contibutor to the economic volatility. **?** empirically studies about Finnish households-level data to find the effect of forecasting errors on the level of excessive debt and possible problems due to it. **?** empirically investigates an effect of the over-borrowing trend of households on the monetary policy transmission procedures. The paper cites that high level of household debt weakens the monetary policy effectiveness from the U.S. data.

3 Model

To observe the stabilization effect of a special case of macroprudential policies on financial and business cycles, this paper builds a new Keynesian DSGE model with price rigidity. Based on **?** and **?**, which provide a canonical baseline model for the analysis on a traditional inflation targeting monetary policy, I combine banking sector with it, following **?** and **?**, which create a market imperfection in their models driven from the information asymmetry between financial intermediaries and financial consumers. Finally, considering about a special case of South Korean economy, which is highly sensitive to a real estate market volatility which takes large portion of the overall financial market, I adopt a part of the model of **?** and **?**, which assume the strong relationship between the housing market volatility and macroeconomic activities.

The model consists of four sectors: Households(saver and borrower), banks(financial intermediaries), firms(entrepreneur and retailer), and policy authorities(monetary and macroprudential policy makers). Households in general consume final goods and real estates and provide unit of labour. Saver, one part of households, deposits money in banks and purchases risk-free securities from them. Borrower, another part of households, borrows money from banks but cannot buy or sell securities. A bank borrows from saver and lends to borrowing households and entrepreneur to maximize its present-value of net asset. Firms make goods in two stages. Entrepreneur borrows capital from banks and buys labour from households to produce a slightly differentiated intermediate good in a monopolistically competitive market. Retailer buys the intermediate goods from entrepreneurs and aggregates them to sell a final good as a bundle. This final good producer is introduced for price stickiness in the economy. A monetary policy authority seeks a conventional Taylor-rule type inflation targeting interest rate control, and a macroprudential policy authority sets a countercyclical capital requirement on each bank based on credit-to-GDP gap observation.

3.1 Households

There are two types of household, $j \in \{s, o\}$, the saving household, s, and the borrowing household, o. The type of the household is assumed to be continued permanently, and the time discounting factor for a type o, β_o is assumed to be larger than that of a type s, β_s for all time horizon, which implies that the borrower prefers the present time more than the saver does. The two types of household share the same utility function, but differ in budget constraints. They consume an amount of final goods, $C_{j,t}$, real estate, $H_{j,t}$, and leisure, expressed as labour supply, $L_{j,t}$, subject to their own budget constraint and time discounting factor, $0 < \beta_{j,t} < 1$.

$$U(C_{j,t}, H_{j,t+1}, L_{j,t}) = E_t \sum_{t=0}^{\infty} \beta_j^t \left[\frac{C_{j,t}^{1-\sigma}}{1-\sigma} + \xi_{h,t} \frac{H_{j,t+1}^{1-\nu}}{1-\nu} - \frac{L_{j,t}^{1+\psi}}{1+\psi} \right] \tag{1}$$

where E_t is an expectation operator, σ stands for an inverse of the inter-temporal elasticity of substitution between final good consumptions, ν stands for an inverse of the inter-temporal elasticity of substitution between housing good consumptions, and ψ is an inverse of Frisch elasticity of labour supply. $\xi_{h,t}$ is a housing market specific exogenous shock, which captures the relative importance of a household's utility on consuming housing good, specified as following AR(1) process:

$$\log \xi_{h,t} = \rho_h \log \xi_{h,t-1} + \epsilon_{h,t}$$

where $\epsilon_{h,t} \sim N(0, \delta_{h,t}^2)$.

Saver Saving household buys risk-free securities,$B_{s,t+1}$ from state-contingent bond market, receives a fixed level of interest, $R_{b,t}$ in the next period, and also receives a fixed level of wage income, W_t for providing perfectly inelastic labour supply, $L_{s,t}$. In addition, she saves deposit $D_{s,t}$ in a bank and receives $R_{d,t}$. With this regard, a budget constraint of the saving agent is defined by

$$P_{c,t}C_{s,t}+\frac{1}{\kappa_t}E_tB_{s,t+1}+P_{h,t}(E_tH_{s,t+1}-(1-\delta)H_{s,t})+(1+\Omega_{s,t})E_tD_{s,t+1} \leq W_tL_{s,t}+R_{b,t}B_{s,t}+R_{d,t}D_{s,t}+T_{s,t}+\Xi_{s,t} \tag{2}$$

where $P_{c,t}$ and $P_{h,t}$ are nominal prices for a final good and a housing good, respectively, $T_{j,t}$ is a tax or transfer for type j levied from government, $\Xi_{j,t}$ is a profits from firms, and δ is defined as a depreciation rate of a housing good. There are two kinds of market imperfections in equation (2). First, κ_t represents for a degree of dynamically changing risk appetite. A propensity to buy a risk-free asset, $B_{j,t}$, is affected by business cycles, as following equation:

$$\kappa_t = \left(\frac{Y_t}{Y}\right)^{-\eta_\kappa} \tag{3}$$

where Y_t is defined by GDP and Y is a steady-state value of Y_t. According to equation (3), assuming that η_κ is smaller than zero, in good times($Y_t > Y$) a relative price for the safe asset is decreased, and a bank can finance more deposits with lower cost. Second, the saving agent pays a certain level of monitoring cost, $(1 + \Omega_{s,t})$, and this cost is assumed to be affected by a prudential condition of the bank's capital. In other words, the better the capital-asset ratio a bank has, the lower interest the bank should pay for and the more deposits the bank can attract as following equation:

$$1+\Omega_{s,t} = \chi_{\Omega 1}\left(\frac{\gamma_t[\omega_{o,t}E_tM_{o,t+1}+\omega_{e,t}M_{e,t+1}]}{V_t}\right)^{\chi_{\Omega 2}}(\gamma_t)^{\chi_{\Omega 3}-\chi_{\Omega 2}} \tag{4}$$

where $M_{o,t+1}$ and $M_{e,t+1}$ are amounts of loans a bank provides to borrowing agents and entrepreneur, respectively, $\omega_{o,t}$ and $\omega_{e,t}$ are regulatory risk weights on each type of borrowers, V_t is a nominal value of the bank's net asset, and γ_t stands for an inverse of the required capital-asset ratio decided by macroprudential policy authority. According to this assumption, the monitoring cost is directly affected by the required capital-asset ratio, and the level of the cost makes an impact on the spread between deposit and risk-free asset return rates. A saving household chooses a set of $\{C_{s,t}, H_{s,t+1}, L_{s,t}, B_{s,t+1}, D_{s,t+1}\}$ to maximize utility function (1) subject to the budget constraint (2), (3), and (4). The first order conditions are derived as following equations:

$$1 = E_t\left[\beta_sR_{b,t+1}\kappa_t\left(\frac{C_{s,t+1}}{C_{s,t}}\right)^{-\sigma}\Pi_{c,t+1}^{-1}\right] \tag{5}$$

$$L_{s,t}^{\psi}C_{s,t}^{\sigma} = \frac{W_t}{P_{c,t}} \tag{6}$$

$$H_{s,t+1} = E_t\left[\frac{1}{\xi_{h,t}}\left(\frac{P_{h,t}}{P_{c,t}}C_{s,t}^{-\sigma}-\beta_s(1-\delta_h)\frac{P_{h,t+1}}{P_{c,t+1}}C_{s,t+1}^{-\sigma}\right)\right]^{-\frac{1}{\nu}} \tag{7}$$

$$(1+\Omega_{s,t}) = \frac{1}{\kappa_t}E_t\left(\frac{R_{d,t+1}}{R_{b,t+1}}\right) \tag{8}$$

where $\Pi_{c,t+1} = \frac{P_{c,t+1}}{P_{c,t}}$ is an inflation rate from period t to $t+1$. Equation (5) represents a standard version of Euler equation in this economy. A special case in this economy is captured by κ_t on the right hand side, which creates an additional marginal cost for consuming one more unit of final good in a present time. Equation (6) represents a real wage income, or a labour supply curve in an equilibrium. Equation (7) implies an equilibrium level of housing goods consumed by the saver. The optimal level of housing good consumption is determined by relative price and the depreciation rate of the housing good, an exogenous shock to the housing sector, and inter-temporal final goods consumption changes. Demand for current housing goods is increased as the relative price of housing decreases, consumption for final goods decreases, or depreciation rate get lower. Finally, equation (8) determines the spread between deposit and risk-free asset return rates. If there is no economic friction, the spread should be zero, but the two economic imperfections in the model creates a certain level of gaps between these two rates.

Borrower Borrowing household takes out an amount of loan, $M_{o,t}$, from banks and pays loan interest, $R_{o,t}$, and consumes final and housing goods. He does not have an accessibility to the security market, and does not have any right on firm's profits. The borrower's budget constraint is defined as follows:

$$P_{c,t}C_{o,t} + P_{h,t}(H_{o,t+1} - (1-\delta)H_{o,t}) + R_{o,t}M_{o,t} \leq W_t L_{o,t} + M_{o,t+1} + T_{o,t} \tag{9}$$

In addition, the borrower faces the following collateral constraint:

$$M_{o,t+1} \leq m_{o,t}\left[\frac{P_{h,t}H_{o,t+1}}{R_{o,t}}\right] \tag{10}$$

where $m_{o,t}$ stands for Loan-to-Value ratio(LTV, hereafter), determined by the macroprudential authority. The borrowing household chooses a set of $\{C_{o,t}, L_{o,t}, H_{o,t+1}, M_{o,t+1}\}$ to maximize the utility function (1) subject to budget and collateral constraints (9) and (10). The first order conditions are derived by:

$$1 = \lambda_{2o,t}\frac{P_{c,t}}{C_{o,t}^{-\sigma}} + E_t\left[\beta_o R_{o,t+1}\left(\frac{C_{o,t+1}}{C_{o,t}}\right)^{-\sigma}\Pi_{c,t+1}^{-1}\right] \tag{11}$$

$$L_{o,t}^{\psi}C_{o,t}^{\sigma} = \frac{W_t}{P_{c,t}} \tag{12}$$

$$H_{o,t+1} = E_t\left[\frac{1}{\xi_{h,t}}\left(\frac{P_{h,t}}{P_{c,t}}C_{o,t}^{-\sigma}\left(1-\frac{m_{o,t}}{R_{o,t+1}}\right) - \beta_o R_{o,t+1}\frac{P_{h,t+1}}{P_{c,t+1}}C_{o,t+1}^{-\sigma}((1-\delta_h) - \frac{m_{o,t}}{R_{o,t+1}})\right)\right]^{-\frac{1}{\nu}} \tag{13}$$

Equation (11) is a varied version of Euler equation for the borrower. $\lambda_{2o,t}$ is a shadow price of the collateral constraint, (10), implying the marginal cost for increasing one unit of loan at time t. According to (11), the borrower's marginal cost for increasing one unit of loan at time t equals to the sum of the shadow cost for borrowing cost expressed in terms of current value of consumption and the expected future income weighted by loan rate. Equation (12) is the equilibrium level of labour income for the borrower, and equation (13) represents an equilibrium level of housing consumption for the borrowing household. The main departure from (7) is that, the borrowing agents are affected by the regulatory variables $m_{o,t}$ and loan rate $R_{o,t+1}$.

3.2 Financial Intermediaries

A bank, or a financial intermediary, pays dividends and deposit interest to households and collects loan interests from borrowing household and entrepreneur. The cash flow of a bank is defined by

$$R_{s,t}D_{s,t}^b + (1+\Omega_{o,t})Q_{o,t}M_{o,t}^b + (1+\Omega_{e,t})Q_{e,t}M_{e,t+1}^b \leq R_{o,t}M_{o,t}^b + R_{e,t}M_{e,t}^b + D_{s,t+1}^b \tag{14}$$

where $Q_{o,t}$ and $Q_{e,t}$ are the present value of loans made to the borrowing households and entrepreneurs, respectively, the superscription b denotes the demand from banks on each variable. For instance, $M_{o,t+1}^b$ implies the amount of bank's willingness to lend to borrowing households. There are two types of monitoring costs, one against borrowing households, and the other against the entrepreneurs:

$$1 + \Omega_{o,t} = \chi_{o1} \left(\frac{(1 - m_{o,t}) P_{h,t} H_{o,t}}{P_{h,t} H_{o,t} - M_{o,t}} \right)^{\chi_{o2}} \quad (15)$$

$$1 + \Omega_{e,t} = \chi_{e1} \left(\frac{(1 - m_{e,t}) P_{e,t} Y_{e,t}}{P_{e,t} Y_{e,t} - M_{e,t}} \right)^{\chi_{e2}} \quad (16)$$

where $m_{o,t}$ and $m_{e,t}$ denote regulatory LTV ratios on the borrowing households and entrepreneurs, respectively, $P_{e,t}$ and $Y_{e,t}$ are the price and the amount of intermediate goods produced at time t, respectively. According to (15) and (16), assuming that χ_{o2} and χ_{e2}, the elasticities of the frictional costs, are smaller than zero, the additional cost created from the market imperfection, the information asymmetries between financial agents in this case, is decreased as the macroprudential authority decreases the LTV ratio. In other words, the LTV ratio, one of the macroprudential policies introduced in the model, directly affects the degree of informational asymmetry problems between banks and the financial consumers by controlling the absolute amount of loan availabilities on each borrowers which are estimated by the current net value of housing good(for borrowing households) or the current net value of the intermediate goods. A bank's balance sheet is defined by

$$Q_{o,t} M^b_{o,t+1} + Q_{e,t} M^b_{e,t+1} = D^b_{s,t+1} + V_t \quad (17)$$

where V_t is a net asset of the bank. The bank chooses a set of $\{M^b_{o,t+1}, M^b_{e,t+1}, D^b_{s,t+1}\}$ to maximize the current value of the net asset, which is defined by

$$E_t \sum_{t=0}^{\infty} \beta_b^t \Lambda_{t,t+1} V_t \quad (18)$$

where $\Lambda_{t,t+1} = \beta_s \frac{C_{s,t+1} P_{c,t}}{C_{s,t} P_{c,t+1}}$, a time discounting factor. The first order conditions for the bank are:

$$Q_{o,t} = \frac{R_{o,t+1} \Lambda_{t,t+1}}{\{R_{o,t+1} - (R_{s,t+1})(1 + \Omega_{o,t})\} \Lambda_{t,t+1} + (R_{s,t+1})(1 + \Omega_{o,t})^2} \quad (19)$$

$$Q_{e,t} = \frac{R_{e,t+1} \Lambda_{t,t+1}}{\{R_{e,t+1} - (R_{s,t+1})(1 + \Omega_{e,t})\} \Lambda_{t,t+1} + (R_{s,t+1})(1 + \Omega_{e,t})^2} \quad (20)$$

Equations (19) and (20) represent the present values of loans made to two types of borrowing agents at the equilibrium. The higher the current values of loans, the higher the monitoring costs, the higher the loan rates, the higher the weights on the future consumptions.

3.3 Firms

Production sector consists of two stages, an entrepreneur who produces an intermediate good and a retailer who aggregates intermediate goods to sell a final good to households. The intermediate good producer finances money from banks to pay income wages to households, who provide labour supplies which are loan production factor in the entrepreneur's production process. The retailer uses intermediate goods to produce a final good. The **?** type price stickiness is introduced in the final good production process, which enables money -non-neutrality in the model.

Entrepreneur A part of labour cost the intermediate good producer should pay to households is financed by the loan from banks. He also participates in the risk-free asset market to sell or buy securities with the fixed interest $R_{b,t}$. Similar to the borrowing consumer's problem, the entrepreneur faces collateral constraint on his loan volume:

$$M_{e,t+1} \leq m_{e,t}\Big[\frac{P_{e,t}Y_{e,t}}{R_{e,t+1}}\Big] \tag{21}$$

where $m_{e,t}$ is a regulatory variable which relates the total volume of loan to the part of present value of the intermediate good. The production function follows Cobb-Douglass form, using labour only:

$$Y_{e,t} = \xi_{e,t}(N_t)^{1-\alpha} \tag{22}$$

where N_t is a labour demanded, which can be specified by $N_t = (N_{s,t})^{\varsigma}(N_{o,t})^{1-\varsigma}$ and $0 < \varsigma < 1$. $\xi_{e,t}$ is an exogenous productivity shock to the intermediate goods sector, which follows stochastic AR(1) process:

$$\log \xi_{e,t} = \rho_e \log \xi_{e,t} + \epsilon_{e,t} \tag{23}$$

and $\epsilon_{e,t} \sim N(0, \delta_{e,t}^2)$. In cash flows of the entrepreneur, total expenditure, the sum of interest payment for total loan, nominal value of labour income, and purchasing value of risk-free asset, is less than or equal to the total revenue, the sum of nominal value of intermediate good productions, interest on the risk-free asset purchase and monetary loan from the bank.

$$R_{e,t}M_{e,t} + W_tN_t + E_{t+1}B_{e,t+1} \leq P_{e,t}Y_{e,t} + R_tB_{e,t} + E_tM_{e,t+1} \tag{24}$$

where $B_{e,t}$ means the nominal value of securities the entrepreneur buys at time t. The intermediate good producer chooses a set of $\{L_{s,t}^e, L_{o,t}^e, M_{e,t+1}, B_{e,t+1}\}$ to maximize the cash flow, (24), subject to (20), (21), and (22). The first order condition of the maximization problem is derived by

$$N_t^e = E_t\left[\beta_e(1-\alpha)\xi_{e,t}\Big(\frac{W_t}{P_{e,t}}\Big)^{-1}\Big(\frac{P_{e,t}}{P_{c,t}}\Big)\Big(1 + m_{e,t}\Big(1 - \frac{R_{b,t+1}}{R_{e,t+1}}\Big)\Big)\right]^{\frac{1}{\alpha}} \tag{25}$$

The above equation depicts the entrepreneur's labour demand function. He demands more units of labour as the real wage is lowered, the available loan value is increased, the loan rates is lowered, or the rate of return on the risk-free asset is increased. In this model, the entrepreneur utilizes the loan from banks to pay for the labour cost, and the current value of total available loan is negatively affected by the loan rate, according to (20). Therefore, by combining equation (20) with (21), one can derive the relationship the labour demand and the loan rate in this sector. If there is no informational friction between banks and the entrepreneur, the loan rate and the risk-free asset rate will be identical, and thus the labour demand function (25) will be reduced to

$$N_t^e = \left[\beta_e(1-\alpha)\xi_{e,t}\Big(\frac{W_t}{P_{c,t}}\Big)^{-1}\Big(\frac{P_{e,t}}{P_{c,t}}\Big)\right]^{\frac{1}{\alpha}} \tag{26}$$

Retailer The retailer, or the final good producer, buys the intermediate good from the entrepreneur and sell it to the households after the following aggregation(separation) process:

$$Y_t = \left(\int_0^1 Y_t(z)^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}} \tag{27}$$

The separated good z is traded in a monopolistically competitive market with an elasticity of intra-temporal substitution $\phi > 0$. Adopting the staggered price assumption from **?** and **?**, prices of a portion θ of the final goods cannot be flexibly adjusted(i.e., θ is a measurement for price stickiness in the market), and thus a retailer selling good z chooses a price $P_{c,t}(z)$ to maximize the present value of the profit, defined by

$$E_t\sum_{\tau=0}^{\infty}\theta^{\tau}\beta_e^{\tau}\Lambda_{t,t+1}\left[\frac{P_{c,t}(z)}{P_{c,t+\tau}}Y_{t+\tau}(z) - \frac{MC_{e,t+\tau}}{P_{c,t+\tau}}Y_{t+\tau}(z)\right] \tag{28}$$

where $MC_{e,t+\tau}$ is a marginal cost to produce one unit of the intermediate good. Since this problem is symmetric for all z, one can drop the z notation. Defining $P^*_{c,t}$ be an equilibrium price of the problem, the first order condition is derived by

$$E_t \sum_{\tau=0}^{\infty} \theta^\tau \beta_e^\tau \Lambda_{t,t+1} \left(P^*_{c,t} + \frac{\theta}{1-\theta} MC_{e,t+\tau} \right) P^{\theta-1}_{c,t+\tau} Y_{t+\tau} = 0 \tag{29}$$

Arranging (29) to derive the overall final goods price level(CPI), one can get:

$$P_{c,t} = \left[(1-\theta) {P^*_{c,t}}^{1-\theta} + \theta {P_{c,t}}^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{30}$$

3.4 Policy Authorities

The policy authorities in this model consists of two parts. A monetary policy maker who sets an interest rate. In this model, for the simplicity of the analysis, is assumed that the monetary authority determines $R_{b,t}$, the risk-free asset rate of return. The other part of the policy makers, a macroprudential authority, sets capital-asset ratio of a bank, $\gamma_{t,}$, and the mortgage rates for two types of borrowers, $m_{o,t}$ and $m_{e,t}$. One can imagine one more macroeconomic policy part, a fiscal authority who can levy taxes and distribute them in a lump-sum fashion, but assuming a balanced fiscal policy for every period, the following equation induces the non-effectiveness of the fiscal policy on a macroeconomic activities:

$$T_{s,t} + T_{o,t} + R_{b,t}(B_{s,t} + Be, t) = B_{s,t+1} + B_{e,t+1} \tag{31}$$

Monetary Policy A monetary policy authority determines $R_{b,t}$ based on the following Taylor-rule type process

$$\log R_{b,t} = \omega_{cb} \log R_{b,t-1} + (1-\omega_{cb}) \left[\log R_b + \kappa_\pi \frac{\Pi_t}{\Pi} + \kappa_y \frac{Y_t}{Y} \right] + \xi_{cb,t} \tag{32}$$

where R_b is a steady-state value of $R_{b,t}$, ω_{cb} captures how much the current base interest rate is affected by the past rates. As **?** points out, this coefficient reflects the interest rate inertia of the monetary policy authority. κ_π and κ_y are the regulatory coefficients which indicate a relative weight on inflation gap and output gap. $\xi_{cb,t}$ is an exogenous monetary shock, which reflects an effect of a possible discretionary decision by the monetary authority, and follows AR(1) stochastic process:

$$\log \xi_{cb,t} = \rho_{cb} \log \xi_{cb,t-1} + \epsilon_{cb,t} \tag{33}$$

where $\epsilon_{cb,t} \sim N(0, \delta^2_{cb,t})$.

Macroprudential Policy Macroprudential authority supervises a banking industry, having two policy options: banks; capital-asset ratio control and borrowers' mortgage ratio control. A main assumption that enables the banking supervisor's policy effective is that business cycles and the financial industry's risk appetite is correlated. The goal of the policy maker is to minimize the procyclicality of the banking industry which can possibly creates excessive credit supplies to the economy and therefore the higher volatilities. The countercyclical policy variable is set by

$$\gamma_t = \gamma + \chi_{\gamma 1} \left(\frac{M_{t+1}/Y_t}{M/T} \right)^{\chi_{\gamma 2}} + \xi_{mp,t} \tag{34}$$

where $M_{t+1} = M_{o,t+1} + M_{e,t+1}$ and $\log \xi_{mp,t} = \rho_{mp} \log \xi_{mp,t-1} + \epsilon_{mp,t}$. M_{t+1} is defined by the overall credit supplied to the non-financial institutions and private sector. The first part of the right hand side in equation (34) implies the minimum capital requirement for each bank, represented by a steady state value. In addition to the above countercyclical capital requirement, the macroprudential policy maker also sets the countercyclical LTV ratio:

$$m_{o,t} = m_o - \chi_{\gamma 3}\left(\frac{Q_{o,t}M_{o,t}/Y_t}{Q_o M_o/Y}\right) \quad (35)$$

$$m_{e,t} = m_e - \chi_{\gamma 4}\left(\frac{Q_{e,t}M_{e,t}/Y_t}{Q_e M_e/Y}\right) \quad (36)$$

where m_o and m_e are the initial level of the requirements. According to (35) and (36), the LTV ratio for each sector should be decreased(i.e., tightening credit policy) if the second part of the right hand side, the current value of the total credit supplied divided by total output in each sector, is estimated to be excessive compared to the steady state level.

Market Clearing Conditions All markets in this economy are assumed to be cleared in each time period. The market clearing conditions for labour, securities, housing, money, and final goods markets are defined by:

$$\begin{aligned}
L_{s,t} + L_{o,t} &= N_t^e = N_t = (N_{s,t})^{\varsigma}(N_{o,t})^{1-\varsigma} && (37)\\
B_{s,t+1} + B_{e,t+1} &= R_{b,t}(B_{s,t} + B_{e,t}) && (38)\\
I_{s,t} &= H_{s,t+1} - (1 - \delta_h H_{s,t}) && (39)\\
I_{o,t} &= H_{o,t+1} - (1 - \delta_h H_{o,t}) && (40)\\
M_{o,t}^b + M_{e,t}^b &= M_t && (41)\\
C_{s,t} + C_{e,t} + I_{s,t} + I_{o,t} &= Y_t && (42)
\end{aligned}$$

4 Simulation

In this section, a result of impulse responses of macroeconomic variables at the equilibrium level to specified exogenous shocks is discussed. There are four types of exogenous shocks introduced in the model: the housing market shock, $\xi_{h,t}$, the productivity shock, $\xi_{e,t}$, the monetary policy shock, $\xi_{cb,t}$, and the macroprudential policy shock, $\xi_{mp,t}$. They are designed to be 1 per cent positive standard deviation shocks. To study the stabilization effect of two types of macroprudential policy, one can control the regulatory coefficients, which would differ the impact of the policy variables on the market imperfections and the real economic activities. Specifically, there two possibilities in the economy, low(or no) macroprudential policy($\xi_{\gamma 1} = \xi_{\gamma 3} = \xi_{\gamma 4} = 0$), or high level of macroprudential policy($\xi_{\gamma 1}, \xi_{\gamma 3}, \xi_{\gamma 4}$ are set to be a positive number such that the model has a solution). With this set up, one can see the effect of the existence of the macroprudential policy on macroeconomic variables. Moreover, one can test the combined effect of those two policies if there is no governance friction in the model. To considerately analyse the second issue, the Nash-type dynamic game between two authorities should be built, but this section considers much simplified version to see the preliminary result. Specifically, the gains from the macroeconomic policies are measured in a quadratic social welfare loss function, derived following **?**, which is defined as a weighted sum of variances of important macroeconomic variables.

4.1 Parameterization

The result of parameterization is shown in Table 1. There are several important things to note. First, I adopt important structural coefficients from **?** and **?**, which use the same baseline new Keynesian DSGE. Furthermore, coefficients related to the market imperfections and the macroprudential aspect are adopted from **?**.[2] Second, to observe the changes in equilibrium variables with the different level of the monitoring costs, some regulatory variables are set to be varied from 0 or 1 to some extents, which provides evidences on

[2]Since it is hard to find an appropriate baseline model with good South Korean calibration data, it is remained as a further study to overcome.

the effect of a monitoring cost created by informational asymmetries on macroeconomic dynamics. Third, it is natural to set bigger intertemporal elasticity of substitution of housing goods than that of final goods, since it is commonly assumed that the consumption turnover ratio on housing units is much slower than that on final goods.

4.2 Simulation Results

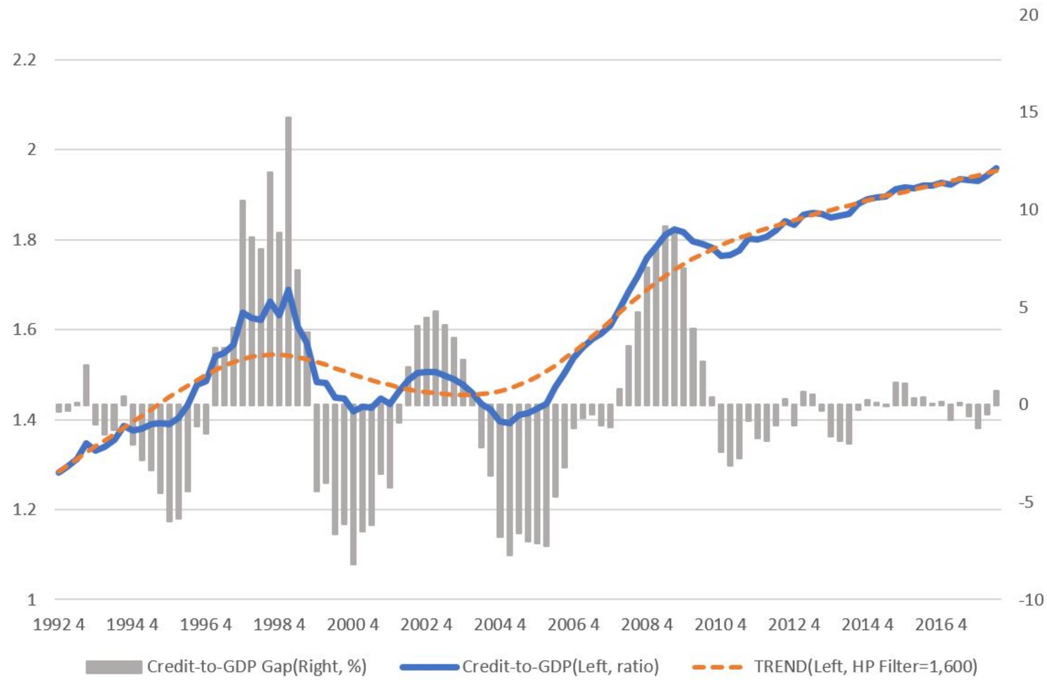
Table 2 represents overall welfare loss measured as a sum of variances of macroeconomic variables, due to the four types of exogenous shocks, when three types of macroprudential policies(CCyB and two LTVs) are operated simultaneously. Considering statistical confidence level, the stabilization effect of the combined macroprudential policies on productivity shock is not clearly found, but the volatilities of the economic variables due to the all other three shocks are reduced significantly when the stronger macroprudential policies are implemented. Tables 3 and 4 show the similar results when CCyB and LTV are separately operated(i.e., Table 3 captures the situation $\xi_{\gamma 3} = \xi_{\gamma 4} = 0$, and Table 4 captures the situation $\xi_{\gamma 1} = 0$) In all tests, it is hard to see any significant stabilization effect of a macroprudential policy under productivity shock, but it is much clearer that the countercyclical credit regulation policies have an impact on the macroeconomic fluctuations when the other types of shocks hit the economy. That said, direct credit control in a countercyclical fashion is an efficient policy option when there are financial(housing price boom) or monetary(expansionary monetary base change) factors which would possibly affect the banks' risk appetites to be more procyclical, by curbing the tendency. But is is vague to say the same argument when there is a real shock to the production sector, such as productivity shock. With the same results, the combined effect of monetary and macroprudential policies on macroeconomic stabilization seems also consistent with the previous literature. The logic behind this is that, in an expansionary phase of the economy, with the higher availability of financial asset and monetary base, the risk appetite of the financial intermediaries will exacerbates the trade-off faced by the monetary policy. But with the macroprudential policy which countercyclically contains the procyclical behavior of the banks, the trade-off could be ameliorated.

5 Conclusion

This paper builds a new Keynesian DSGE model with price rigidity to investigate the effect of countercyclical credit regulation policy on macroeconomic volatilities. To do so, a risk-loving behavior of the financial intermediaries is introduced which creates the procyclical credit supplies, and two types of macroprudential policies which can directly control for the financial procyclicality by requiring the higher capital-asset ratio of banks and limiting the loan-to-asset ratio of borrowers. As a result, high level of the macroprudential policies along with the conventional type of monetary policy can improve the social welfare, which is estimated as a quadratic welfare loss function of macroeconomic variances, when there are positive housing market shock or positive monetary shock. But the stabilization effect is not clear when there is a positive productivity shock. This result can be interpreted that the countercyclical financial regulation can be effective as a macroeconomic stabilization policy against some financial shocks, when it is mixed with the conventional monetary policy.

There are a lot of room to be improved at this stage. First, the model should be more specified. Second, the parameterization should be improved to correctly calibrate the real data. One possibility is using Bayesian technique, which derives prior-posterior estimation of the parameters. Third, the social welfare loss function should be considerately derived. **?** would be good example to follow. Fourth, the regulatory coefficient should be correctly calibrated as well.

Figure 1: Credit-to-GDP Gap in South Korea



Source: Bank of Korea

Table 1: Result of Parameterization

Parameter	Value	Explanation	Source
σ	2	Intertemporal Elasticity of Substitution of Final Goods	?
ν	8	Intertemporal Elasticity of Substitution of Housing Goods	?
ψ	5	Inverse of Frisch Income Elasticity of Labour	?
β_s	0.993	Time Discounting Factor for Saving Households	?
β_o	0.987	Time Discounting Factor for Borrowing Households	?
β_b	0.992	Time Discounting Factor for Banks	?
β_e	0.988	Time Discounting Factor for Entrepreneur	?
α	0.3	Discounting Factor in Production Function	?
ς	0.68	Share of Demand for Saving Households	?
θ	0.66	Degree of Price Stickiness	?
ϕ	11	Intra-temporal Elasticity of Substitution of Intermediate Goods	?
δ	0.011	Depreciation Rate of Housing Goods	?
η_κ	$(0,\infty)$	Regulatory Coefficient on Elasticity of Risk Appetite	
$\chi_{\Omega 1}$	$(1,\infty)$	Regulatory Coefficient on Monitoring Cost	
$\chi_{\Omega 2}$	0.002	Regulatory Coefficient on Monitoring Cost	?
$\chi_{\Omega 3}$	0.01	Regulatory Coefficient on Monitoring Cost	?
χ_{o1}	$(1,\infty)$	Regulatory Coefficient on Borrowing Households	
χ_{o2}	0.005	Regulatory Coefficient on Borrowing Households	?
χ_{e1}	$(1,\infty)$	Regulatory Coefficient on Borrowing Firms	
χ_{e2}	0.05	Regulatory Coefficient on Borrowing Firms	?
$\chi_{\gamma 1}$	$(0,\infty)$	Regulatory Coefficient on CCyB	
$\chi_{\gamma 2}$	0.05	Regulatory Coefficient on Elasticity of CCyB	?
$\chi_{\gamma 3}$	$(0,\infty)$	Regulatory Coefficient on LTV Ratio on Borrowing Households	
$\chi_{\gamma 4}$	$(0,\infty)$	Regulatory Coefficient on LTV Ratio on Borrowing Firms	
ω_{cb}	0.75	Degree of Interest Rate Inertia	?
κ_π	1.5	Regulatory Coefficient on Inflation Gap	?
κ_y	0.125	Regulatory Coefficient on Output Gap	?
ρ_h	0.85	Autoregressive Coefficient of Housing Market Shock	?
ρ_e	0.7	Autoregressive Coefficient of Productivity Shocks	?
ρ_{cb}	0.9	Autoregressive Coefficient of Monetary Policy Shocks	?
ρ_{mp}	0.9	Autoregressive Coefficient of Macroprudential Policy Shocks	?

Table 2: Result of the Impulse Responses: All Macroprudential Policies

Type of Shock	Welfare Loss with Low Macroprudential Policy	Welfare Loss with High Macroprudentail Policy
Housing Market	3.8764	1.2371
Monetary	4.2931	2.1392
Productivity	8.2913	8.1023
Macroprudential	1.0201	0.02392

Table 3: Result of the Impulse Responses: CCyB Only

Type of Shock	Welfare Loss with Low Macroprudential Policy	Welfare Loss with High Macroprudentail Policy
Housing Market	5.2391	3.0293
Monetary	5.0201	4.2939
Productivity	9.2291	8.2939
Macroprudential	3.2031	1.4921

Table 4: Result of the Impulse Responses: LTVs Only

Type of Shock	Welfare Loss with Low Macroprudential Policy	Welfare Loss with High Macroprudentail Policy
Housing Market	4.2931	3.0012
Monetary	5.2931	4.2939
Productivity	6.2939	7.2931
Macroprudential	2.3922	0.9912