The Expectation Effects and the Optimal Rules of the Countercyclical Capital Buffer Regulation *

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Abstract

We examine the expectation effects of the countercyclical capital buffer (CCyB) regulation and suggest some optimal rules for the policy. We first estimate a dynamic stochastic general equilibrium (DSGE) model with a banking sector using the Korean macro data. Then we obtain the optimal rules for the CCyB regulation to minimize the variations in the business cycle. The main finding is that the optimal CCyB regulation should be less strong when the agents expect the regulation to be effective in the near future than they don't. For example, when the credit-output ratio is 5% higher than its steady state, the CCyB should be raised by 0.6% with expectation and 1.2% with no expectation.

Keywords: Countercyclical Capital Buffer, BASEL III, Macroprudential Policy

JEL Classification Codes: E32, E44

1 Introduction

The countercyclical capital buffer (CCyB) regulation is one of the macro-prudential tools introduced by the Financial Stability Board (FSB) and the Basel Committee on Banking

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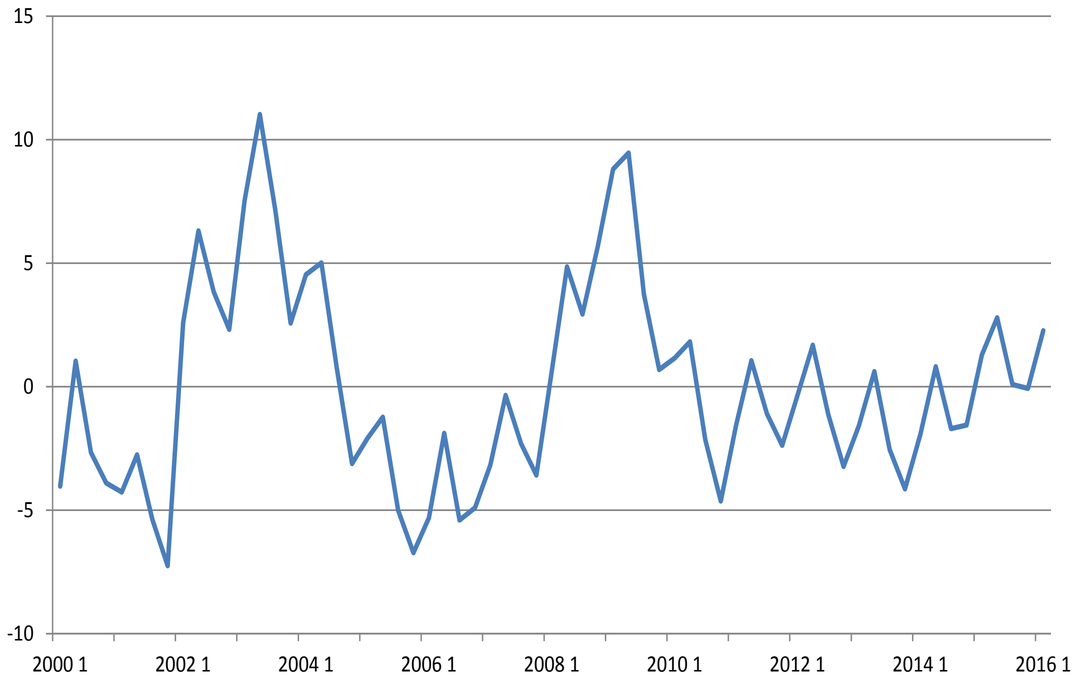
Figure 1: Credit to Output Ratio Deviation in Korea



Source: Bank of Korea

Supervision (BCBS) as one of bank capital regulations in BASEL III. The government can make banks raise their capital-asset ratios (CAR) when credit is expanding faster than output. Banks need to either decrease their assets or lending or increase their net worth or bank capital once the CCyB regulation is effective. The additionally acquired capital could play an important role as buffer when the credit boom ends and credit contraction starts. This means that the CCyB regulation might enhance the soundness of the banks and decrease economic volatility.

Accoding to Yoo and Jo (2012), the Tier 1 ratios and the BIS ratios of the Korean commercial banks are 11.33% and 14.29% on average, respectively. These numbers are higher than the BASEL III minimum ratios, which are 8.5% and 10.5%. In addition, as Figure 1 shows, the credit-output ratio is around the long-term average in the first quarter of 2016. This means that the banks in Korea seem to have enough capital for the time being and the government does not need to carry out the CCyB regulation right now. However, based on the fact that the credit-output gap had been around 10%p twice for the last 15 years in Korea, the Korea economy may have such credit booms in the near future and the regulation authority should prepare for them by setting out specific plans for the CCyB regulation.

Even though the CCyB regulation is expected to be used as a major macro-prudential tool, neither theoretical nor practical research has been done much yet. This paper intends to provide some practical guides for the CCyB regulation. We first estimate a dynamic stochastic general equilibrium (DSGE) model with a banking sector using the Korean macro data. Then we find the optimal rules for the CCyB regulation to minimize the variations in the business cycle. The main finding is that the optimal CCyB regulation should be less strong when the agents expect the regulation to be effective in the near future than they don't. For example, when the credit-output ratio is 5% higher than its steady state, the CCyB should be raised by 0.6% with expectation and 1.2% with no expectation.

There have been a few papers on CCyB in the literature. Kowalik (2011) explains many issues on CCyB but does not show any quantitative results. Drehmann and Gambacorta (2012) present an empirical results, which is that CCyB reduces credit growth during booms, based on a regression model. The following three papers are similar to ours since they all use DSGE models. Yoo and Jo (2012) show that CCyB decreases the volatility of the business cycle and has different effects than the traditional monetary policy. Lambertini and Uysal (2014) also argue that the capital regulations of BASEL III, including CCyB, make the economy less volatile. Benes and Kumhof (2015) show that CCyB improves welfare. However, they do neither present any practical guide for the CCyB policy nor consider the expectation effects of the regulation. This paper incorporates the banking sector following Gertler and Karadi (2011) and the CCyB regulation following Yoo and Jo (2012) to consider the effects of the CCyB regulation.

When we investigate the expectation effects of the CCyB regulation, we utilize the MSRE

(Markov switching Rational Expectation) models. The MSRE models are introduced first by Davig and Leeper (2007) and a few methods to solve the models are suggested by Farmer et al. (2011), Cho (2016) and Foerster et al. (2016). In this paper, we use the method by Cho (2016) since it provides us with an economically meaningful and unique solution if the determinacy condition holds.

This paper is organized as follows. Section 2 sets up a baseline DSGE model with a banking sector. In Section 3, we present the estimation and simulation results. Section 4 concludes this paper.

2 Model

In this chapter, we introduce the baseline model which is similar to that in Gertler and Karadi (2011) and incorporate the countercyclical capital buffer regulation into it.

2.1 Households

We assume a continuum of households with a measure of one. A household consists of workers and bankers. Workers supply labor and take the wage back to the household and bankers run a bank and bring the revenue to the household, too. The portion of workers is $1-f$ and that of bankers is f at a specific time. A banker this period can be a banker next period with a probability of θ, which means that the expected duration of being a banker is $1/(1-\theta)$. The reason why the expected lifetime of a banker is set to be finite is to make sure that a banker needs deposit as well as her own equity to make loans. At each time, $(1-\theta)f$ of bankers becomes workers, bringing the net worth of the banks, and households provide some amount as a net worth to the new bankers.

The representative household chooses consumption (C_t), labor supply (L_t), and the amount of 1 period risk-free real bond (B_{t+1}) to maximize the following expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t a_t u\left(C_t, L_t\right)$$

where β is the time discount factor ($0 < \beta < 1$), $u(\cdot)$ is the utility function, and a_t is the preference shock. The risk-free bond is considered deposit in this paper. The budget constraint for the household is expressed by

$$C_t + B_{t+1} \leq W_t L_t + B_t R_t + D_t$$

where R_t is the interest rate, W_t is the wage, and D_t is the revenue from banks and firms. We assume the following utility function:

$$u(C_t, L_t) = \frac{1}{1-\sigma}(C_t - hC_{t-1})^{1-\sigma} - \chi \frac{1}{1+\tau} L_t^{1+\tau}$$

where σ is the relative risk averseness, $h(0 < h < 1)$ is the habit formation, $\chi(> 0)$ is the relative (dis)utility for labor, and $\tau(> 0)$ is the inverse of the Frisch labor supply elasticity. The first-order conditions are arranged as follows:

$$u_C(t) = \beta R_{t+1} E_t u_C(t+1) \tag{1}$$

$$-\frac{u_L(t)}{u_C(t)} = W_t \tag{2}$$

where $u_C(t)$ and $u_L(t)$ are the differentiation of the utility function with respect to consumption and labor supply, respectively.

2.2 Banks

Banks receive deposit from households and make loans to producers. The balance sheet of a bank j is

$$Q_t S_{j,t} = N_{j,t} + B_{j,t+1} \tag{3}$$

where Q_t is the (real) price of physical capital, $S_{j,t}$ is the asset or loan of the bank j, $N_{j,t}$ is the net worth of it, and $B_{j,t+1}$ is the deposit from households. The dynamics of the net worth of bank is

$$N_{j,t+1} = R_{k,t+1} Q_t S_{j,t} - R_{t+1} B_{j,t+1} \tag{4}$$

$$= (R_{k,t+1} - R_{t+1}) Q_t S_{j,t} + R_{t+1} N_{j,t} \tag{5}$$

where $R_{k,t+1}$ is the loan rate.

Bank j maximizes the following present value of the future net worths:

$$V_{j,t} = \mathrm{E}_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+i} N_{j,t+1+i} \tag{6}$$

$$= \mathrm{E}_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+i} \left[(R_{k,t+1+i} - R_{t+1+i}) Q_{t+i} S_{j,t+i} + R_{t+1+i} N_{j,t+i} \right] \tag{7}$$

where $\Lambda_{t,t+i} = \frac{u_C(t+i)}{u_C(t)}$. If the financial market is frictionless, the loan rate is equal to the deposit rate ($R_{k,t+1+i} = R_{t+1+i}$), with no risk premium. However, if there is a friction in the financial market and there is a limit of borrowing from depositors, the risk premium would be positive. This paper introduces a costly enforcement problem as follows. At the beginning of time t, a banker can divert λ of the asset and, observing that, depositors can liquidate the bank and take the rest. Therefore, for a bank to induce deposit, the following incentive constraint should be satisfied.

$$V_{j,t} \geq \lambda Q_t S_{j,t} \tag{8}$$

The franchise value of bank j can be expressed as

$$V_{j,t} = \eta_t N_{j,t} + \nu_t Q_t S_{j,t} \tag{9}$$

where

$$\nu_t = \mathrm{E}_t \left[(1-\theta)\beta\Lambda_{t,t+1}(R_{k,t+1} - R_{t+1}) + \beta\Lambda_{t,t+1}\theta x_{t,t+1}\nu_{t+1} \right] \tag{10}$$

$$\eta_t = \mathrm{E}_t \left[(1-\theta)\beta\Lambda_{t,t+1}R_{t+1} + \beta\Lambda_{t,t+1}\theta z_{t,t+1}\eta_{t+1} \right] \tag{11}$$

$$x_{t,t+1} = Q_{t+1}S_{j,t+1}/Q_t S_{j,t} \tag{12}$$

$$z_{t,t+1} = N_{j,t+1}/N_{j,t} \tag{13}$$

Under the assumption that the incentive constraint holds with equality, we obtain the following equation.

$$\frac{Q_t S_{j,t}}{N_{j,t}} = \frac{\eta_t}{\lambda - \nu_t} \equiv \phi_t \tag{14}$$

which means that the asset of a bank ($Q_t S_{j,t}$) is restricted by its net worth ($N_{j,t}$). We call ϕ_t the leverage ratio and this is the reciprocal to the capital-asset ratio (CAR). Note that

ϕ_t does not depend on the characteristics of individual banks, which generates the following equation:

$$Q_t S_t = \phi_t N_t \tag{15}$$

where S_t and N_t are the aggregate asset and the aggregate net worth of banks.

Now, the aggregate net worth consists of that of surviving bankers ($N_{e,t}$) and that of new bankers.

$$N_t = N_{e,t} + N_{n,t} \tag{16}$$

Since only θ of bankers survives to the next period, the dynamic of the net worth of surviving bankers is

$$N_{e,t} = \theta \left[(R_{k,t} - R_t)\phi_{t-1} + R_t \right] N_{t-1} \tag{17}$$

The new banks are assumed to be provided with $\omega Q_t S_{t-1}$ by households, which means

$$N_{n,t} = \omega Q_t S_{t-1} \tag{18}$$

Finally, the aggregate net worth of the bank industry is determined as

$$N_t = \theta \left[(R_{k,t} - R_t)\phi_{t-1} + R_t \right] N_{t-1}\epsilon_{u,t} + \omega Q_t S_{t-1} \tag{19}$$

where $\epsilon_{u,t}$ is the bank capital shock.

2.3 Production

There are three kinds of producers: entrepreneurs, capital producers, and retailers. Entrepreneurs borrow funds from banks and buy capital with the fund. Combining the capital and labor from households, they produce intermediate goods. After the production, entrepreneurs sell the capital to the capital producers and the capital producers produce new capital using the capital bought from the entrepreneurs. The intermediate goods are purchased and converted to the final goods by retailers and sold to households.

2.3.1 Entrepreneurs

Entrepreneurs borrow Q_tS_t from banks at t and buy Q_tK_{t+1} capital from capital producers such as

$$Q_tS_t = Q_tK_{t+1} \tag{20}$$

Combining the capital and labor from households, they produce intermediate goods ($Y_{m,t}$) through the following production function:

$$Y_{m,t} = f(z_tK_t, L_t) = (z_tK_t)^{\alpha}L_t^{1-\alpha} \tag{21}$$

where z_t is the capital quality shock. The first-order conditions for demand for labor and capital are

$$W_t = f_L(t)mc_{H,t} \tag{22}$$

$$R_{k,t+1} = \frac{mc_{H,t+1}f_K(t+1) + Q_{t+1}(1-\delta)}{Q_t} \tag{23}$$

where $f_L(t)$ and $f_K(t)$ are the derivatives of labor and capital, δ is the depreciation rate, and $mc_{H,t}$ is the marginal cost.

2.3.2 Capital Producers

Capital producers buy some intermediate goods and produce investment goods (I_t) using a linear technology production. Combining the investment goods and the previous capital (K_t), they sell the new capital K_{t+1} to entrepreneurs. With the capital adjustment cost being second order polynomial, capital producers chooses I_t to maximize the following:

$$Q_tI_t - I_t - \frac{\kappa}{2}\left(\frac{I_t}{K_t} - \delta\right)^2 k_t$$

where the budget constraint is

$$K_{t+1} = I_t + (1-\delta)K_t \tag{24}$$

where Q_t is the (relative) price of capital and $\kappa > 0$ is the parameter for capital adjustment. The first-order condition is

$$Q_t = 1 + \kappa \left(\frac{I_t}{K_t} - \delta \right), \tag{25}$$

which is also known as Tobin's Q.

2.3.3 Retailers

Retailers buy the intermediate goods ($Y_{m,t}$) from the entrepreneurs and produce and sell the final goods (Y_t) to households as follows:

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}} \tag{26}$$

where $\epsilon > 0$ is the rate of substitution between the intermediate goods. To introduce the price rigidity a la Calvo (1983) and Yun (1996), we assume that ω_H of retailers cannot adjust the price at the monopolistically competitive market in each period. Then retailer i chooses $P_{H,t}(i)$ to maximize the following:

$$E_t \sum_{k=0}^{\infty} \omega_H^k \beta^k \frac{u_c(t+k)}{u_c(t)} \frac{D_{H,t+k}(i)}{P_{H,t+k}} \tag{27}$$

where

$$\frac{D_{H,t+k}(i)}{P_{H,t+k}} = \frac{P_{H,t}(i)}{P_{H,t+k}} y_{t+k}(i) - \frac{MC_{H,t+k}}{P_{H,t+k}} y_{t+k}(i) \tag{28}$$

and

$$mc_{H,t} \equiv \frac{MC_{H,t}}{P_{H,t}}. \tag{29}$$

Under the symmetric equilibrium, the first-order condition is

$$E_t \sum_{k=0}^{\infty} \omega_H^k \beta^k \frac{u_c(t+k)}{u_c(t)} \left(P_{H,t}^{new} + \frac{\epsilon}{1-\epsilon} MC_{H,t+k} \right) P_{H,t+k}^{\epsilon-1} y_{t+k} = 0 \tag{30}$$

where $P_{H,t}^{new}$ is the newly adjusted price. Finally, the aggregate price index is determined by

$$P_{H,t}^{1-\epsilon} = (1-\omega_H) P_{H,t}^{new\,1-\epsilon} + \omega_H P_{H,t-1}^{1-\epsilon}. \tag{31}$$

2.4 Monetary Policy and Market Clearance

The central bank adjusts the nominal interest rate, $i_t(= R_{t+1}\mathrm{E}_t\pi_{t+1})$, the following Taylor rule:

$$i_t = (1-\rho)\left[i + \kappa_\pi \pi_t + \kappa_y(\log Y_t - \log Y_{ss})\right] + \rho i_{t-1} + \epsilon_{r,t} \tag{32}$$

where Y_{ss} is the steady state value of Y_t and $\epsilon_{r,t}$ is the monetary policy shock.

Finally, the condition of market clearance is

$$Y_t = C_t + I_t \tag{33}$$

2.5 Countercyclical Capital Buffer Regulation

The baseline model does not have the countercyclical capital buffer regulation The long-term CAR is determined by the values of parameters and banks changes the CAR around the long-term value according to Equation 15 whenever there is an exogenous shock. While the baseline model is very similar to Gertler and Karadi (2011), we revise it by incorporating the CCyB regulation into the model. Before we do so, we assume that banks maintain the CAR above the ratio that BIS requires unless there is a huge negative shock. Also we assume that banks increase the CAR when the the countercyclical capital buffer regulation takes effective. That is, banks lift the CAR even though the CAR is already higher than the BIS ratio.

We model the countercyclical capital buffer regulation by adding a restriction on Equation 15 as follows:

$$\frac{Q_t S_t}{N_t} = \phi_t \psi_t \tag{34}$$

$$\psi_t = \left(\frac{Q_t S_t / S_{ss}}{Y_t / Y_{ss}}\right)^{-\psi} \tag{35}$$

where ψ is the parameter to determine the size of the countercyclical capital buffer regulation and the positive ψ means that the regulation depress the credit expansion when credit increases more than output.

Note that the above equation does not change the steady state value of CAR but the short-term dynamics of CAR. In practice, the countercyclical capital buffer regulation is asymmetric, which means that it requires the increase in CAR during the credit expansion but does not require the decrease in CAR during the credit contraction. Considering the fact, we are going to use Equation 34 and 35 when the CCyB regulation is effective while 15 when it is not.

3 Empirical Analysis

3.1 Data and Calibration

Table 1: Fixed Parameters

parameter		value
β	time discount rate	0.988
θ	survival probability of bankers	0.972
ω	endowment for new bankers	0.002
λ	share of diverting by bankers	0.374
α	share of capital income	0.4
δ	depreciation rate	0.025
ϵ	rate of substitution between intermediate goods	4.167
R_k	long-run loan rate	5.07%
R	long-run risk-free rate	3.87%

Before estimation, we fix some parameters as shown in Table 1. The time discount rate (β) is set to the inverse of the long-run risk-free rate, which is 3.87%. The survival probability of bankers (θ) is set to be 0.972 following Gertler and Karadi (2011). ω and λ are set as such that the long-run risk premium is 1.2% and the long-run CAR of banks is 12/50. The risk premium is defined as the difference between the loan rate and the risk-free rate. The long-run CAR is determined based on the fact that the average CAR of the banks is around 12% and the half of their assets is corporate loan. The long-run loan rate is set to be equal to the average AA- corporate bond yield with maturity of 3 years while the long-run risk-free rate is equal to the average CD yield with maturity of 3 month over the sample.

We estimate the baseline model without CCyB using the Korean macro data. The data consist of real GDP, CPI inflation, the CD rate (91 days), and the total loan by commercial banks and span from 2000Q1 to 2016Q1. We download the data from the website of the Bank of Korea and use the HP filtered and seasonally adjusted data for Bayesian estimation.

3.2 Estimation

Table 2 shows the estimation results by the Bayesian method. Most estimates are similar to those in the literature. Figures 2 to 4 show the impulse responses to the preference shock, the capital quality shock, and the monetary policy shock, respectively. When we compare the impulse responses with the banking sector (denoted by FA) and with no banking sector (denoted by noFA), we find that the frictions in the banking sector amplify the business cycles. Especially, the economy becomes much more volatile when the capital quality shock (z_t) hits the economy with the financial frictions. For example, the credit (qk) expands by 5% responding to one standard deviation of the capital quality shock with the financial frictions while it would expand just by 1% without the frictions. As shown later, the CCyB regulation can mitigate this accelerator effects.

3.3 Optimal CCyB Policy

In this section, we explore optimal CCyB policy rules under commitment as in Soderlind (1999). Assuming that the monetary policy rule does not change, we obtain the value of ψ in Equation 35 to minimize the variations in inflation, output and the CCyB policy, as follows:

$$\min\ E_0 \sum_{t=0}^{\infty} \beta^t (\hat{\pi}_t^2 + \hat{y}_t^2 + \lambda_\psi \hat{\psi}_t^2). \tag{36}$$

The second column of Table 3 shows the optimal values of ψ for different values of λ_ψ. As expected, the more we intend to minimize the variations in ψ_t, the more we tolerate the variations in credit. Figure 5 shows the impulse responses to the capital quality shock ($\epsilon_{z,t}$) when $\lambda_\psi = 0.2$ or $\psi = 5.895$. When we compare the case with CCyB (denoted by FAccyb) and one with no CCyB (denoted by FA) we find that the CCyB policy moderates the increases in output, investment, credit, and the credit-output ratio while the bank capital and CAR stay high.

Based on the impulse responses, we construct the optimal CCyB rule for each λ_ψ. For example, according to Figure 5, when the credit-output ratio increases by 3%, it is optimal to increase the CAR around by 0.7%p in the case of $\lambda_\psi = 0.2$. Figure 6 shows the derived rules which indicate the amount of the optimal CCyB as a function of the credit-output ratio.

3.4 Expectation Effects of the CCyB Policy

It is advised that the government announce the CCyB regulation at least a year earlier than it becomes effective so that banks could have some time to comply to the regulation. In this case, there could be some expectation effects of the CCyB policy. To investigate this expectation effects, we introduce a discrete state variable, $Z_t (= 0 \text{ or } 1)$, which follows a Markov process with the transition probabilities:

$$Pr[Z_t = 0 | Z_{t-1} = 0] = p_{00}, \quad Pr[Z_t = 1 | Z_{t-1} = 1] = p_{11}.$$

The state $Z_t = 0$ is identified as the no CCyB regime while the state $Z_t = 1$ as the regime when the CCyB is effective as follows:

$$\psi_t = \left(\frac{Q_t S_t / S_{ss}}{Y_t / Y_{ss}} \right)^{-\psi} Z_t \tag{37}$$

This kind of model is called MSRE (Markov switching rational expectation) model in the literature and a few solution methods have been recently suggested. In this paper, we use the method by Cho (2016) since it gives us an economically meaningful and unique solution if it exists. Based on the assumption that the agents anticipate that the CCyB regulation becomes effective in a year and lasts for a year, we set the both transitional probabilities to be 0.75. We do the same simulation as the previous subsection and obtain the implied rule for the CCyB regulation as in Figure 7. When we compare Figure 7 and 6, we find that the CCyB regulation should be moderate if there is any expectation effect. For example, when $\lambda_\psi = 0.2$ and the credit-output ratio is 5% higher than its steady state, the CCyB regulation should be 1.2% with no expectation and 0.6% with expectation.

Figure 8 shows the impulse responses to the capital quality shock when the CCyB regulation is expected to be effective in a year (denoted by FAccybEx). We see that the credit-output ratio decreases and the CAR increases when the agents anticipate the CCyB regulation even though it is not effective yet. All this implies that the government should consider this expectation effects when it decides to make the CCyB regulation effective.

4 Conclusions

This paper suggests some practical guides for the CCyB regulation by calculating the optimal rules to minimize the variations in the business cycle. We also find that the optimal rules depend on whether the agents expect the CCyB regulation to be effective soon or not. The differences between the optimal rules with expectations and those with no expectations turn out to be quite substantial. Therefore, the government or the central bank should consider this expectation effects when they make decision on the CCyB regulation.

While this paper focuses on when the CCyB regulation should become effective and how strong it should be, it might be another important practical matter when the regulation should become ineffective or what is the rules for the ineffectiveness. In this case, the duration of the CCyB regulation should be one of the choice variables of the government. This matter should be seriously investigated in a future research.

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Table 2: Estimation Results

	Prior			Posterior	
	Distr	mean	s.d.	mean	90% HPDI
ρ	beta	0.5	0.2	0.0694	[0.0150 , 0.1303]
σ	gamma	1.5	0.2	1.0854	[0.8118 , 1.3315]
τ	gamma	3	0.2	3.1804	[2.8184 , 3.4985]
ω_H	beta	0.5	0.2	0.7844	[0.7423 , 0.8202]
γ	beta	0.5	0.2	0.3526	[0.0715 , 0.6209]
κ	gamma	10	3	16.2323	[12.8359 , 19.0590]
χ	gamma	10	3	9.6226	[5.9406 , 13.4289]
α_r	beta	0.8	0.1	0.6711	[0.6119 , 0.7294]
α_π	gamma	1.5	0.1	1.6929	[1.5394 , 1.8432]
α_y	gamma	0.3	0.1	0.3350	[0.2058 , 0.4581]
ρ_a	beta	0.8	0.1	0.4804	[0.3642 , 0.5946]
ρ_z	beta	0.8	0.1	0.2865	[0.1930 , 0.3803]
σ_a	invg	3	Inf	2.0824	[1.5716 , 2.5044]
σ_z	invg	3	Inf	3.6485	[2.8263 , 4.3470]
σ_r	invg	0.3	Inf	0.3770	[0.3258 , 0.4369]
σ_u	invg	3	Inf	24.6226	[18.8896 , 29.4521]

Table 3: Optimal Values for ψ

λ_ψ	ψ
0.1	10.998
0.2	5.895
0.3	3.977

Figure 2: Impulse Responses to $\epsilon_{a,t}$

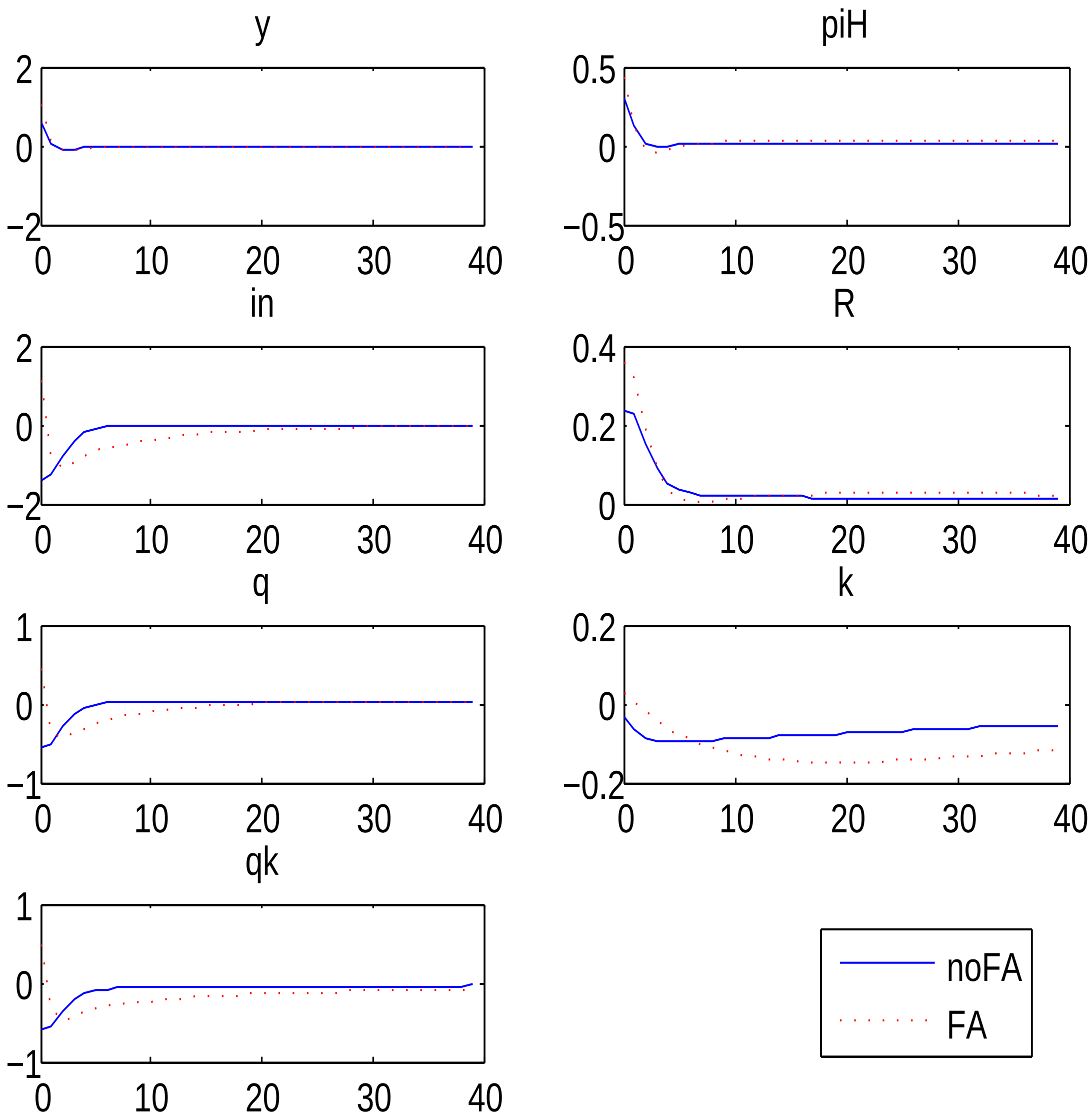

Figure 3: Impulse Responses to $\epsilon_{z,t}$

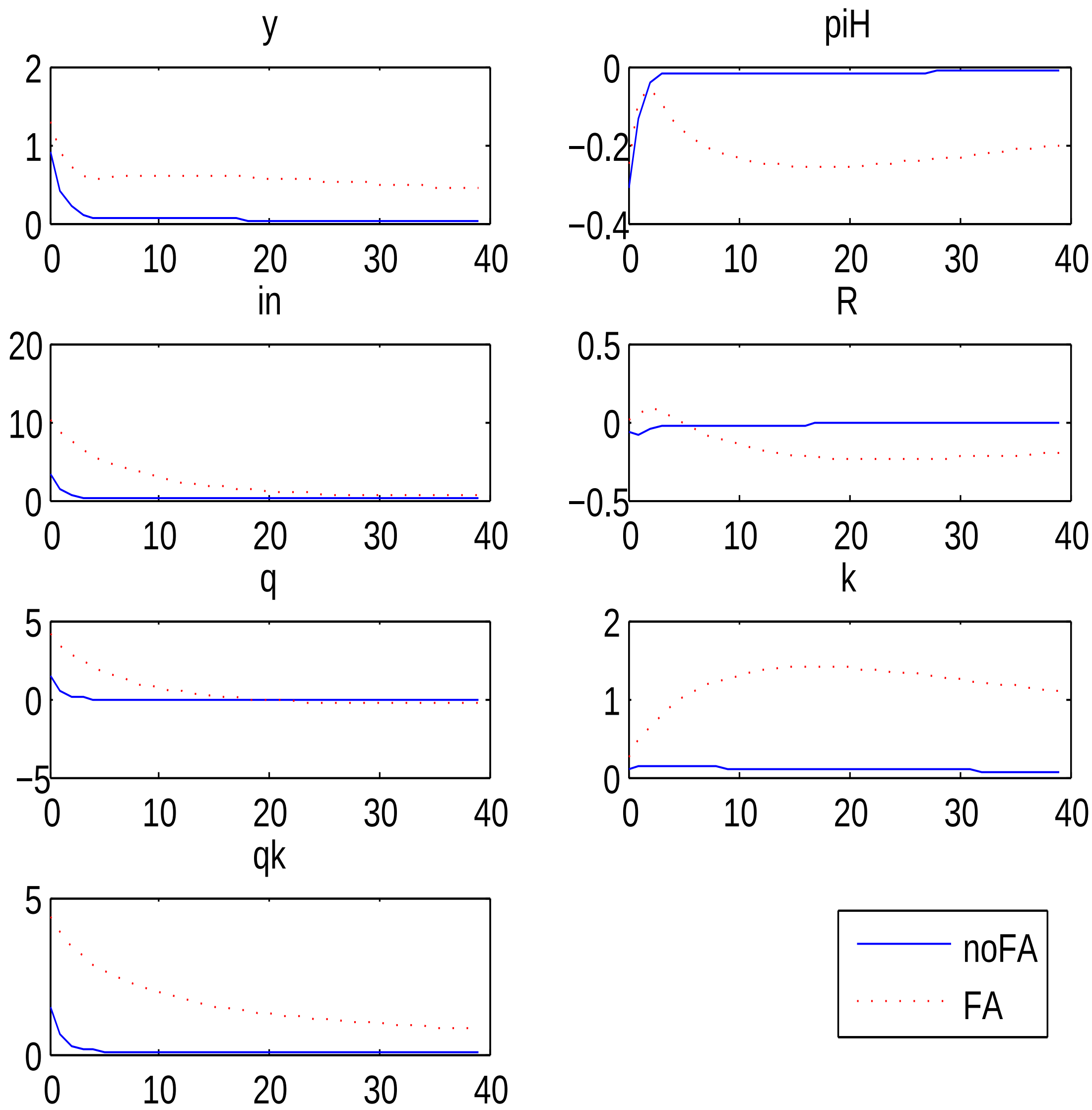

Figure 4: Impulse Responses to $\epsilon_{r,t}$

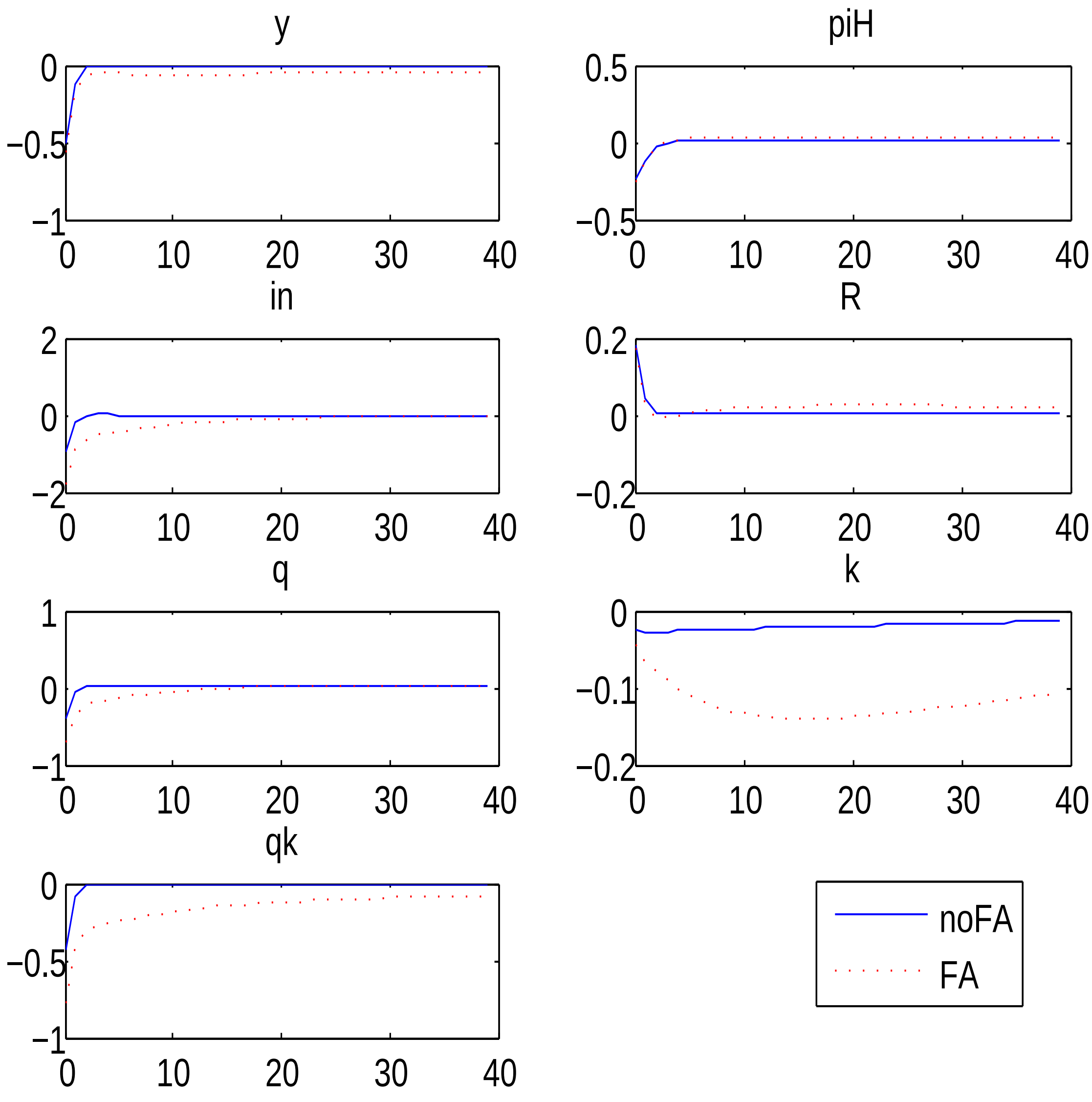

Figure 5: Impulse Responses to $\epsilon_{z,t}$

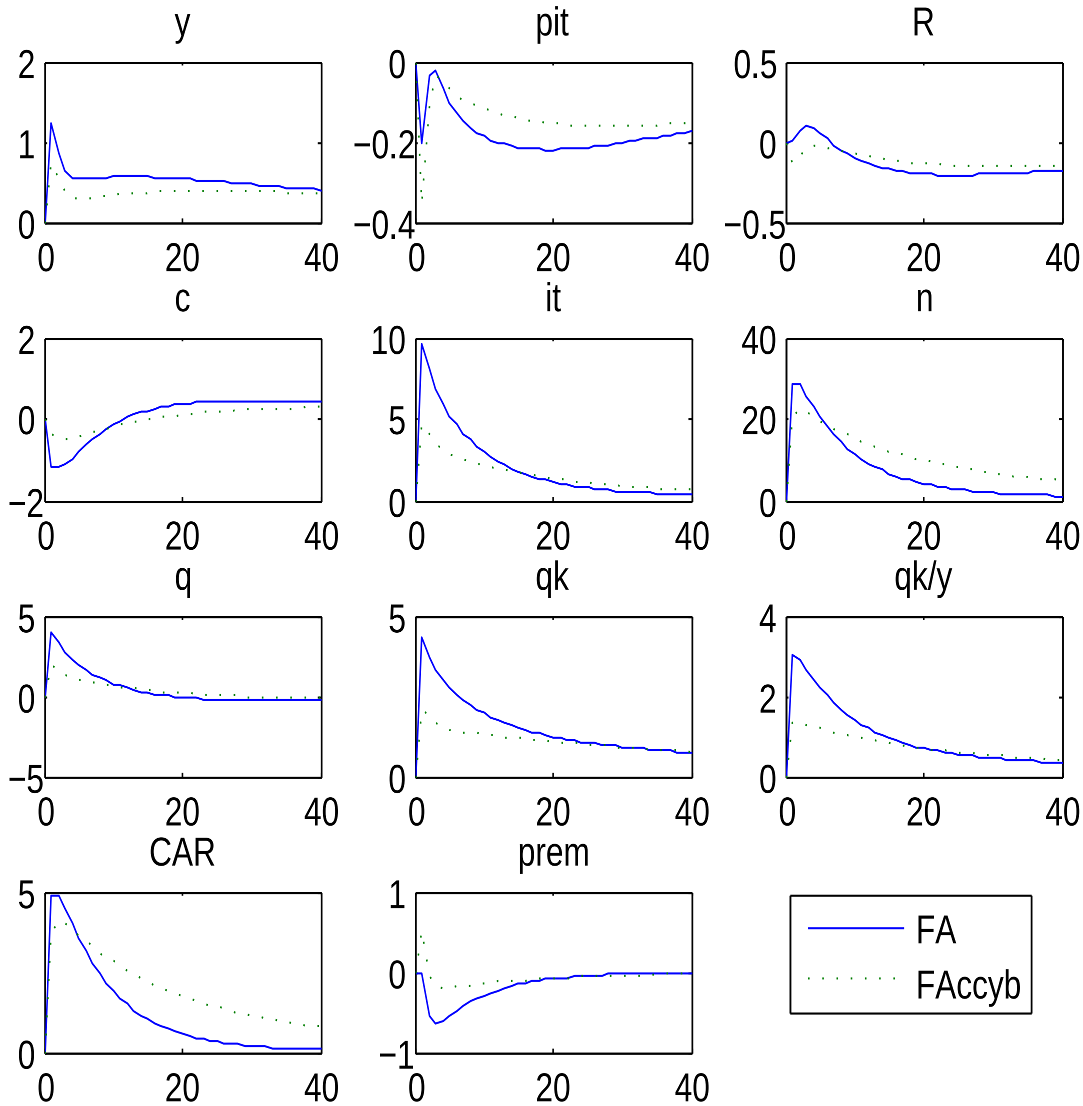

Figure 6: Optimal CCyB Rules

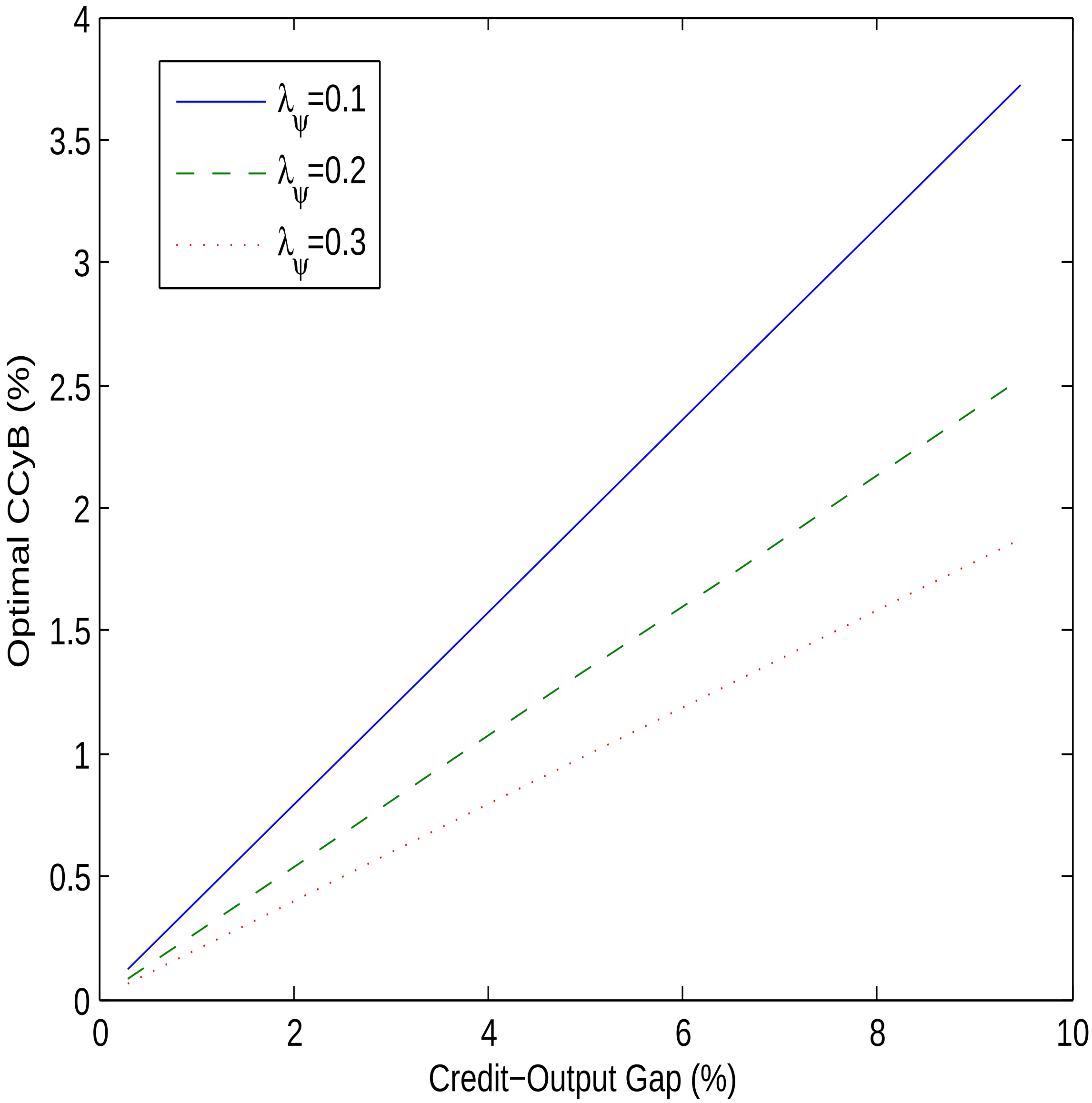

Figure 7: Optimal CCyB Rules When Expected

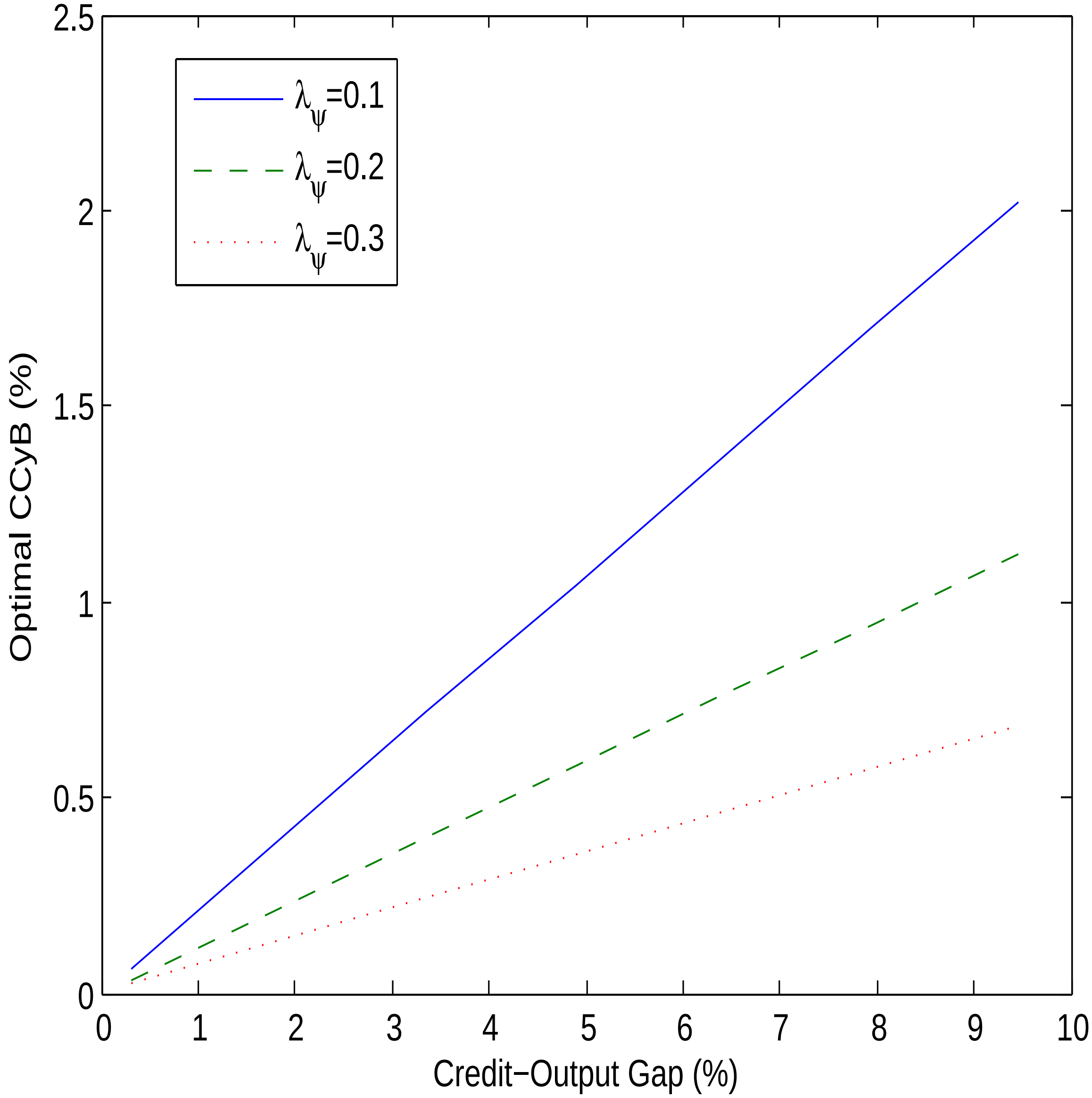

Figure 8: Impulse Responses to $\epsilon_{z,t}$ When Expected