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**Abstract**

This paper examines whether Japanese monetary policy had been working through the credit channel and its sub-channels between March 2000 and March 2016 using time-varying parameter VAR. The identification of credit transmission channels is a very difficult problem due to the impossibility to observe the conditions of credit supply and demand. However, using the credible data collected from the ‘Senior Loan Officer Opinion Survey on Bank Lending Practices at Large Japanese Banks’ (SLOS), we identified the credit channel and its sub-channels. To the best of the authors’ knowledge, there are no previous studies that have employed SLOS data for the evaluation of transmission channels. The estimation findings show a high possibility that large and middle-sized firms had little effect on monetary policy through the credit channel, but did have an effect through portfolio rebalancing. Small firms are thought to have an effect through the credit channel and its sub-channels, but it is not a big effect. The detailed reason as to why the effect of monetary easing differed by the firm size should be considered by looking at more specific portfolio rebalancing effects and loans to overseas.

**Keywords:** Time-Varying Parameter vector autoregressive (TVP-VAR) model, Credit Channel, Credit supply, Lending standards, Monetary policy.

**JEL classification:** E41; E44; E51; E52; G21

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# 1 Introduction

Some preceding studies (Honda et al., 2007; Ijiri, 2016) suggest that Japanese monetary policy from 2001 to 2006 did not work much through the banking sector, in other words, Credit Channel<sup>1</sup>. However, these studies did not consider the determinants of loans. Based on this fact, this paper tries to disentangle the determinants of loans into loan demand and lending standards to understand whether those factors really affected the amounts of loans. Here, we break the credit channel into two sub-channels: the Bank Incentive Channel (BIC) and the Bank Observe Channel (BOC) following the way of Ciccarelli et al. (2015)<sup>2</sup>. These sub-channels express bank factor and corporate factor. As the main contribution, we verify the effect of monetary policy using Japanese SLOS and the time-varying parameter VAR (TVP-VAR). Then, we use TVP-VAR for estimation, because we aim to assess the effect of monetary policy in several policy terms including the zero lower bound (ZLB). In this way, the paper tries to analyse the extent to which Japan's monetary policy affected Indices of Industrial Production (IIP) through the credit channel from 2000 to 2016 depending on the policy terms. In particular, we focus on the following four questions: (1) Did Japanese monetary policy really affect IIP through the credit channel? (2) Which factors explain the loan amount fluctuation, loan demand and lending standard? (3) If lending standards significantly affect loans, then specifically which factor affected this effect, the bank factor or the corporate factor? (4) Do the effects from these factors on loans differ depending on the firm size or the policy term? To answer these questions, we try to identify the credit channel by using data from the 'Senior Loan Officer Opinion Survey on Bank Lending Practices at Large Japanese Banks' (SLOS), which allows us to disentangle the factors<sup>3</sup>. The results showed that the effect of monetary policy and the scale of the credit channel differ depending on the firm size. Table 1 reports the summary of monetary transmission channels in this paper.

[Table 1]

This paper is structured as follows. Section 2 explains the transmission channel and the framework of channels. Section 3 describes SLOS data and how to calculate the channel variables. Section 4 summarises the data used in this paper. Section 5 reviews the models. Section 6 closely looks at the estimation results. Section 7 presents the conclusions.

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<sup>1</sup> Bernanke and Blinder (1988, 1992), Kashyap and Stein (1994) and Bernanke and Gertler (1995) describe Credit Channel and its sub-channels in detail.

<sup>2</sup> According to Ciccarelli et al. (2015), which used FRB's SLOS and ECB's BLS, it is difficult to identify the credit channel and its sub-channels with loans due to restricted information about the loan demand and the supply; however, the approach of this paper works well to identify them.

<sup>3</sup> Basically, 'bank' in this paper refers to financial institutions in general, including 'shinkin' and others.

## 2 Transmission channels

In this paper, we follow Ciccarelli et al. (2015) and regard the lending standard as the broad credit channel (BCC) variable in order to disentangle the sub-channels of BCC into the bank incentive channel (BIC) and bank observe channel (BOC). This approach is different from Ciccarelli et al. (2015) as they regard fluctuation of loans as BCC whereas we regard them as different variables. We explain each variable below.

First, the cost of capital channel (CCC or demand) expresses the variable of loan demand as described by Ciccarelli et al. (2015). Observing this channel allows us to determine how firms' real economic activities and financing are affected by the monetary policy.

Second, the broad credit channel (BCC) is also named following Ciccarelli et al. (2015). BCC is thought to be a variable that allows us to capture the fluctuation of the lending standards. For example, banks react to the monetary policy and ease their lending standards by easing the condition of collaterals and real interest rate. In this paper, we regard this variable different from loans because the amount of loans might be determined by the loan demand and the lending standard. BCC is more flexible variable than loans at this point. Moreover, we use this variable to disentangle BCC into two sub-channels: BIC and BOC.

Third, the BIC expresses how much the bank's balance sheet expansions explain the fluctuation of lending standard. BIC represents the size of bankers' emotions. This corresponds to the bank lending channel (or bank assets channel) of Bernanke and Gertler (1995); however, we named this variable 'bank incentive channel' to differentiate from the bank lending channel, which often uses the stock price of banks as an alternative variable that includes expectations. BIC strongly relates with portfolio rebalancing<sup>4</sup>. This is because it is expected that the Bank of Japan (BOJ) purchases government bonds from commercial banks, reserve deposit balances (high-powered money) increase and the compositions of the banks' balance sheets change. Then, banks have some choices to deal with changes in the portfolios of their balance sheets: (1) increase loans; (2) repurchase bonds; or (3) increase stocks. One or some of them will be taken into practise from these choices. Here, the expansion in BIC means the ratio of loans in banks' portfolios increase or the asset price in the banks' balance sheets increase.

Finally, the BOC expresses the extent to which the banks' prospects of firms explain the fluctuation of lending standard. The BOC is a psychological variable of the banks. At this point, this does not fit with the balance sheet variable of Bernanke and Gertler (1995) or Oliner and Rudebusch (1996).

The framework of monetary policy transmission channel in this paper should be referred in Figure 1.

[Figure 1]

In the next chapter, we will explain how those variables are derived from the SLOS data.

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<sup>4</sup> Bernanke and Reinhart (2004) explain portfolio rebalancing effect in detail.

### 3 Survey

The unique point of this paper is that estimates have been done with some variables created by the authors from SLOS data. Following Ciccarelli et al. (2015), these variables are calculated and used for estimation to analyse the effects of monetary policy at a macro level. In other words, by using these variables, we can determine whether changes in lending standards are due to bank assets or due to banks' views of firms' business prospects. In this way, we can also determine the effectiveness of each channel. In an attempt to evaluate these channels, many empirical analyses have been conducted using variables created from the questionnaire data. However, most of these studies use the BOJ's 'Tankan', which incorporates the viewpoint of firms<sup>5</sup>. Analysing the credit channel with SLOS is thought to be much more accurate than using Tankan or each firm's micro data. This is because SLOS is answered by bankers who fully understand the capital situation of their own financial institutions, which means we can capture the macro economy from the financial institution's perspective with these data. As in Figure 2, which shows the movement of BCC created from SLOS and Lending Attitude calculated from Tankan, we can observe that the sentiments of demand side and supply side on loans are largely different after 2014. To the best of the authors' knowledge, there is no study that has used SLOS data for the evaluation of transmission channels.

[Figure 2]

The SLOS data are obtained from the BOJ's website. The survey began in April 2000 and the answers are taken quarterly by the BOJ from 50 Japanese large private banks. These respondents are chosen from the viewpoint of lending volume. As mentioned in the BOJ's website, 'the aggregate loan size of these banks account for approximately 75 percent of the loan market of Japanese private banks (city banks, regional banks, regional banks II, trust banks, long-term credit banks and shinkin banks)'. In addition, respondents of this survey are reconsidered every 3 years. The survey includes several questions related to changes in loan demand and changes in lending standards to several types of firms. Firms are mainly classified as small, medium or large. Banks are also asked to provide the reason why they changed their lending standard by rating seven possible reasons on a three-point scale: 3 = important, 2 = somewhat important, 1 = not important. The BOJ takes a weighted average of these ratings while considering banks' share and the scale of products (see the BOJ's website for detailed information).

The way of making CCC and BCC follows Lown and Morgan (2006) and Ciccarelli et al. (2015). They used FRB's SLOS and ECB's BLS. Regarding the BIC and BOC, the way of creating them is considered by the authors. The BIC and BOC are divided by 100 to match the size with the CCC and BCC. We will explain the way of calculating each channel.

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<sup>5</sup> For example, Ogawa (2003) uses the Tankan's 'banks' Lending Attitude'.

The CCC is created from Q2<sup>6</sup>.

$$CCC = (\text{percentage of respondents selecting 'substantially stronger'} + \text{'moderately stronger'}) - (\text{percentage of respondents selecting 'moderately weaker'} + \text{'substantially weaker'}) \quad (1)$$

The BCC is created from Q7<sup>7</sup>.

$$BCC = (\text{percentage of respondents selecting 'eased considerably'} + \text{'eased somewhat'}) - (\text{percentage of respondents selecting 'tightened somewhat'} + \text{'tightened considerably'}) \quad (2)$$

The BIC and BOC are created from Q7, Q8.a. and Q8.b.

Regarding Q8, (i)–(iii) are as follows: (i) An improvement (or deterioration) in your bank's asset portfolio; (ii) A more (or less) favourable or less (more) uncertain economic outlook; (iii) An improvement in (or worsening of) industry or firm specific problems<sup>8</sup>.

$$BIC = \{(\alpha_1 \times \text{Number of banks answering 'eased' in Q7}) - (\beta_1 \times \text{Number of banks answering 'tightened' in Q7})\} / 100 \quad (3)$$

$$BOC = \{(\alpha_{23} \times \text{Number of banks answering 'eased' in Q7}) - (\beta_{23} \times \text{Number of banks answering 'tightened' in Q7})\} / 100 \quad (4)$$

Here,  $\alpha_1$ ,  $\alpha_{23}$ ,  $\beta_1$  and  $\beta_{23}$  are as follows:

$\alpha_1$ : scale value weighted averaged of (i) in Q8.a.

$\alpha_{23}$ : sum of scale value weighted averaged of (ii) and (iii) in Q8.a. divided by 2.

$\beta_1$ : scale value weighted averaged of (i) in Q8.b.

$\beta_{23}$ : sum of scale value weighted averaged of (ii) and (iii) in Q8.b. divided by 2.

The availability of these variables should be discussed because banks have no incentive to answer honestly. In the preceding studies, the availability of data made by SLOS or BLS is checked roughly in two ways. The first involves applying a multi-regression model. The second is to check the correlation between the loan and BCC. The details of the regression and ways to confirm the availability should be referred to Lown et al. (2000), Lown and Morgan (2006), Maddaloni and Peydró (2011), Del Giovane et al. (2011) and Bassett et al. (2014). These studies suggest that the data from SLOS or BLS have a significant effect on forecasting loans and GDP. Focussing on Japanese data made from SLOS, Kano (2006) refers to its reliability and credibility. Outside of this paper, we performed a multi-regression using the method of Newey

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<sup>6</sup> Q2. How has demand for loans from firms changed over the past 3 months according to the industry and the firm size?

<sup>7</sup> Q7. Over the past 3 months, how have your bank's credit standards for approving applications for loans from firms and households changed?

<sup>8</sup> Q8.a. If your bank has eased its credit standards for loans to firms (that is, the answer to question 7 is either 'eased considerably' or 'eased somewhat'), to what factors do you attribute this easing? (Please rate each possible reason using the following scale: 3 = important, 2 = somewhat important, 1 = not important.)

Q8.b. If your bank has tightened its credit standards for loans to firms over the past 3 months (as described in question 7), what were the important factors that led to the change? (Please rate each possible reason using the following scale: 3 = important, 2 = somewhat important, 1 = not important.)

and West (1987) and found that within a 15% significance level, the CCC and BCC have a significant effect on loans. However, the specific point of this paper is that we do not regard BCC as an alternative variable of loan. This means that it is not necessary to check the availability of BCC as an alternative variable of loan. Therefore, based on this evidence, we use these data in a TVP-VAR regression.



## 4 Data and Models

### 4-1. Data

We use quarterly data between March 2000 and March 2016. This is because the data sampling of SLOS started in April 2000. SLOS includes the different sampling periods, though SLOS asks about the last 3 months' fluctuation; hence, we regard the sample period of SLOS corresponds to the other data. Another specific point is that we use IIP instead of GDP. This is because IIP is expected to make the relationship between the monetary policy and loans for investment much clearer than GDP. The summary of data and variables utilised in the estimation are described in Table 2. It should be noted that these variables are seasonally adjusted by E-views8, ARIMA X-12 and all data are demeaned. For Y, L and M, logs are taken before they are demeaned. In this paper, firm size categorisation follows that of the BOJ (see the BOJ's website for details).

[Table 2]

### 4-2. Models

We estimate five models: Model 1 (L,Y,M), Model 2 (BCC,L,Y,M), Model 3 (CCC,L,Y,M), Model 4 (BIC,L,Y,M) and Model 5 (BOC,L,Y,M) for each firm size (large, middle and small). The details of the variables are described in Table 1.

In Model 1 (L,Y,M), we check the effect of monetary policy to loans. Then, in Model 2 (BCC,L,Y,M), we observe the effect of monetary policy on loans considering the channel through the lending standard. In estimating Model 3 (CCC,L,Y,M), we test the hypothesis that the monetary policy did not affect the real economy through the channel of loans to IIP because of its invalid effect on loan demand. Lastly, from Model 4 (BIC,L,Y,M) and Model 5 (BOC,L,Y,M), we consider whether bank problems, such as bad loans and non-performing loans, or low capital adequacy ratio caused the low growth of loan, or the bad prospects on firms caused this problem.

There are some cautions in these models: (1) the sample period includes ZLB; (2) we do not use the interest rate or the monetary bond as a monetary policy variable and (3) the price variable is not concerned in this paper. The first point recognises the sample period to include the zero lower bound (ZLB) period. Nakajima (2011b) describes the way to deal with this problem by utilising the Tobit-type non-linearity method to the nominal interest rate to make it a censored variable<sup>9</sup>. However, as a result of using this method in the framework of TVP-VAR, Nakajima (2011b) concluded that there are not any big difference in the result of models with or without considering the ZLB<sup>10</sup>. Based on this finding, in this paper, we make ZLB as a problem to tackle in the future and we will estimate without using the Tobit-type non-linearity method<sup>11</sup>. The second problem to tackle is selecting the monetary policy variable dealing with

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<sup>9</sup> Details are also in Iwata and Wu (2006).

<sup>10</sup> Details should be referred to Nakajima (2011b).

<sup>11</sup> Other papers such as Nakajima and West (2013) and Kimura and Nakajima (2016) deal with the ZLB period by utilising the 'latent threshold model (LTM)' to let the model change its regime between

the fact that the monetary policy differs in every policy term. Regarding TVP-VAR, this method has a restriction with its number of variables in the model. Thus, we deal with this problem using the CAB as a monetary policy variable<sup>12</sup>. We also do not consider the interest rate in this model for the following reasons: (1) the short-term interest rate in this sample period transitioned around 0% and (2) Honda et al. (2007) mention that in reacting to the monetary policy, the long-term interest rate did not go down, but rather increased during 2001–2006. The last point is that we do not use a price variable for the estimation for the following reasons. First, the number of variables that can be used in TVP-VAR is limited. Second, Honda et al. (2007), which estimates for the quantitative easing period from 2001 to 2006, states that the consumer price response to the monetary policy shock is very small and not significantly far from zero in the whole period. This means the effect of monetary easing policy on price is uncertain. Lastly, Williams (2012) of the Federal Reserve Bank of San Francisco at the time also stated that the ‘reserve deposit balance hardly affects money stock, bank lending and inflation’.

In this sub-chapter, we will explain the orders of variables in detail. The order utilised in this paper is different from the one in Christiano et al. (1999). This is because we set the following assumptions in the models. First, we assume that the monetary policy is determined after the central bank observes IIP (Y), loans (L) and SLOS (C). In other words, it is assumed that monetary policy influences other variables one term later. Second, we assume private banks individually decide loan amount (L) while observing loan demand, prospects of firms and changes in bank assets(C). Lastly, private banks are assumed that they can observe changes in loan demand and changes in bank assets(C) prior to IIP (Y) and that a private bank can determine loan (L) before IIP (Y) is observed. Originally, this order should be determined using the marginal likelihood method. In this paper, however, checking some orders, such as (Y,L,M), (Y,C,L,M) and (Y,L,C,M), did not reveal any big difference; thus, we adopt the order (C,L,Y,M).

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conventional and unconventional policies.

<sup>12</sup> Refer to Kimura and Nakajima (2016) about why we can use CAB on this terms’ monetary policy variable.

## 5 Estimation

### 5-1. Estimation Method

We employ the TVP-VAR model in a similar manner to Primiceri (2005), Nakajima (2011a) and Nakajima et al. (2011). Estimations were done by MATLAB, created by Nakajima (2011a) and arranged by the authors. The TVP-VAR system with lag  $s$  is given as

$$\begin{aligned} A_t y_t &= C_{1t} y_{t-1} + C_{2t} y_{t-2} + \dots + C_{st} y_{t-s} + \epsilon_t \\ \epsilon_t &\sim N(0, \Phi_t), \quad (t = s + 1, \dots, n). \end{aligned} \quad (5)$$

where  $C_{it}$  and  $A_t$  are matrixes of  $(k \times k)$  time-varying coefficients ( $i = 1, \dots, s$ ), with  $y_t = (y_{1t}, \dots, y_{kt})'$  and  $\epsilon_t$  is a vector of the fundamental structural shocks ( $k \times 1$ ). Also,  $\Phi_t$  is a variance-covariance matrix  $(k \times k)^4$ .

Translating (5), we get reduced form (6) as follows:

$$\begin{aligned} y_t &= B_{1t} y_{t-1} + B_{2t} y_{t-2} + \dots + B_{st} y_{t-s} + u_t \\ u_t &\sim N(0, A_t^{-1} \Phi_t A_t^{-1'}), \quad (t = s + 1, \dots, n). \end{aligned} \quad (6)$$

where  $B_{it} = A_t^{-1} C_{it}$  and  $B_{it}$  is a matrix of  $(k \times k)$  time-varying coefficient and ( $i = 1, \dots, s$ ),  $u_t$  is an error term vector of  $(k \times 1)$ .

Then, the variance of  $u_t$  can be reformed with a Cholesky decomposition to impose recursive restriction:

$$A_t^{-1} \Phi_t A_t^{-1} = A_t^{-1} \Sigma_t \Sigma_t' A_t^{-1'} \quad (7)$$

Therefore, the error term  $u_t$  follows the  $k$  variable normal distribution with an average of 0 and the time-varying covariance matrix  $\Phi_t$ . Reorganizing further, we get

$$\begin{aligned} y_t &= X_t \beta_t + A_t^{-1} \Sigma_t e_t \\ e_t &\sim N(0, I_k)^{13}, \quad (t = s + 1, \dots, n) \end{aligned} \quad (8)$$

where,  $\beta_t = \text{vec}[B'_{1t}, \dots, B'_{st}]$  and  $X_t = I_k \otimes (y'_{t-1}, y'_{t-2}, \dots, y'_{t-s})$  are scaled structural shocks.  $A_t$  is a lower triangular matrix in which the diagonal elements are equal to one and  $\Sigma_t$  is the diagonal matrix:

$$A_t = \begin{pmatrix} 1 & 0 & \dots & 0 \\ a_{21t} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ a_{k1t} & \dots & a_{k,k-1,t} & 1 \end{pmatrix} \quad (9)$$

<sup>13</sup>  $I$  is an identity matrix.

$$\Sigma_t = \begin{pmatrix} \sigma_{1t} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \sigma_{kt} \end{pmatrix} \quad (10)$$

Additionally,  $a_{ijt}$  is the simultaneous relations of the structural shock parameter that the structural shock of the variable  $j$  affects variable  $i$ . Hence, we define the lower triangular elements of  $A_t$  as  $a_t = (a_{21t}, a_{31t}, a_{32t}, \dots, a_{kk-1t})'$ .

Converting the diagonal components of  $\Sigma_t$  into a single row, it can be represented as  $h_{it} = \log \sigma_{it}^2$ . Then, we define  $h_t = (h_{1t}, \dots, h_{kt})'$ . Here,  $\sigma_{it}^2$  is the time-varying variance of the structural shock of the variable  $i$ .

In addition, we assume that the time-varying parameters  $(\beta_t, a_t, h_t)$  follow the following random walk process:

$$\beta_{t+1} = \beta_t + u_{\beta t}, \quad a_{t+1} = a_t + u_{a t}, \quad h_{t+1} = h_t + u_{h t}. \quad (11)$$

Here, the error term vector of each variables is as follows:

$$\begin{pmatrix} e_t \\ u_{\beta t} \\ u_{a t} \\ u_{h t} \end{pmatrix} \sim N \left( 0, \begin{pmatrix} I_k & 0 & 0 & 0 \\ 0 & \Sigma_\beta & 0 & 0 \\ 0 & 0 & \Sigma_a & 0 \\ 0 & 0 & 0 & \Sigma_h \end{pmatrix} \right), \quad (12)$$

where it is assumed that  $(\Sigma_\beta, \Sigma_a, \Sigma_h)$  are time-varying variance.

For sampling, we set the following normal distribution for the initial state of the time-varying parameters. This can be said to be setting a sufficiently flat prior distribution:

$$\beta_0 \sim N(0, 10I), \quad a_0 \sim N(0, 10I), \quad h_0 \sim N(0, 10I). \quad (13)$$

We also set the same prior distributions for all models and let the distribution of structural shocks be well captured. Hence, we determine these prior distributions:

$$(\Sigma_\beta)_i^2 \sim IG(60, 10^{-4}I), \quad (\Sigma_a)_k^2 \sim IG(6, 2 \times 10^{-2}I), \quad (\Sigma_h)_k^2 \sim IG(6, 2 \times 10^{-2}I). \quad (14)$$

where  $(\Sigma_\beta)_i^2$  are the  $i$ -th elements of  $\Sigma_\beta$ . Also,  $(\Sigma_a)_k^2$  and  $(\Sigma_h)_k^2$  are the  $k$ -th diagonal elements of  $\Sigma_a$  and  $\Sigma_h$ .

From these prior distributions, the extent of time-varying parameters' movements is determined. Tighter prior is set for  $\beta_t$  than  $a_t$  and  $h_t$  to avoid the implausible behaviours of the time-varying parameters following the way of Nakajima (2011a) with considering the datasets. This time, two lags are taken in all models because more than three lags may absorb

the shock of variance<sup>14</sup>. In this paper, we use  $\tilde{\sigma}_i = \Sigma_{t=s+1}^n \exp(h_{it}/2)$  for the average volatility of the structural shock in the sample period.

## 5-2. MCMC Method

In the following, we will explain the way of utilising the Markov chain Monte Carlo (MCMC) method for sampling. This study conducts a Bayesian estimation using the MCMC method based on Nakajima (2011a). First, we define  $y = \{y_t\}_{t=1}^n$ ,  $\beta = \{\beta_t\}_{t=s+1}^n$ ,  $a = \{a_t\}_{t=s+1}^n$ ,  $h = \{h_t\}_{t=s+1}^n$  and  $\omega = (\Sigma_\beta, \Sigma_a, \Sigma_h)$ . Then, from the posterior distribution  $\pi(\beta, a, h, \omega|y)$ , we generate the sample from the posterior probability density function. The steps of MCMC algorithm are as follows:

1. Set initial values of  $\beta, a, h, \omega$ .
2. Sample  $\beta|a, h, \Sigma_\beta, y$ .
3. Sample  $\Sigma_\beta|\beta$ .
4. Sample  $a|\beta, h, \Sigma_a, y$ .
5. Sample  $\Sigma_a|a$ .
6. Sample  $h|\beta, a, \Sigma_h, y$ .
7. Sample  $\Sigma_h|h$ .
8. Go back to 2.

An initial sample of 30,000 is generated and then it is discarded and another sample of 30,000 generated. Next, the sampling frequency is defined as follows. Here, for example,  $\beta|a, h, \Sigma_\beta, y$  represents a conditional distribution of  $\beta$  conditioned on  $(a, h, \Sigma_\beta, y)$ . For further details on sampling using the MCMC method, see Koop (2003) and Nakajima (2011a).

In the following, Geweke's CD statistics and the sample autocorrelations of selected parameters are reported in the tables and figures. The sample autocorrelations listed in Table 3 are the (5, 5) and (15, 15) components of the time-varying parameter  $\Sigma_\beta$ , (1,1) and (3,3) components of  $\Sigma_a$ , (1,1) and (3,3) components of  $\Sigma_h$ . As for CD,  $n_0=1,000$  and  $n_1=5,000$  following Nakajima (2011a). The sample autocorrelation function of these parameters reported in Table 3 is sufficiently converged. Based on these facts, we can say that the convergence with 30,000 sampling is sufficient.

[Table 3]

[Figure 3]

[Figure 4]

[Figure 5]

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<sup>14</sup> Most of the results with three lags were almost the same as with two lags.

[Figure 6]

[Figure 7]

## 6 Results

The results presented in the figures are estimated and drawn by the MATLAB program created by Nakajima (2011a) and arranged by the authors. Before interpreting the results, we will explain the figures of impulse response itself. Following Nakajima and Watanabe (2011), these impulse responses are drawn with posterior medians of the impulse response (solid line, green) and significant influences (dotted line) of 25% and 75%. For example,  $\varepsilon_m \uparrow \rightarrow l$  looks at the response of loans when the BOJ's CAB received a shock. The horizontal axis represents the March 2000 to March 2016 period and the vertical axis shows the size of the response. Focusing on the horizontal axis, the sample period is divided into three periods: the first break is March 2006 and the second break is March 2013. This is determined while considering the policy terms and policy objectives. The figures are arranged to see the impulse response after 6 months to see the short-term and 2 years to see the long-term. From these figures, it is possible to check the impact of monetary policy shocks by time and size of firms.

### 6-1. Result interpretation of Model 1

Looking at the results of Model 1(L,Y,M) (Figs.8–10), effects of monetary easing shock on loans (M→L) differ by the firm size. Specifically, large firms have positive effect after 2010 but no effect in other periods. Middle-sized firms have no significant effect and small firms have a shifted effect from short-term negative to long-term positive. The reason why short-term and long-term effects of monetary policy on loans (M→L) are different in small firms may well be due to portfolio rebalance effects. Another noteworthy point is that the effect from loan shock to IIP (L→Y) is always negative in large and middle-sized firms. This can be thought that these firms are issuing corporate bonds, but do not borrow from banks.

[Figure 8]

[Figure 9]

[Figure 10]

### 6-2. Result interpretation of Model 2

Next, to take into account the possibility that loan stagnation in Model 1 was caused by the supply side of loans, we incorporate BCC to capture fluctuation in the lending standard. In Model 2 (BCC,L,Y,M), we will look at the effects of M→BCC, BCC→L and L→Y.

Looking at the effect from easing shock to BCC(M→BCC) and the effect of BCC shock on loan(BCC→L), we can say that even if the banks' lending standard (BCC) is eased, loans do not increase in large and middle-sized firms. The lending standard affects the loan volume only for small firms. This is probably because BCC can rise due to corporate factors when the corporate performance is good, which leads to a decrease in loan demand. A more detailed study of this

hypothesis will be considered in models that include loan demand (CCC), bank factors (BIC) and corporate factors (BOC)<sup>15</sup>. Moreover, taking the effect of  $L \rightarrow Y$  into consideration, the channel to output through BCC increased output through loan increase ( $BCC \rightarrow L \rightarrow Y$ ), but only in the short term of small firms. To sum up, the effect of monetary policy through the credit channel is limited; however, large and middle-sized firms have a negative effect on output from increasing loans. This is probably because the portfolio rebalancing effect works strongly in large and middle-sized firms. Thus, although easing lending standards has a positive effect on output, it is not thought to have an effect through loans.

[Figure 11]

[Figure 12]

[Figure 13]

### 6-3. Result interpretation of Model 3

In previous models, it is also possible to consider that the easing of shocks' low effects on loans is caused by low loan demand in the first place. Therefore, we will consider Model 3(CCC,L,Y,M). Here, we are going to look at  $M \rightarrow CCC$  and  $CCC \rightarrow L$ .

Focussing on  $M \rightarrow CCC$ , the effect from easing shock on loan demand ( $M \rightarrow CCC$ ) is positive for almost all firm sizes and policy periods. This means that monetary easing certainly affects corporate activities or corporate finance positively. The effect of loan demand shock on loans ( $CCC \rightarrow L$ ) is positive or insignificant in large and small firms. On the other hand, in middle-sized firms, the effect is negative in some periods. This seems strange that an increase in loan demand leads to a decrease in loans. This strange result may be because the financial institutions might have concerns about unstable corporate management and do not increase loans even CCC rises. Considering these results, it can be said that increase in the loan demand (CCC) has a positive effect on loan(L) even if it is different in degree.

[Figure 14]

[Figure 15]

[Figure 16]

### 6-4. Result interpretation of Model 4

Considering the results so far, we can see that the demand for loans is rising in response to monetary easing. This means that the hypothesis we set up in Model 2, 'even if BCC rises, loans

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<sup>15</sup> As another interpretation, there is a possibility that BCC has relaxed the decrease of loan (L).



are sluggish due to decrease in loan demand<sup>7</sup>, turns out to be wrong. Therefore, the reasons for sluggish loan volume are considered with classifying BCC as bank factor (BIC) and corporate factor (BOC).

First, Model 4 (BIC,L,Y,M) can clearly consider the possibility that lending has been sluggish due to bank-side problems such as bad loans and low capital adequacy ratio. Here, we are going to look at  $M \rightarrow BIC$ ,  $BIC \rightarrow L$ ,  $BIC \rightarrow Y$  and  $L \rightarrow Y$ .

Looking at  $M \rightarrow BIC$  and  $BIC \rightarrow L$ , it is possible to say that banking assets might have affected loans to small firms. The reason why the effect of BIC on  $L(BIC \rightarrow L)$  changes is thought to be because bad loan disposal is ongoing in the first policy term until March 2006. In addition, considering IIP while looking at  $BIC \rightarrow Y$ , it was confirmed that the channel of bank assets, or BIC is functioning in all firm sizes<sup>16</sup>. Also, since  $L \rightarrow Y$  has a negative effect in large and middle-sized firms, we can consider the possibility that IIP has increased through the rise in the stock price due to the portfolio rebalancing effect. To sum up, the results of this model tells us that the channel of loan increase through bank assets did not work effectively for large and middle-sized firms. On the other hand, in small firms, this channel seems have worked only for a certain period. However, since the effect of monetary easing shock on BIC ( $M \rightarrow BIC$ ) for small firms is weak, it is considered that the effect of  $BIC \rightarrow L \rightarrow Y$  is not large. Therefore, the bank factor (BIC) explains some of the reasons why lending is sluggish in large and middle-sized firms even though the lending standard (BCC) is eased.

[Figure 17]

[Figure 18]

[Figure 19]

## 6-5. Result interpretation of Model 5

In Model 5 (BOC,L,Y,M), we will focus on the effects of  $M \rightarrow BOC$ ,  $BOC \rightarrow L$  and  $L \rightarrow Y$ .

From the results of  $M \rightarrow BOC$ , monetary easing policy improves the business outlook for large and small firms. Based on this, it is conceivable that some small firms are the subsidiaries of large firms; on the other hand, middle-sized firms do not have sufficient sales channels in overseas nor their managements are becoming unstable due to the exchange rate fluctuations. Indeed, for middle-sized firms, easing shock on IIP ( $M \rightarrow Y$ ) effects are negative<sup>17</sup>. Next, looking at  $BOC \rightarrow L$ , this effect is basically negative for large and middle-sized firms, whereas small firms have a positive effect in second and third policy terms. This is thought to be because large

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<sup>16</sup> Using bank stock prices, Harada and Masujiima (2008) analyse banks' balance sheet channels between 2001 and 2006. They conclude that this channel worked in their sample period based on the results that easing shock has a positive effect on the bank stock price and the bank stock price has a positive effect on the production.

<sup>17</sup> This result is not posted in this paper.

and middle-sized firms can procure their own funds with stocks and corporate bonds when the business outlook improves. In this regard, the channel of BOC on loans is effective only for small firms. At the same time, however, this channel seems to have very weak effect for small firms considering the effect of monetary easing shock on BOC ( $M \rightarrow BOC$ ). In addition, focussing on  $L \rightarrow Y$ , this has a negative effect for large and middle-sized firms. It seems that there is a high possibility that the portfolio rebalancing effect was working. Considering these results, it is conceivable that corporate factors effectively explain the reasons why loans are sluggish in large and middle-sized firms even if the lending standard is eased.

[Figure 20]

[Figure 21]

[Figure 22]

## 7 Conclusion

Below, we review and summarise five models in this sample period. At the end, we then will consider the importance of each transmission channel.

First, we focus on large firms. As the results of this paper show, large firms might have increased IIP through the effect on stock prices caused by portfolio rebalancing. As another hypothesis, we can consider that even if loans to large firms increase, large firms can decrease their output to prepare for corporate finance such as exchange rate fluctuations, or it is also possible to think that loans are devoted to overseas investment and, therefore, are not much reflected in the Japanese IIP. Regarding this possibility, we should consider how firms finance overseas investment, but we set this as a future task. At the same time, we also have to consider the possibility that loans from domestic banks to the foreign branches cause a decrease in the accuracy of estimation in this paper.

Second, it seems that middle-sized firms are unlikely to have a favourable effect by monetary easing policy; rather, they are likely to be influenced negatively due to the instability of management<sup>18</sup>. The reason for this might be because the development of overseas sales is not substantial and preparation for exchange rate fluctuations is not sufficient. Indeed, in most of the results, middle-sized firms have a negative shock from monetary easing on IIP.

Regarding small firms, the effect on IIP through loans tends to be positive compared with other firm sizes. We observed in the long term that easing shock has a positive effect on loan to small firms. However, loans will not grow at the beginning maybe because the management of small firms is not stable. Then, as the performance of small firms becomes stable, loans increase to invest or produce more goods.

To summarise the above points, it can be confirmed that the effect of monetary easing policy on loans and the effect of loan increase on output are different depending on the firm size. This can be because the ways of financing overseas investment and the components of assets—the composition of the balance sheet and the degree of dependence on financial institutions—are different depending on the firm size. The detailed reason as to why the effect of monetary easing differed by the firm size should be considered by looking at more specific portfolio rebalancing effects, which we set as a future task<sup>19</sup>. One more important thing to be mentioned is that the effect on IIP through loans tends not to work positively except for small firms.

In conclusion, we will summarize the importance of each channel.

First, regarding BCC, this channel does not work for large and middle-sized firms. On the other hand, for all firm sizes, CCC had been effective for some periods. Therefore, the reason why loans are sluggish is not explained by demand for loans, but by the bank factors and the

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<sup>18</sup> Regarding the case of Tokyo, the survey about the effect of exchange rate on middle- or small-sized firms' managements are uploaded on the website of The Tokyo Chamber of Commerce and Industry.

<sup>19</sup> Saito and Hogen (2014) investigated the details of portfolio rebalancing and mentioned that the Japanese domestic banks have reacted to the Quantitative and Qualitative Monetary Easing (QQE) policy by rebalancing their portfolios; increasing loans and investment in equities.

corporate factors within the lending standard. In detail, focussing on the bank factors (BIC), we can say that even if BIC rises, it will not lead to a rise in loans for large and middle-sized firms. For small firms, however, loans will increase in the second and third policy terms even this effect is thought to be very weak. In this respect, the effect of bank factors improving loans seems to be small. Next, looking at corporate factors (BOC), only for small firms, loans increase as BOC improves in response to easing shock. This means that the channel through BOC is effective only in small firms. However, as well as BIC, this channel seems to have a very weak effect. Therefore, the reason why the credit channel does not work is explained by BIC and BOC and improvement of these factors does not increase loans and even if it grows, the effect is limited. In summary, it is possible to say that (1) Japanese monetary easing policy had little influence on Japanese output through loans; (2) fluctuation in loan volume is largely explained by the lending standard more than a change in loan demand; (3) broadly speaking, bank factors and corporate factors within the lending standard do not have a positive effect on loans even if they react to monetary easing shock and (4) the channel can be working effectively only for small firms even if the effect is considered to be small.

A more detailed approach on loans and portfolio rebalancing is needed to analyse this with better precision, but these implications are important for central banks when considering the effects of monetary easing policy on loans from the perspective of banks and figuring this channel out from macro-perspective.

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## Appendix: Tables and Figures.

Table 1: Transmission Channel Variables

Variable	Purpose
CCC or demand (cost of capital channel)	To express the loan demand from firms that banks recognise.
BCC (broad credit channel)	To express changes of lending standards to firms that banks recognise.
BIC (bank incentive channel)	To express the volume of financial institutions' sentiment; i.e. how much banks' assets (or balance sheets) affect the lending standard.
BOC (bank observe channel)	This variable expresses the volume of financial institutions' sentiment; i.e. how much is the business outlook for firms affected by the lending standard.

Table 2: Summary of Data and Sources

Data	Description and Source
IIP(Y)	Industrial production index. These data are obtained from the website of the Ministry of Economy, Trade and Industry (seasonally adjusted series, 2010 average = 100).
BOJ current account balances(M)	These data are obtained from the BOJ's website: Monetary base/current account balances/average amounts outstanding. The data are seasonally adjusted by E-views.
Loans and bills discounted by sector (by scale of enterprises) (L)	Loan data are obtained from the BOJ's website except for SME_CAL. Detailed information is on the BOJ's website: <a href="https://www.boj.or.jp/en/statistics/outline/exp/exyo.htm/">https://www.boj.or.jp/en/statistics/outline/exp/exyo.htm/</a> . The following notes are taken from the BOJ's website: 'These data include (1) Domestically licensed banks (banking accounts, trust accounts and overseas office accounts), (2) Shinkin Banks (banking accounts); (3) Other financial institutions (banking accounts), e.g. the Norinchukin Bank, the Shoko Chukin Bank, Development Bank of Japan, Japan Finance Corporation (Micro Business and Individual Unit, Small and Medium Enterprise Unit and Agriculture, Forestry, Fisheries and Food Business Unit), Japan Bank for International Cooperation and the Okinawa Development Finance Corporation'.
L:BIG and L:MID	Large or middle-sized enterprises/corporations including financial corporations, outstanding bank accounts, trust accounts and overseas office accounts and domestically licensed banks. These data are seasonally adjusted by E-views.
L:SME_CAL	Loans for small enterprises (SME_CAL) are calculated by the authors as $(SME\_CAL) = (ALL) - (BIG) - (MID)$ . This is seasonally adjusted by E-views after this calculation. Bank loan amounts of small firms existed at the time of April 2016, but there was a subsequent change in the dataset of the BOJ. Calculations based on the above formula showed that there was almost no difference between these values.
Channel variables	Data from the 'Senior Loan Officer Opinion Survey on Bank Lending Practices at Large

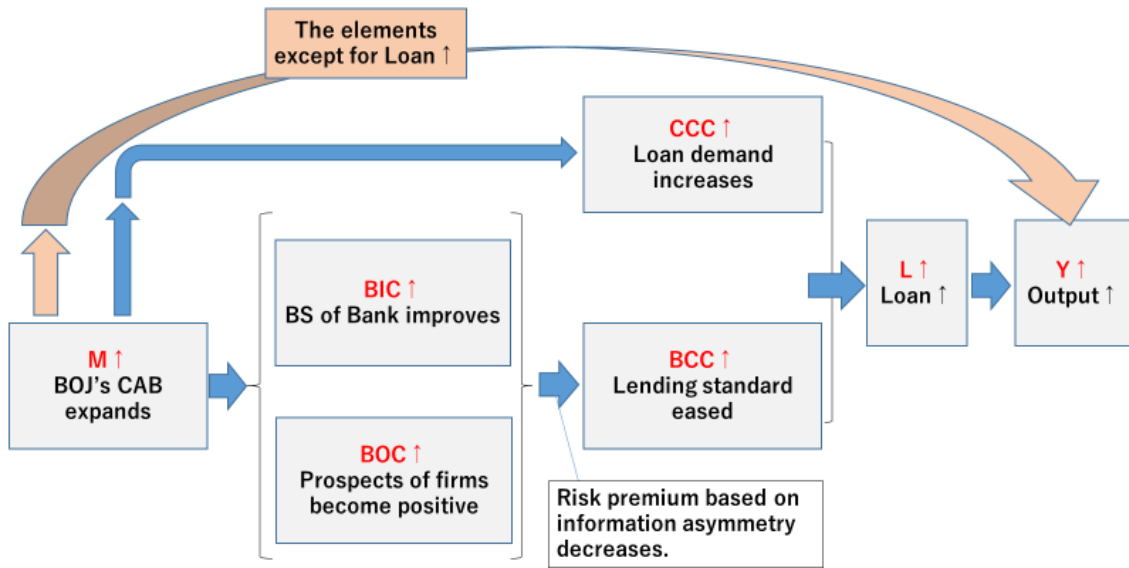
created from SLOS(C)	<p>Japanese Banks' survey is obtained from the BOJ website. The authors then calculated and seasonally adjusted by E-views. An explanation of SLOS is here:  <a href="https://www.boj.or.jp/en/statistics/outline/notice_2000/ntloos01.htm/">https://www.boj.or.jp/en/statistics/outline/notice_2000/ntloos01.htm/</a>.</p> <p>According to the BOJ citation, the aggregated loan amount of the surveyed 50 banks accounts for about 75 percent of the total amount outstanding of loans held by all domestically licensed banks and shinkin banks (the average during fiscal 2015). The questionnaire target is reconsidered every 3 years based on the total amount of loans and was changed in April 2003, 2006, 2009, 2012 and 2015.</p>
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Table 3: Geweke's CD statistics (*p*-value)

Parameter	$(\Sigma_{\beta})_5$	$(\Sigma_{\beta})_{15}$	$(\Sigma_a)_1$	$(\Sigma_a)_3$	$(\Sigma_h)_1$	$(\Sigma_h)_3$
Model 1 Large firms	0.905	0.382	0.665	0.062	0.855	0.117
Model 1 Middle firms	0.543	0.397	0.190	0.919	0.112	0.443
Model 1 Small firms	0.950	0.103	0.398	0.219	0.218	0.475
Model 2 Large firms	0.601	0.372	0.999	0.643	0.276	0.980
Model 2 Middle firms	0.549	0.941	0.243	0.159	0.775	0.717
Model 2 Small firms	0.948	0.096	0.493	0.718	0.254	0.456
Model 3 Large firms	0.983	0.191	0.557	0.589	0.479	0.658
Model 3 Middle firms	0.874	0.214	0.208	0.112	0.501	0.733
Model 3 Small firms	0.739	0.610	0.073	0.393	0.782	0.988
Model 4 Large firms	0.755	0.381	0.060	0.186	0.516	0.718
Model 4 Middle firms	0.820	0.751	0.717	0.840	0.649	0.997
Model 4 Small firms	0.391	0.045	0.547	0.060	0.294	0.386
Model 5 Large firms	0.409	0.403	0.925	0.160	0.060	0.174
Model 5 Middle firms	0.117	0.136	0.627	0.200	0.212	0.481
Model 5 Small firms	0.521	0.959	0.753	0.695	0.093	0.697

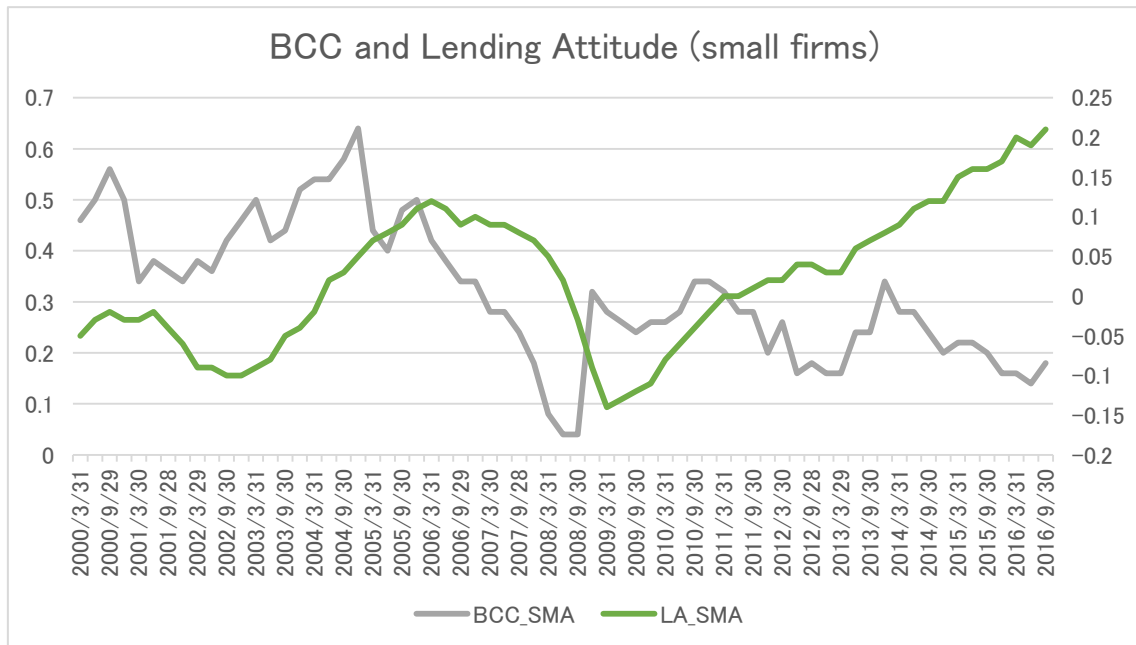


Figure1: Expected framework of transmission channels.



Note: Figures 1 is created by the authors based on Uchida (2013) and Ciccarelli et al. (2015).

Figure2: The movements of BCC and Lending Attitude.



Note: The scale of LA is on the right-side and BCC on left-side. Lending Attitude is observed and calculated by BOJ (see the BOJ's website for detailed information).

Figure3: Sample autocorrelations of Model 1 for selected parameters.

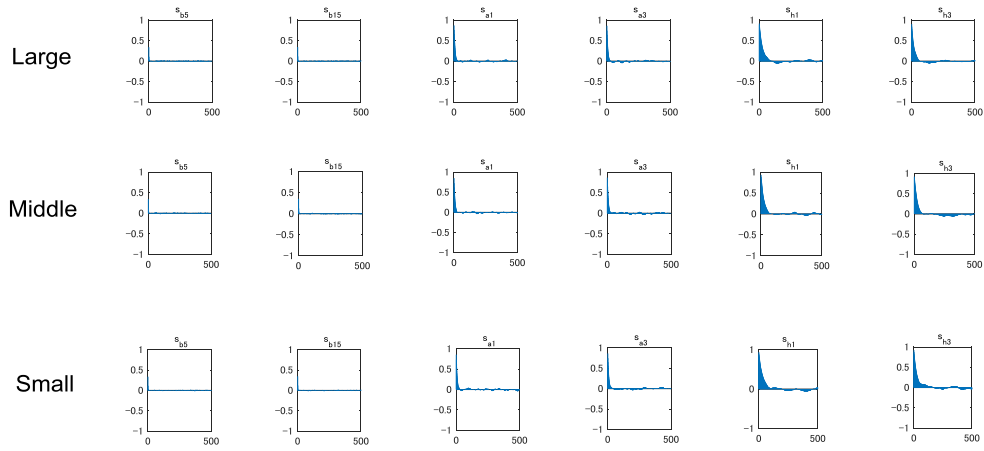


Figure4: Sample autocorrelations of Model 2 for selected parameters.

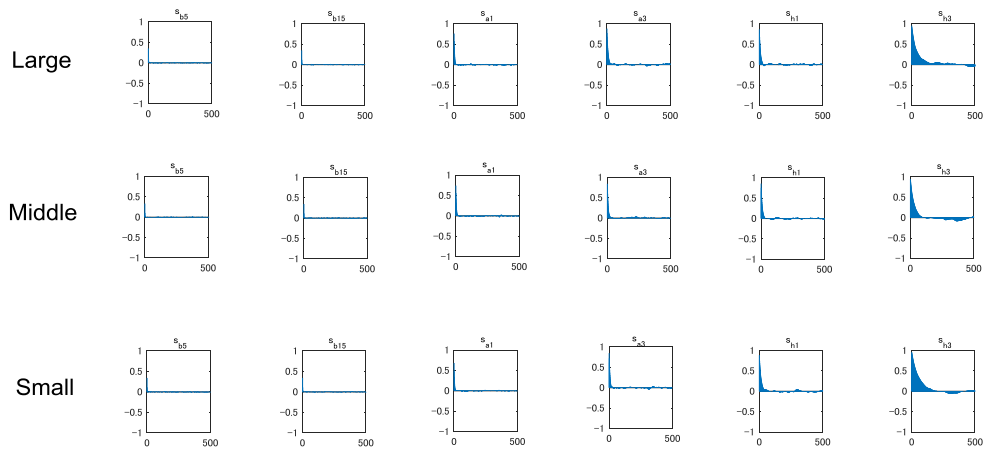


Figure5: Sample autocorrelations of Model 3 for selected parameters.

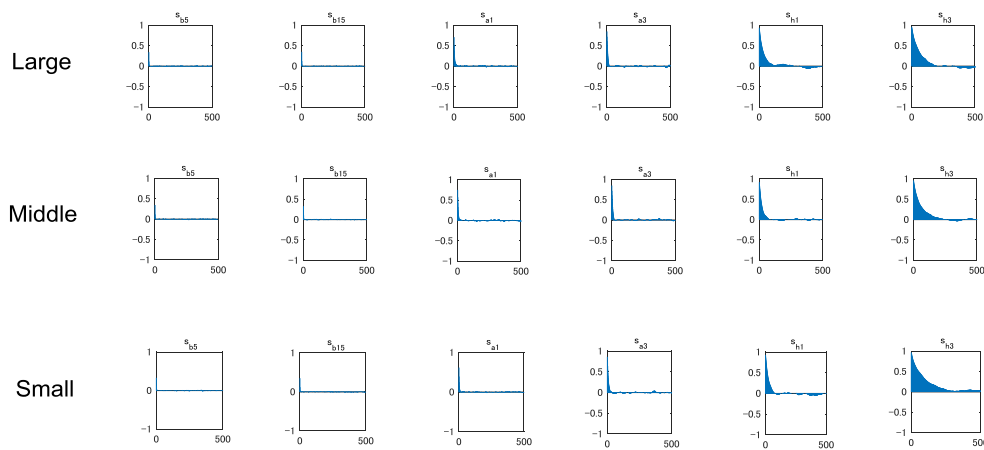


Figure6: Sample autocorrelations of Model 4 for selected parameters.

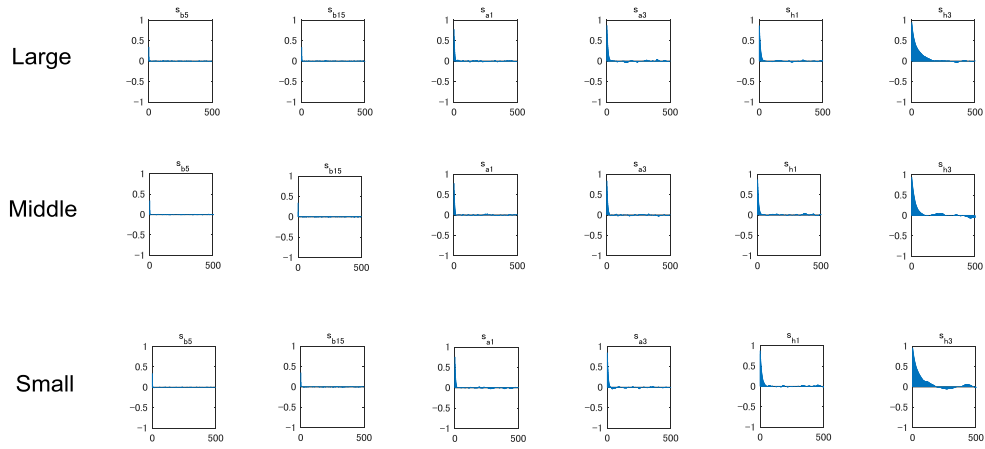


Figure7: Sample autocorrelations of Model 5 for selected parameters.

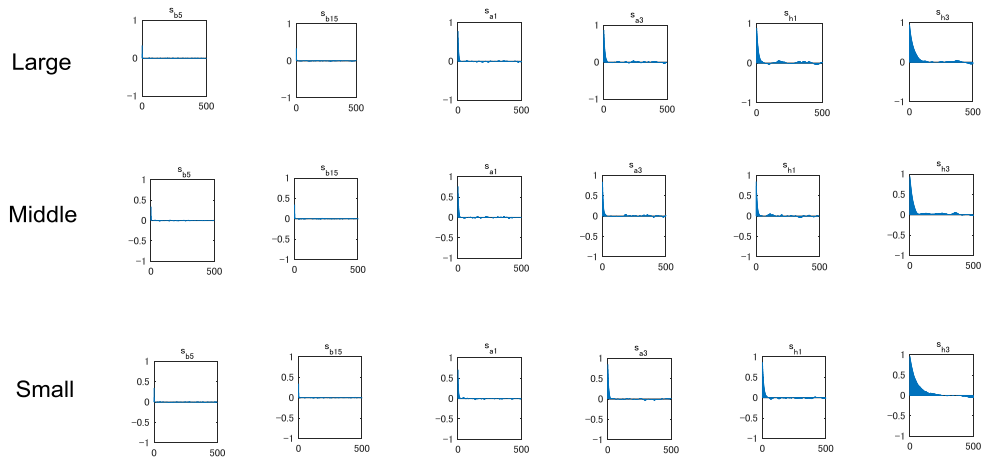


Figure8: Model 1 (large firms)

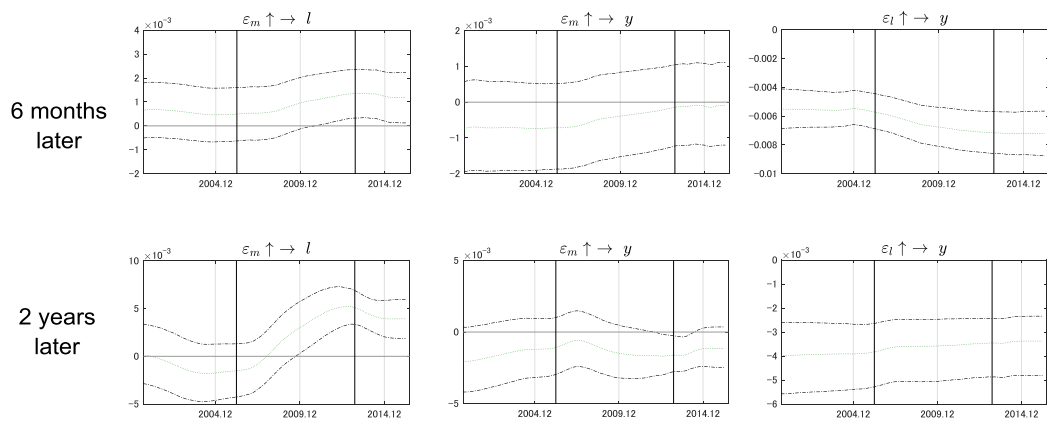


Figure9: Model 1 (middle-sized firms)

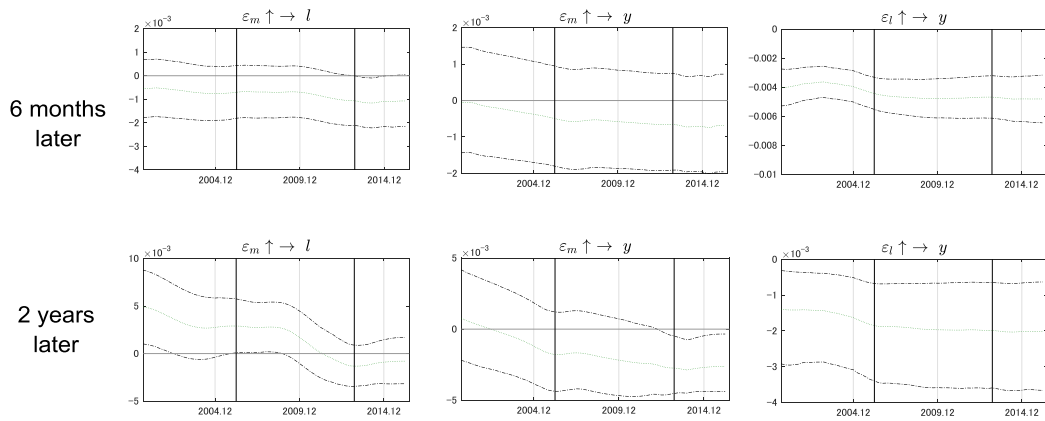


Figure10: Model 1 (small firms)

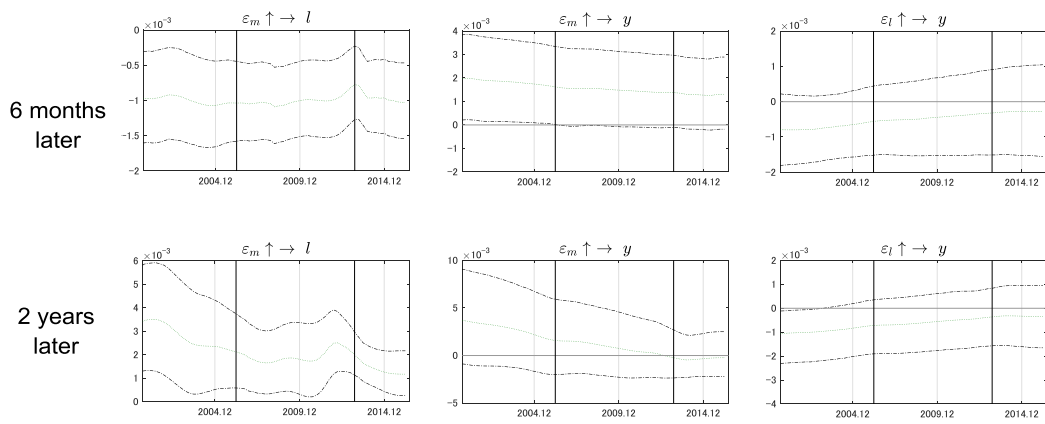


Figure11: Model 2 (large firms). (For simplicity, BCC is indicated as 'bc' in Figs.11–13.)

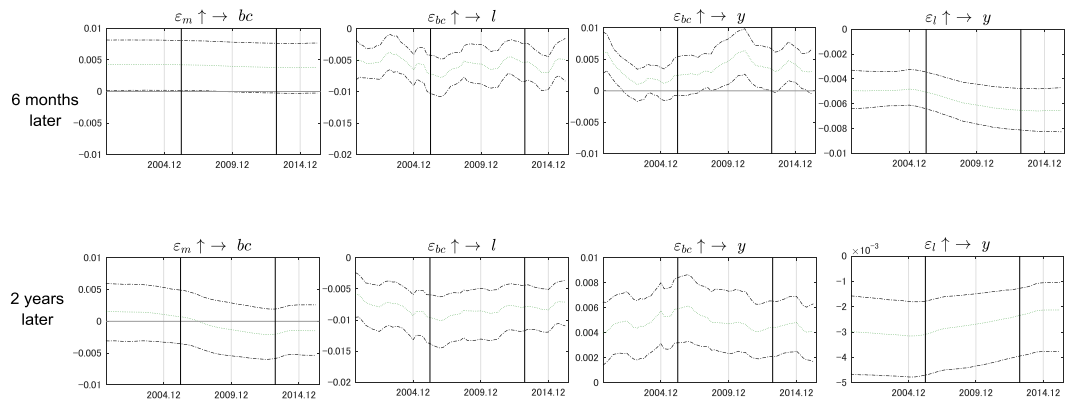


Figure12: Model 2 (middle-sized firms)

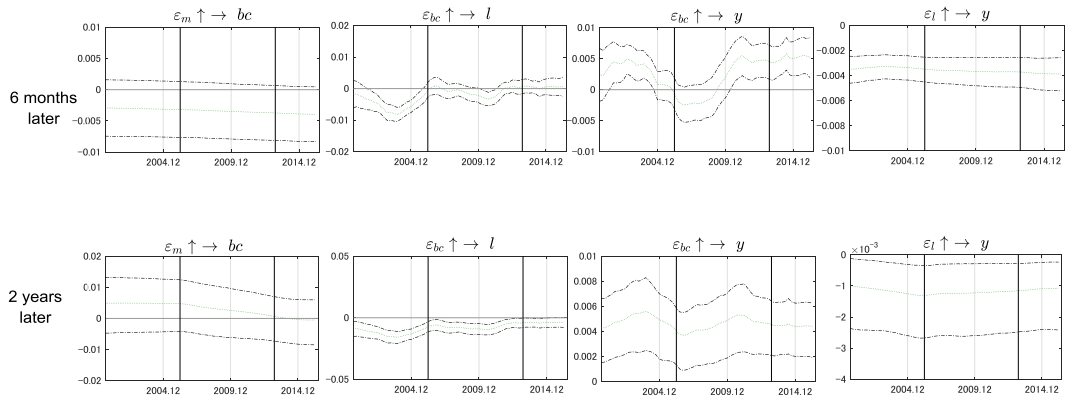


Figure13: Model 2 (small firms)

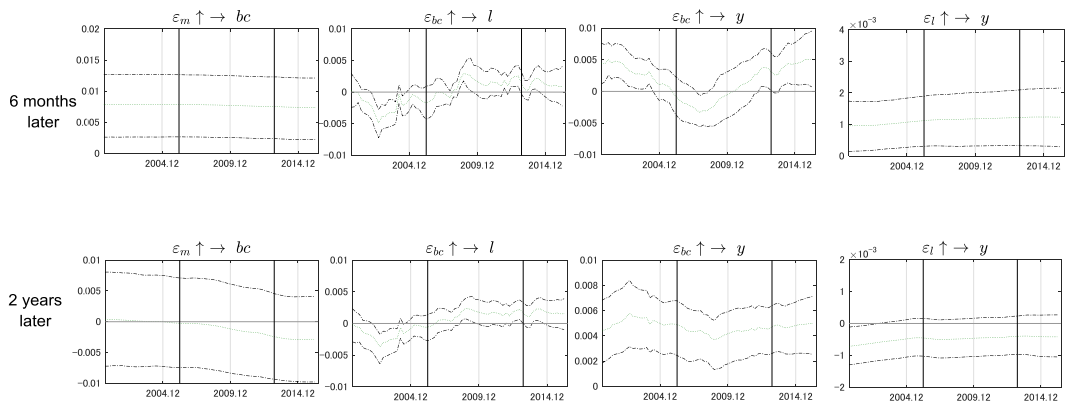


Figure14: Model 3 (large firms). (For simplicity, CCC is indicated as 'cc' in Figs.14–16.)

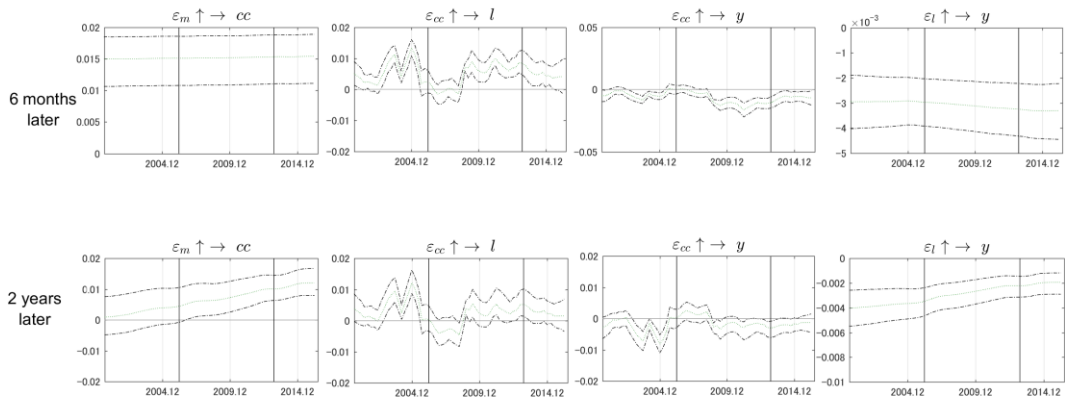


Figure15: Model 3 (middle-sized firms)

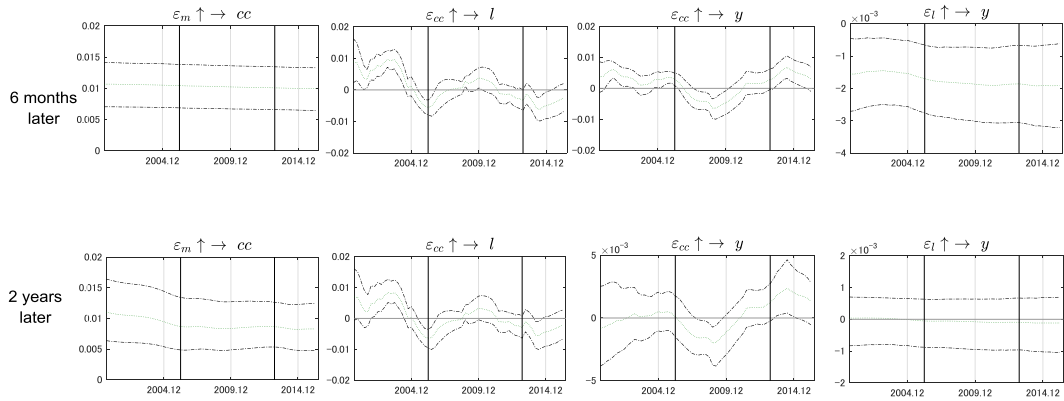


Figure16: Model 3 (small firms)

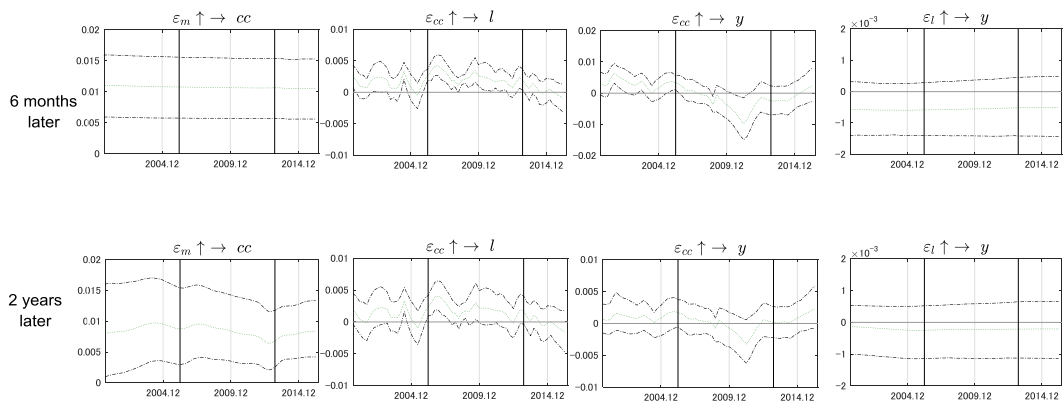


Figure17: Model 4 (large firms) (For simplicity, BIC is indicated as 'bi' in Figs.17–19.)

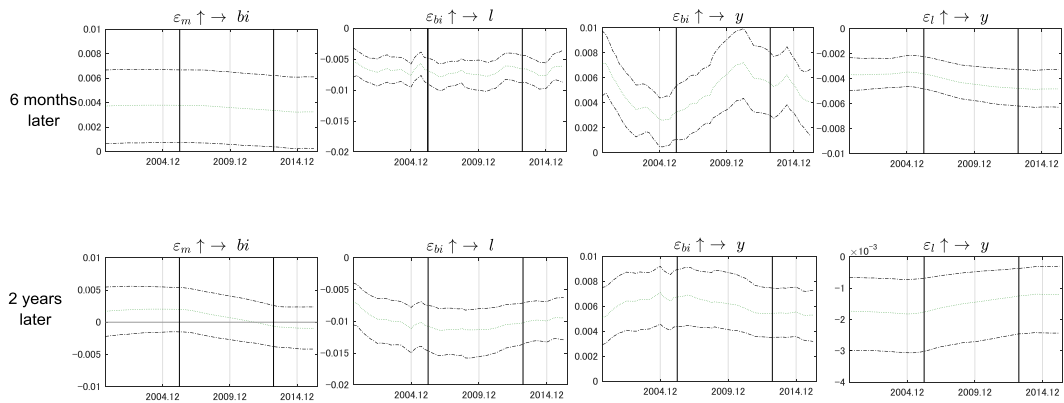


Figure18: Model 4 (middle-sized firms)

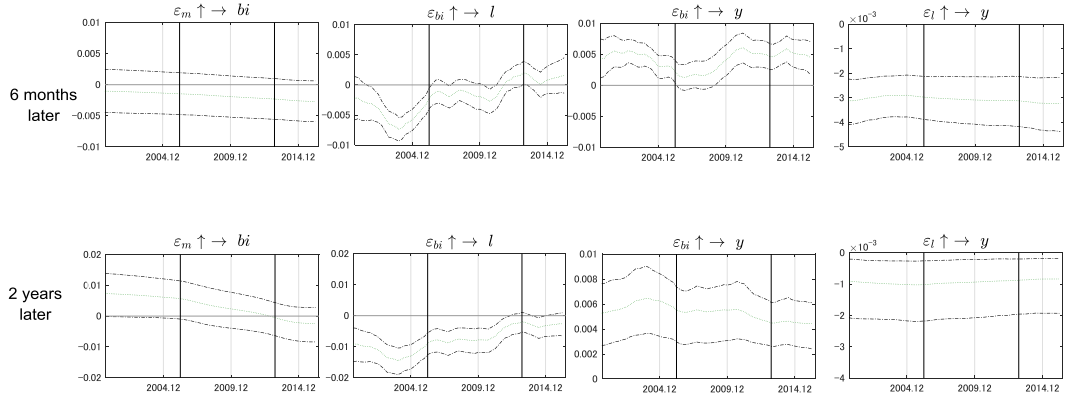


Figure19: Model 4 (small firms)

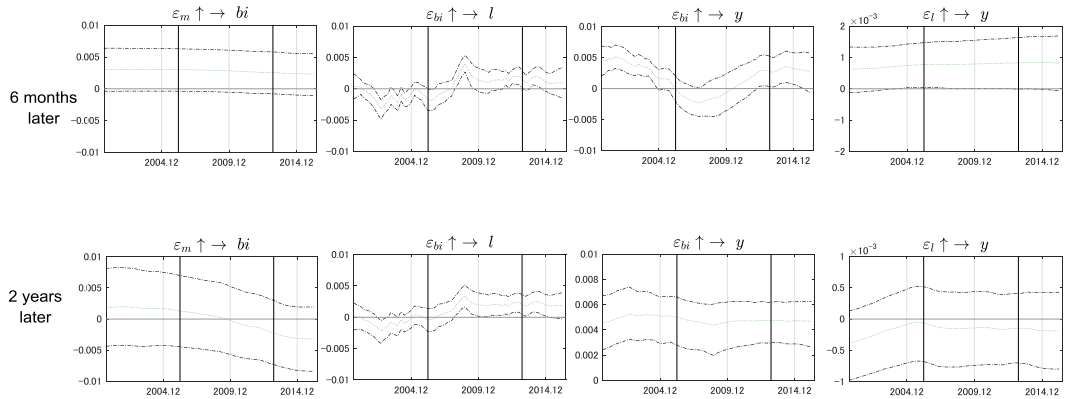


Figure20: Model 5 (large firms). (For simplicity, BOC is indicated as 'bo' in Figs. 20–22.)

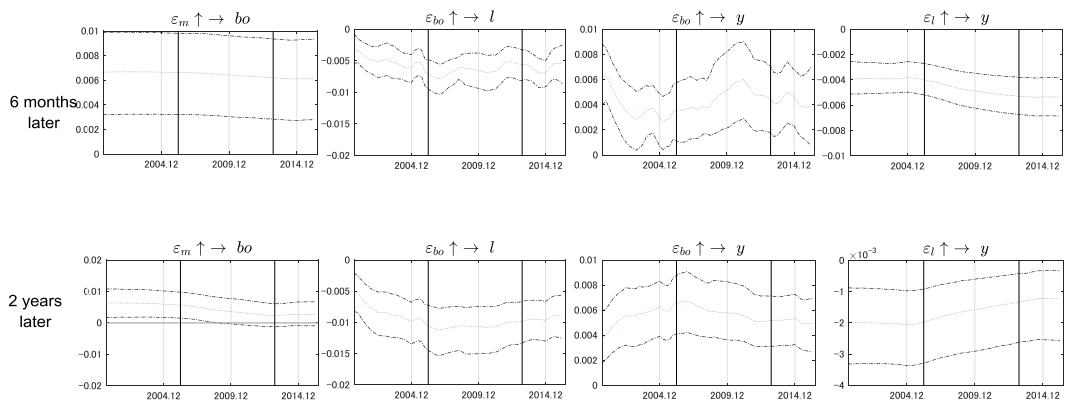


Figure21: Model 5 (middle-sized firms)

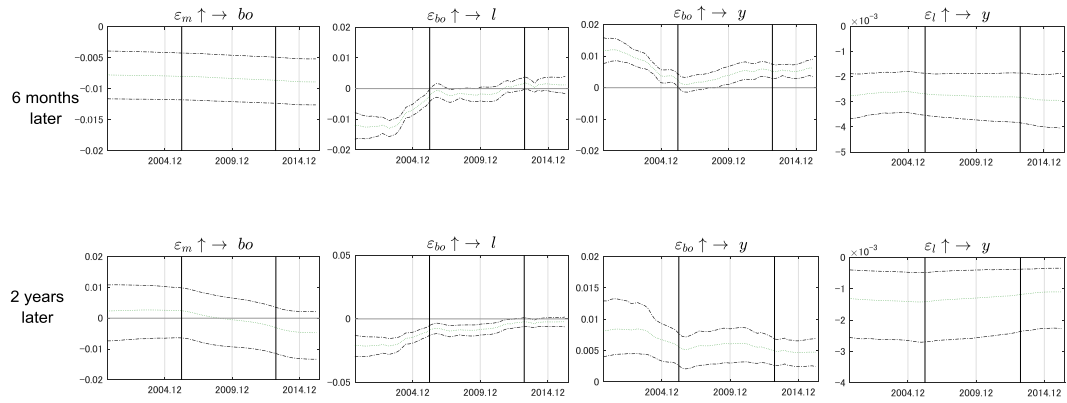


Figure22: Model 5 (small firms)

