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Quantitative Easing Policy, Exchange Rates and Business Activity by Industry in Japan from 2001-2006*

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Abstract

This study empirically investigates the dynamic effect of Japan's quantitative easing (QE) policy on industry-specific business activity using a time-varying parameter model and monthly data spanning 2001-2006. This model yields more reliable and precise results than earlier fixed effects models using quarterly data. Its first major finding is that the effect of QE on yen-dollar exchange rates varied during the period and is most evident in its final phases, whereas its effect on stock prices persisted almost continuously. Second, QE's effect on Japan's real economy—that is, on industrial production—varies by industry and over time. Most notably, QE raised production via yen-dollar depreciation in the machinery sector (e.g. General and Transport machinery), Chemical, Nonferrous metal, and Iron and steel during its latter phases. This study is the first to investigate how unconventional monetary policy influences Japan's real economy by analyzing the yen-dollar exchange rate during the second half of QE implementation in Japan.

Keywords: Quantitative easing (QE) policy, Time-Varying Parameter vector autoregressive (TVP-VAR) model, exchange rates, stock prices, export.

JEL classification: E44; E52; E58

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1 Introduction

1.1 Overview of Japan's quantitative easing policy from 2001-2006

After its financial bubble burst in the early 1990s, Japan entered a lengthy period of economic stagnation. The Bank of Japan (BOJ) introduced a zero interest rate policy in February 1999, reducing its call rate to near zero and aggressively promoting further monetary easing. However, after the collapse of asset bubble, non-performing loans of financial institutions were disposed, leading to insufficient funds supply for real economy, and Japan could not overcome its lengthy stagnation and deflation. With the call rate near zero, the BOJ could not promote further easing via that policy tool, and Japan's macro instability escalated as the IT bubble in the US collapsed. To stabilize Japan's financial system and prevent deflation, on 19 March 2001, the BOJ introduced quantitative easing (QE), switching its policy target from the call rate to current account balances (CAB) held at the BOJ.

[Figure 1]

The BOJ sought to meet the asset demand in the real economy by purchasing government bonds and supplying assets to financial institutions. As a condition for terminating QE, the BOJ specified that growth in the consumer price index (CPI) had to exceed zero percent compared with the same month of the previous year. On 10 October 2003, the BOJ set two more detailed conditions: CPI growth had to exceed zero percent across several months (not a single month) versus the same month of the previous year, and it had to show prospects of not turning negative. On 9 March 2006, the BOJ judged those conditions to be satisfied and terminated QE. Initially, the BOJ had set 5 trillion as its CAB target. During the QE era, however, it raised that target eight times based on economic conditions (Figure 1). Also, the BOJ initially set a fixed numerical value as the CAB target. To enhance flexibility of monetary policy, it set a lower limit after September 2001 and upper and lower limits after December 2001.

1.2 Previous studies

Kamada and Sugo (2006), Iwata (2010) and Schenkelberg and Watzka (2013) evaluate Japan's zero interest rate policy and QE and find that BOJ policy from the 1990s to the 2000s exerted varied effects on Japan's economic structure[1]. Fujiwara (2006), Inoue and Okimoto (2008) and Girardin and Moussa (2011) adopt Markov-switching VAR model. They showed that one of the regimes prevails throughout most of QE period. Therefore, to precisely evaluate QE, it is important to examine only the QE implementation period for analysis data or to use a time-varying parameter model.

[1] Although researchers have extensively examined the effects of QE, they have not yet reached a consensus.

Using monthly data spanning 2001-2006 in a fixed parameter model, Honda et al. (2013) indicate that QE affected Japan's real economy via the stock price channel, not the exchange rate channel. However, financial structures were transforming substantially during QE, and its effectiveness could have varied significantly at differing periods.

Franta (2011), Nakajima et al. (2011), Moussa (2011), Kimura and Nakajima (2013), Michaelis and Watzka (2014) and Kimura et al. (2003) analyse QE using a TVP model with quarterly data[2]. Since the BOJ regularly revised its CAB target at monthly policy meetings, only monthly data can evaluate QE's effectiveness. Ijiri (2015) uses monthly data and a time-varying parameter model VAR (TVP-VAR) to evaluate QE's effect at each point. Data indicate that QE's effects on real economic activity and its main transmission channels varied over time[3]. The stock price channel was effective throughout the entire period, whereas the bank lending and exchange rate channels were only partially effective throughout the QE period.

Following Honda et al. (2013), who indicate that the stock price channel functioned throughout QE, and Ijiri (2015), who indicates the exchange rate channel functioned after 2005 and the stock price channel throughout QE, we examine both channels. Almost all previous studies suggest that the exchange rate channel did not function significantly. Their findings are surprising, as exports dominate Japan's economy and changes in exchange rates affect economic conditions considerably.

[Table 1]

Nevertheless, not all Japanese industries depend on exports, as Table 1 (showing export ratios) confirms. If exchange rates had been a transmission channel for monetary policy during 2001-2006, QE's effect should have differed for each industry. Therefore, it is important to verify industry-specific effects.

Moreover, Ijiri (2015) indicates that QE affected production significantly throughout QE.

[Table 2]

Table 2 shows that each industry ratios by entire manufacturing industry differ greatly for each industry in Japan's macro economy. Therefore, it is important to verify which industries drove economic recovery throughout QE. This study uses the industrial production index of each industry, exchange rates and stock price, following Honda et al. (2013) and Ijiri (2015).

Our main findings are as follows. First, the effect QE exerted on the yen-dollar exchange rate varied over time and was most influential during the final period of the policy implementation, whereas QE stimulated stock prices almost continuously. Second, its effect on the real economy varied by industry and over time. In particular, QE assisted exports in the machinery sector, such as electric and transport machinery, via

[2] In Kimura et al. (2003) use fixed parameter across time for the variances of the structural shock.

[3] Ijiri (2015) examined stock price, exchange rate and bank lending channels, to confirm the transmission mechanism of QE.

exchange rate depreciation. This paper proceeds as follows. Section 2 explains our TVP-VAR model. Section 3 outlines our estimation technique. Section 4 explains estimated results. Section 5 concludes.

2 Model and Estimation

2.1 TVP-SVAR model

We employ the TVP-VAR model in a manner similar to Primiceri (2005), Nakajima (2011) and Nakajima and Watanabe (2011). The TVP-VAR system is given by

$$\Theta_t y_t = \Psi_{1t} y_{t-1} + \Psi_{2t} y_{t-2}, \cdots, + \Psi_{st} y_{t-s} + \epsilon_t \tag{1}$$
$$\epsilon_t \sim N(0, V_t), t = s+1, s+2, \cdots, T$$

where Θ_t and Ψ_{it} are matrices of time-varying coefficients$(n \times n)(i = 1, 2, \cdots, s)$, y_t is a vector of economic variables$(n \times 1)$, ϵ_t is a vector of the fundamental structural shocks $(n \times 1)$, and V_t is a variance-covariance matrix $(n \times n)$[4]. Rewrite (1) as for reduced form as

$$y_t = B_{1t} y_{t-1} + B_{2t} y_{t-2}, \cdots, + B_{st} y_{t-s} + u_t \tag{2}$$
$$u_t \sim N(0, \Theta_t^{-1} V_t \Theta_t^{-1\prime}), t = s+1, s+2, \cdots, T$$

where $B_{it} = \Theta_t^{-1} \Psi_{it}$, and $u_t = \Theta_t^{-1} \epsilon_t$. u_t is an error term vector $(n \times 1)$. Then, the variance of u_t was performed a Cholesky decomposition to impose recursive restriction,

$$\Theta_t^{-1} V_t \Theta_t^{-1\prime} = \Theta_t^{-1} \Sigma_t \Sigma_t{}' \Theta_t^{-1\prime} \tag{3}$$

where Θ_t is a lower triangular matrix in which the diagonal elements are equal to one, and Σ_t is the diagonal matrix[5]. When impulse response analysis is conducted, Θ_t indicated identifying condition for each shock. Then,

$$y_t = X_t \beta_t + \Theta_t^{-1} \Sigma_t e_t \tag{3}$$
$$e_t \sim N(0, I_n)$$

where $\beta_t = vec[B_{1t}{}', \cdots, B_{st}{}']$, and $X_t = I_s \otimes (y_{t-1}{}', y_{t-2}{}', \cdots, y_{t-s}{}')$[6]. Here, the lower triangular elements of Θ_t and the natural logarithm for diagonal elements of Σ_t were defined as $\theta_t = (\theta_{21,t}, \theta_{31,t}, \theta_{32,t}, \cdots, \theta_{nn-1,t})'$ and as $h_t = (h_{11,t}, \cdots, h_{nn,t})'$. Then, the dynamics of these parameters are determined according to random

[4] Θ_t indicates the simultaneous relations among the economic variables.
[5] Σ_t is time-varying SD matrix of ϵ_t.
[6] I is an identity matrix.

walk process:

$$\beta_{t+1} = \beta_t + u_t^\beta \tag{4}$$

$$\theta_{t+1} = \theta_t + u_t^\theta \tag{5}$$

$$h_{t+1} = h_t + u_t^h \tag{6}$$

Moreover, the error term vector of each of the variables is

$$\begin{pmatrix} u_t^\beta \\ u_t^\theta \\ u_t^h \end{pmatrix} \sim N\left(O, \begin{pmatrix} w_\beta & O & O \\ O & w_\theta & O \\ O & O & w_h \end{pmatrix}\right) \tag{7}$$

where it is assumed that (w_β, w_θ, w_h) are diagonal matrices[7].

2.2 Data and Methods

We used monthly data spanning April 1998 to March 2008[8]. Variables include the industrial production index for each industry (y), BOJ CAB (m), the TOPIX sector indices (s), and the real yen-dollar exchange rate for each industry (ex)[9]. We estimated two forms of the model: Model 1 (y, m, ex) and Model 2 (y, m, ex, s) for each industry. The orders of variables are described. Previous studies indicate that the stock price channel for the real economy functioned during the QE implementation periods. However, Fujiwara (2013) indicates that a synoptic correlation with exchange rates and stock price arose after 2005. Moreover, the prior timing correlation of exchange rates increased after 2005. Therefore, for the 2000s period in Japan, it is important to note that QE reduced the exchange rate, raised stock prices and then boosted production[10].

We modified the program of the TVP-VAR model in Nakajima (2011) to simulate impulse response analysis[11]. Deriving from Nakajima ' s (2011) study, we conducted a Bayesian estimation using the Markov chain Monte Carlo method. We generated an initial sample of 30,000, discarded it and generated another

[7] The dimensions of w_β, w_θ, and w_h are $(n^2s \times n^2s), ((n^2 - n)/2 \times (n^2 - n)/2)$, and $(n \times n)$.

[8] All data are logarithmic and demeaned.

[9] TOPIX sector indices are end-of-month values. The exchange rate is the actual yen-dollar rate of each industry. We prepared the data from nominal yen-dollar exchange rate and the Producer Price Index of each industry in the US and Japan. Current Account Balances and the Producer Price Index are seasonally adjusted using X-12 ARIMA. Other data are seasonally adjusted. The industrial production index of each industry is sourced from the Ministry of Industry, Trade and Economy. Other data were sourced from Datastream.

[10] In the Appendix, we check the impulse responses of stock prices to positive exchange rate shocks.

[11] The estimation of outline appears in the Appendix.

sample of 30,000. The initial state of the time-varying parameters is set as follows:

$$\beta_0 \sim N(0, 10I)$$

$$\theta_0 \sim N(0, 10I)$$

$$h_0 \sim N(0, 10I)$$

where $\tilde{w}^2_{\beta i}$ are the i-th elements of w_β and $\tilde{w}^2_{\theta j}, \tilde{w}^2_{hj}$ are the k-th diagonal elements of w_θ, w_h. The priors of Models 1 and Models 2 are assumed as:

$$\tilde{w}^2_{\beta i} \sim IG(50, 0.001)$$

$$\tilde{w}^2_{\theta k} \sim IG(5, 0.001)$$

$$\tilde{w}^2_{hk} \sim IG(5, 0.001)$$

We set two lags in each model. Estimated results for impulse responses are similar to those generated by setting three lags and are given in the next section[12].

[12]Stability of the estimated results is discussed in the Appendix.

3 Estimated results

3.1 Main results

This section discusses impulse responses by industry. Figures 2-7 and 9-20 show the impulse responses of Models 1 and 2. They vary over time because parameters are in a TVP-VAR estimation. These figures illustrate each variable's responses six months and one year after monetary easing. The horizontal axis represents the January 2000 to December 2006 period; the impulse responses are calculated with parameters estimated for each point in time. The vertical axis denotes the size of the response. Based on 30,000 samples, the solid lines indicate posterior medians of the impulse responses. The dashed lines represent the 25th and 75th percentiles, indicating significant influence, as per Nakajima and Watanabe's (2011) study. The two solid vertical lines show the starting and ending dates of QE implementation: March 2001 and March 2006, respectively. The monetary policy shock is represented by one standard error of the estimated structural shocks, averaged over all the periods in each model. The following section focuses on QE by period and examines impulse responses from each model. In the following, the first period spans the start of QE (March 2001) to around 2004. The second period spans 2004 to the end of QE, i.e., March 2006.

[Figure 2]

[Figure 3]

[Figure 4]

[Figure 5]

[Figure 6]

[Figure 7]

Figures 2-7 illustrate responses in the machinery sector (General, Transport and Electric machinery). There is a possibility that QE caused the yen-dollar exchange change rate to depreciate and stimulated both exports and the real economy. This mechanism holds for the machinery sector because of its dependence on exports (Table 1). Model 1 (Figures 2, 4, 6) indicates that QE diminished the real yen-dollar exchange change rate in the sector, especially during its second period. The influence of exchange rates on industrial production was remarkably significant for Transportation machinery and almost universally positive and significant for Electrical and General machinery. These results indicate that exchange rates were QE's primary transmission channel during its second period.

Figures 3, 5 and 7 display results from Model 2 for the machinery sector. Stock prices for firms in General and Transport machinery responded positively throughout QE. For General machinery, industrial production exhibits a larger response than that in Model 1 throughout the indicated periods. Responses in the Transport machinery industry are larger than in Model 1 during the second period. These findings suggest that stock prices boosted production and thereby transmitted QE to the real economy during the periods at each industry. The Electric machinery industry's significant response to lower exchange rates diminishes during the second period compared with Model 1. Thus, the exchange rate was a limited transmission channel during the second period.

[Figure 8]

Figure 8 indicates the terms of trade index. The gap for the Electric, General and Transport machinery industry grew after 2003, when the Electric machinery sector could not shift higher material costs to consumers. The weak yen stimulated export production, but the higher cost of material was damaging. The impulse response to exchange rates is not significantly positive, and stock prices show only a slightly significant positive response. Thus, exchange rates and stock prices were not significant channels for QE's functioning. However, it may be that industrial production exhibited multiple responses during the second period. During the first period, stock prices responded positively and significantly. From the middle of the first period, industrial production rose slightly compared to responses in Model 1. Therefore, the stock price channel functioned from the mid-first period to the end.

[Figure 9]

[Figure 10]

[Figure 11]

[Figure 12]

[Figure 13]

[Figure 14]

[Figure 15]

[Figure 16]

Figures 9-16 summarize impulse responses for the primary materials sector, which includes Chemicals, Fabricated metals, Nonferrous metals and Iron and steel. Initially, in Model 1, industrial production and exchange rates for Chemicals and Nonferrous metals responded significantly and positively during the second period. As with the machinery sector, Chemicals shows higher exposure exports in Table 1. The positive responses of industrial production and exchange rates were due to higher export production associated with the weak yen.

The Nonferrous metals industry shows a relatively low ratio of exports in Table 1, but industrial production and exchange rates show significantly positive responses during the second period. That result arises because the Nonferrous metals industry delivered components to the machinery sector, and demand for its components rose with the latter's export production. Industrial production and stock prices show significant positive responses during the first and second periods. In short, stock prices channeled monetary policy and boosted production throughout QE.

Production in the Iron and steel industry shows a significantly positive response to exchange rates around 2004, relatively earlier than other industries. Dependent on imported material inputs, Iron and steel suffered higher costs from the weak yen, but it enjoyed greater demand from China after 2000 and was able to absorb higher costs by raising prices. Figure 8 indicates the terms of trade index rose from mid-2004 to 2005 despite the weak yen. The post-2004 response of industrial production is not significantly positive because the response to exchange rates, although positive, was not sufficient to offset increasing costs. In Model 2, stock prices in the industry responded significantly and positively throughout QE, and industrial production is significantly positive except for the final year of QE. This result suggests stock prices channeled QE to the real economy and boosted production. In Models 1 and 2, the production response for fabricated metals is not significantly positive because the industry was declining compared with others in Table 2 and benefited less from QE.

[Figure 17]

[Figure 18]

[Figure 19]

[Figure 20]

Figures 17-20 show responses for Textiles and Paper & pulp in Models 1 and 2. Industrial production for Paper and pulp shows a significantly positive but small response to exchange rates. Its response to stock prices is not significantly positive. Textile industry production shows no significantly positive response to exchange rates or stock prices. As with fabricated metals, that industry also is declining, and QE had limited effect.

3.2 QE policy and yen-dollar rate in the 2000s

Japan's QE led to a depreciation of the yen versus the dollar, especially around 2004 and 2005. Three factors facilitated its depreciation.

[Figure 21]

The first was a discrepancy between Japanese and US monetary policies reflected in the significant interest rate differences in Figure 21. Japan's robust QE significantly lowered intermediate-term and long-term interest rates, whereas the US federal funds rate had been rising since 2004 against the backdrop of a housing bubble. Second, during the early 2000s, investors borrowed low-cost yen to buy higher-yielding assets worldwide. This practice accelerated the yen's depreciation under a widening US-Japan interest rate gap. Third, massive foreign market intervention in 2004 influenced the exchange rate. From August 2003, speculators shifted to yen as Iraq destabilised. As the yen-dollar appreciated sharply, Japanese authorities intervened in amounts estimated to exceed $3 trillion, reversing foreign market sentiment ever since.

4 Conclusions

Japan's policy of QE from 2001-2006 was the world's first trial of unconventional monetary policies. Although numerous studies argue its effects, empirical studies are unsatisfying because earlier fixed-parameter VAR models disregard the dynamic nature of QE's effectiveness, and time-varying VAR models use quarterly data that do not capture substantial monthly changes. Moreover, no study focuses on industry-specific effects of QE. These are serious shortcomings, especially because export demand drives Japan's macro economy—albeit not uniformly among all industrial sectors. This study has offered a fuller investigation of the effects of Japan's QE by adopting a time-varying parameter model with monthly data and examining QE's effects on export-sensitive sectors such as machinery.

The study has produced two signature findings. First, QE diminished the yen-dollar exchange rate and stimulated production in the machinery sectors (General and Transport machinery), Chemical, Nonferrous metal, and Iron and steel during its final period of implementation. Second, QE expanded stock prices throughout its period of implementation and raised production in almost all industries (excluding Fabricated metals, Textile, and Iron and steel.).

Although further study should consider a fuller range of transmission channels, our results confirm the high likelihood that the exchange rate and stock prices stimulated Japan's real economy during QE. These findings are crucially important for central banks in developed countries that have adopted QE during recent years.

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Appendix

Outline of estimation

This study conducts a Bayesian estimation using the Markov chain Monte Carlo (MCMC) method based on Nakajima's (2011) study. To begin with, $y = \{y_t\}_{t=s+1}^{T}, \beta = \{\beta_t\}_{t=s+1}^{T}, \theta = \{\theta_t\}_{t=s+1}^{T}, h = \{h_t\}_{t=s+1}^{T}$ and $w = (w_\beta, w_\theta, w_h)$ are defined. Moreover, a sample is obtained from the posterior probability density function $\pi(\beta, \theta, h, w|y)$ by the following order. An initial sample of 30,000 is generated. Then, it is discarded and another sample of 30,000 generated. Next, the sampling frequency is defined as $j = 1, 2, \cdots, 30,000$. The sample of j times is defined as $(\beta^j, \theta^j, h^j, w^j)$. The steps of MCMC algorithm are as follows:

1. Set initial values of $\beta^0, \theta^0, h^0, w^0$
2. Sample β^{j+1} from $\pi(\beta|\theta^j, h^j, w_\beta^j, y)$
3. Sample θ^{j+1} from $\pi(\theta|\beta^{j+1}, h^j, w_\theta^j, y)$
4. Sample h^{j+1} from $\pi(h|\beta^{j+1}, \theta^{j+1}, w_h^j, y)$
5. Sample w_β^{j+1} from $\pi(w_\beta|\beta^{j+1})$
6. Sample w_θ^{j+1} from $\pi(w_\theta|\theta^{j+1})$
7. Sample w_h^{j+1} from $\pi(w_h|h^{j+1})$
8. Perform sampling repeatedly from step 2 to step 7 until $j = 30,000$

Stability of estimated results

[Figure 22]

[Figure 23]

Figures 22 and 23 show autocorrelations of samples generated in Models 1 and 2[13]. Here, (β, θ, h) is the element $(1, 1)$ of November 1999. Moreover, in Models 1 and 2, (w_β, w_θ, w_h) are the element $(1, 1)$. Figures 22 and 23 illustrate that the autocorrelation of each parameter attenuates sufficiently, indicating that the method efficiently produces samples with low autocorrelation.

[Table 3]

[Table 4]

Furthermore, in Tables 3 and 4, we check the p value of Geweke's convergence diagnostics statistics for a number of parameters for each model[14]. The hypothesis does not meet the 10% significance level, indicating efficient generation of estimated samples for each model.

[13]The vertical line shows the autocorrelation function; the transverse axis shows sampling frequency (300 of 30,000 samples).

[14]The null hypothesis indicates that the sample converges in the posterior distribution of the parameter in each model. See Geweke (1993).

Response of stock prices to positive exchange rates shock

[Figure 24]

Almost all industries display positive responses to positive exchange rate shocks.

	Export share			Import input share
Year	2000	2003	2006	2000
General machinery	28.22%	31.18%	33.31%	0.093
Electric machinery	32.04%	37.26%	43.55%	0.184
Transport machinery	28.98%	30.35%	34.49%	0.032
Chemical	14.78%	17.46%	21.32%	0.117
Textile	22.46%	27.98%	32.64%	N.A
Fabricated metals	4.22%	5.17%	6.66%	0.098
Primary metal	11.43%	13.85%	16.01%	N.A
(Nonferrous metal)	N.A	N.A	N.A	0.052
(Steel)	N.A	N.A	N.A	0.070
Paper and pulp	3.43%	3.99%	4.65%	N.A

Table 1: Export share and import input share by industry

	2000	2003	2006
General machinery	9.51%	8.88%	10.13%
Transport machinery	14.19%	17.22%	17.50%
Electric machinery	17.89%	15.43%	14.15%
Chemical	8.73%	9.14%	8.94%
Fabricated metals	4.49%	4.24%	4.01%
Primary metal	7.79%	8.22%	11.50%
Textile	0.95%	0.81%	0.65%
Paper and pulp	2.93%	2.82%	2.50%

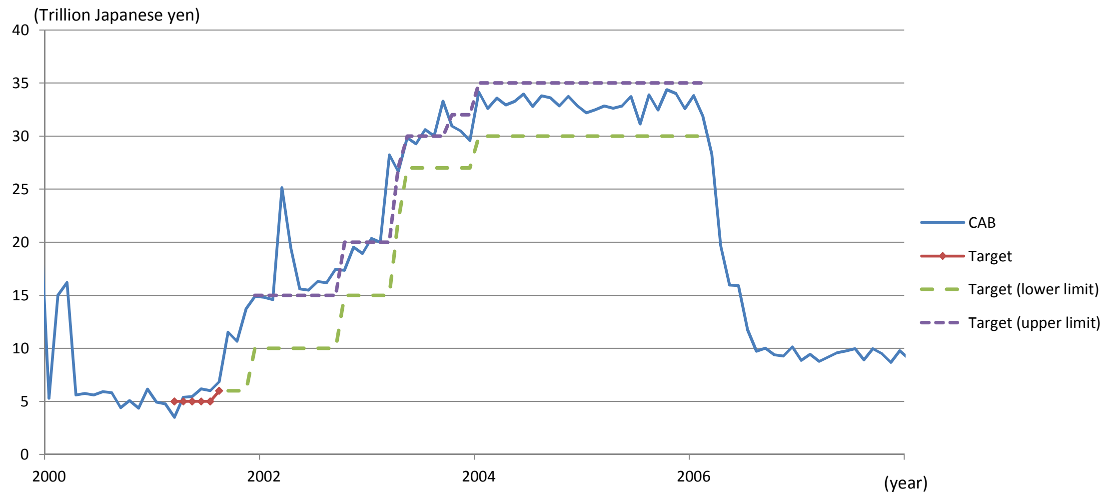
Table 2: Each industry share by total manufacturing industry

Parameter	β	θ	h	w_β	w_θ	w_h
General machinery	0.654	0.253	0.493	0.542	0.701	0.252
Transport machinery	0.750	0.927	0.114	0.731	0.148	0.104
Electric machinery	0.984	0.693	0.516	0.924	0.243	0.243
Chemical	0.676	0.530	0.816	0.955	0.149	0.907
Fabricated metals	0.266	0.278	0.984	0.711	0.447	0.156
Nonferrous metals	0.995	0.811	0.692	0.845	0.840	0.794
Iron and steel	0.365	0.148	0.932	0.275	0.129	0.828
Textile	0.199	0.943	0.573	0.247	0.822	0.364
Paper	0.916	0.668	0.995	0.193	0.180	0.792

Table 3: CD statistics (p-value) of Model 1

Parameter	β	θ	h	w_β	w_θ	w_h
General machinery	0.619	0.929	0.271	0.617	0.396	0.375
Transport machinery	0.652	0.496	0.388	0.572	0.644	0.685
Electric machinery	0.540	0.677	0.850	0.427	0.762	0.430
Chemical	0.133	0.717	0.275	0.547	0.968	0.650
Metal	0.143	0.452	0.579	0.201	0.514	0.187
Nonferrous metal	0.856	0.157	0.863	0.116	0.181	0.726
Iron and steel	0.872	0.149	0.277	0.825	0.636	0.663
Textile	0.267	0.539	0.124	0.362	0.153	0.236
Paper	0.317	0.212	0.649	0.375	0.568	0.483

Table 4: CD statistics (p-value) of Model 2



(Note) The time series of CAB was adusted by X-12-ARIMA (E-views).
(Source) Datastream

Figure 1: Current Account Balances (CAB) and target

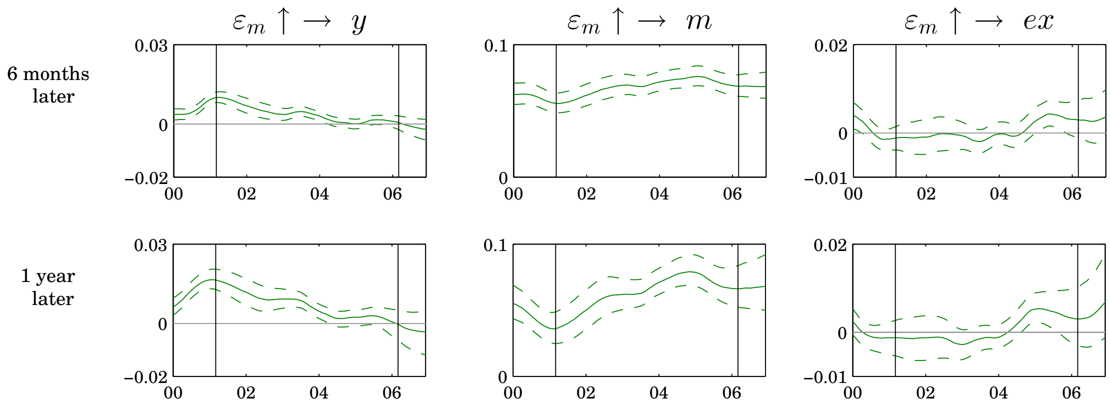


Figure 2: The impulse responses of Model 1 (General machinery)

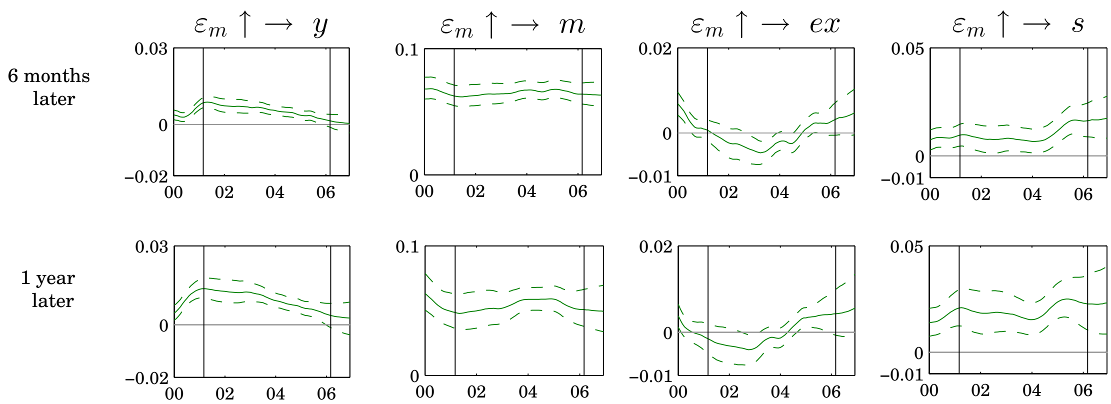


Figure 3: The impulse responses of Model 2 (General machinery)

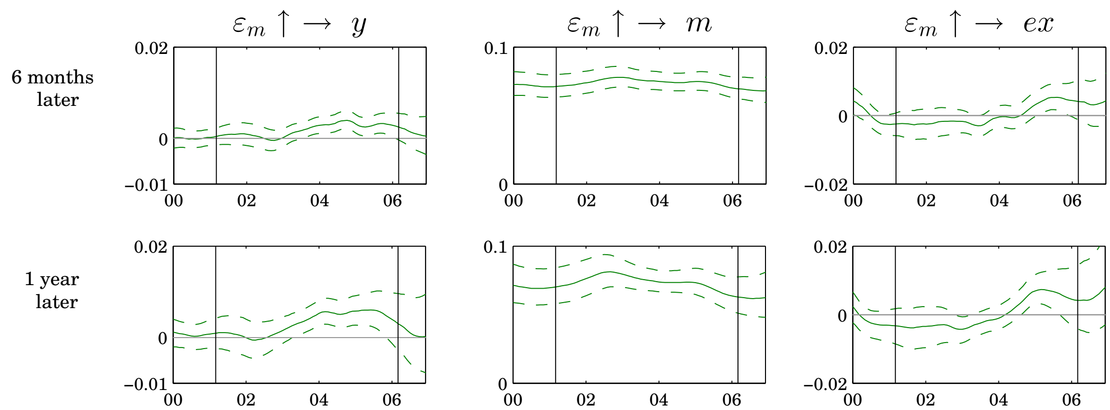


Figure 4: The impulse responses of Model 1 (Transport machinery)

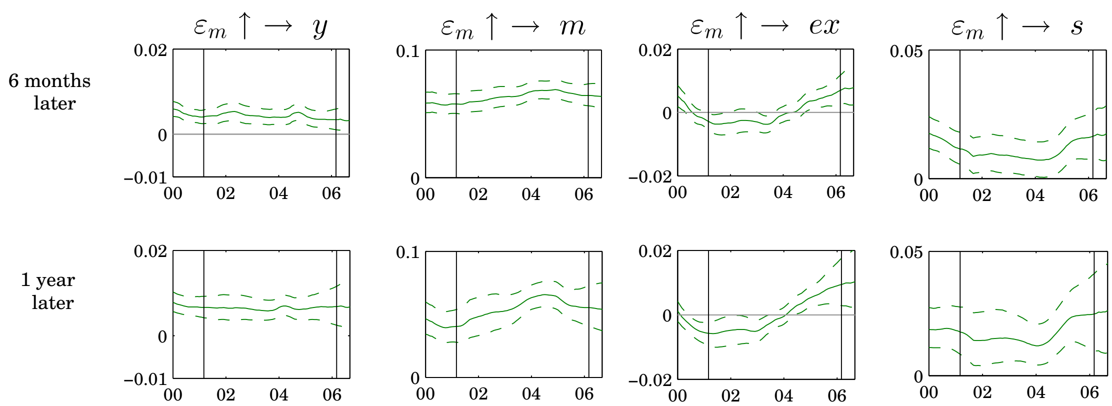


Figure 5: The impulse responses of Model 2 (Transport machinery)

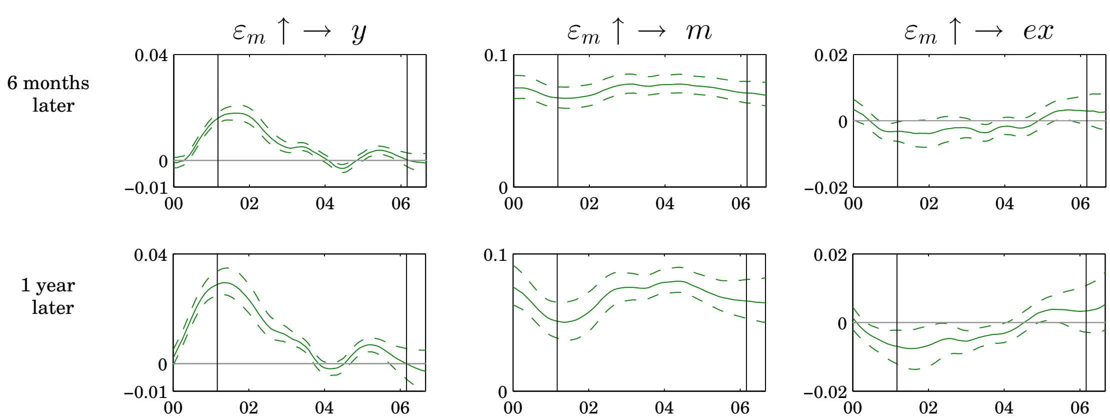


Figure 6: The impulse responses of Model 1 (Electric machinery)

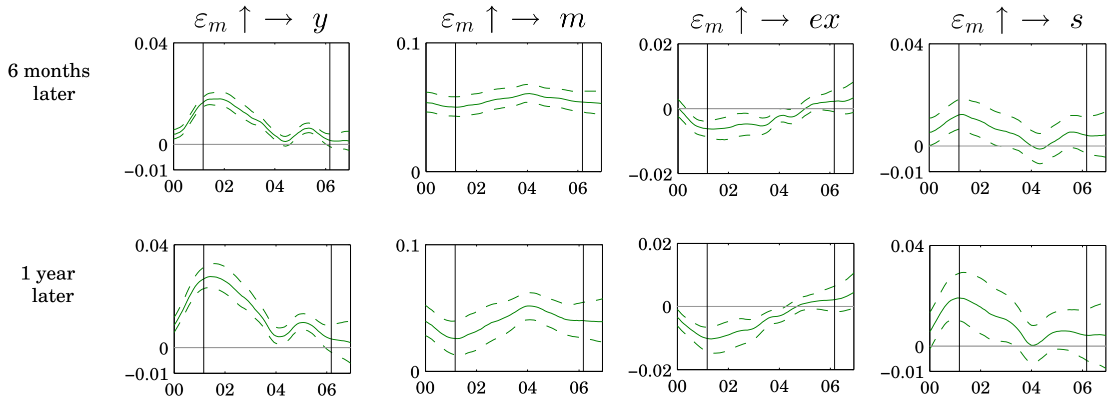


Figure 7: The impulse responses of Model 2 (Electric machinery)

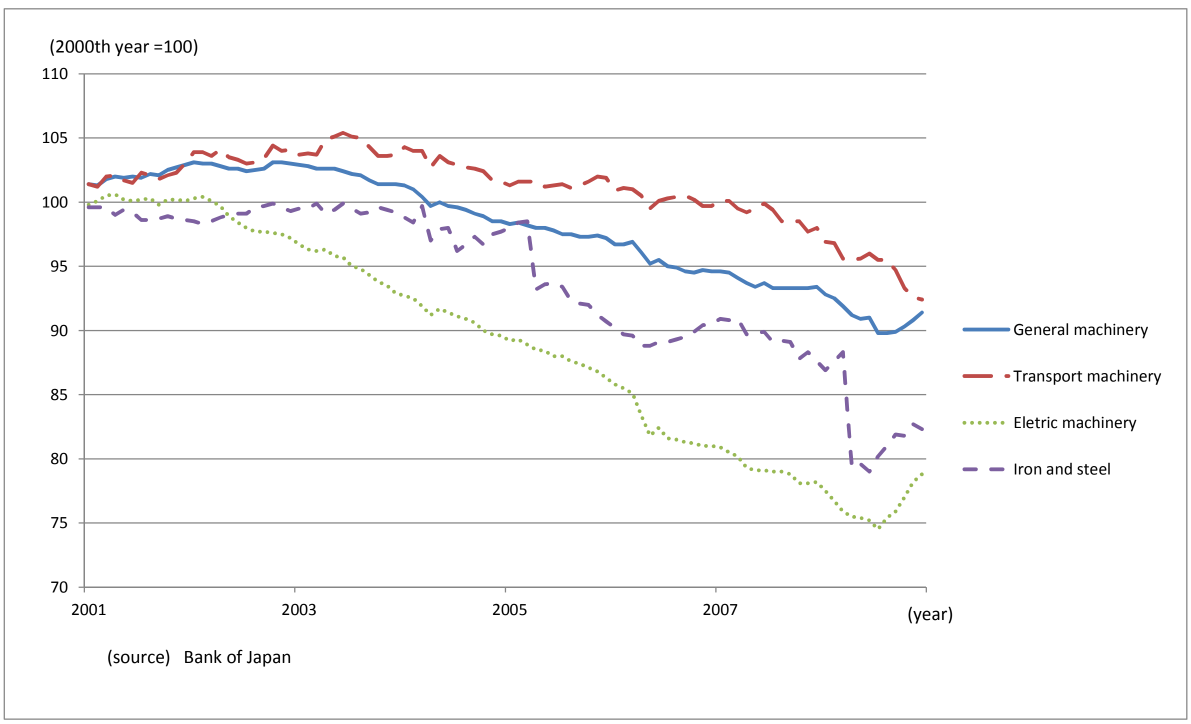


Figure 8: Terms trade index

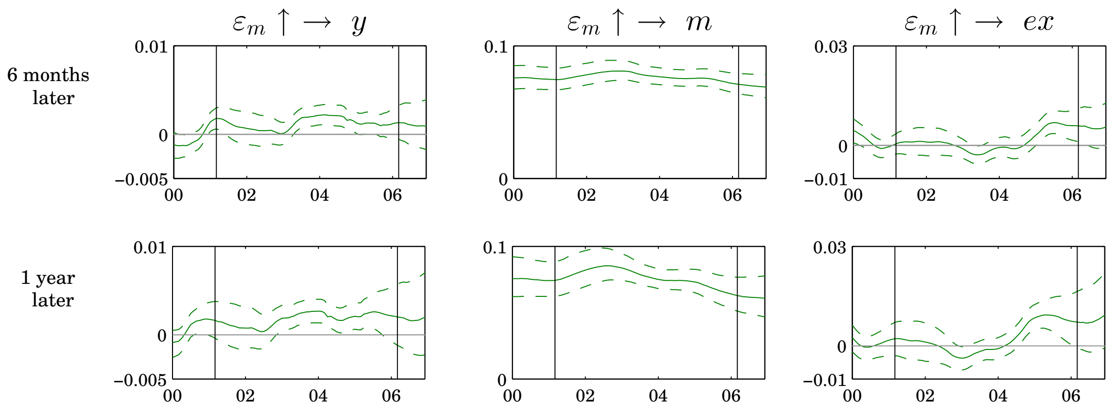


Figure 9: The impulse responses of Model 1 (Chemical)

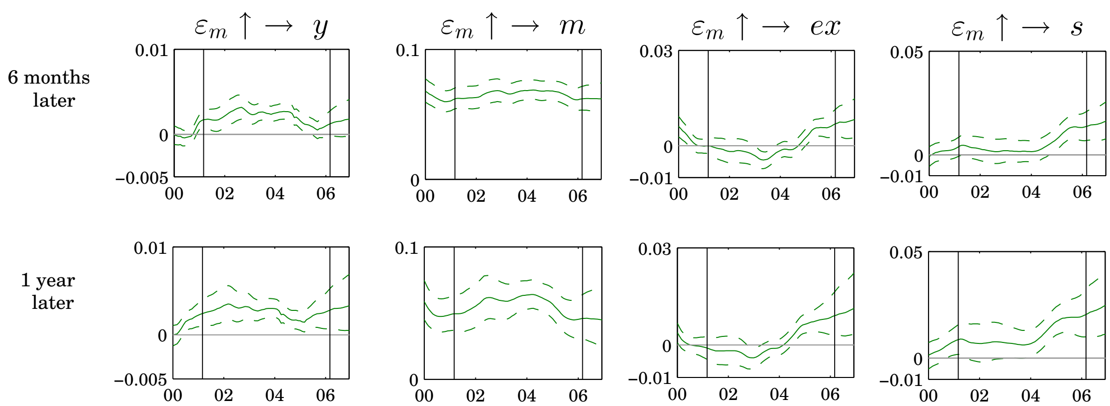


Figure 10: The impulse responses of Model 2 (Chemical)

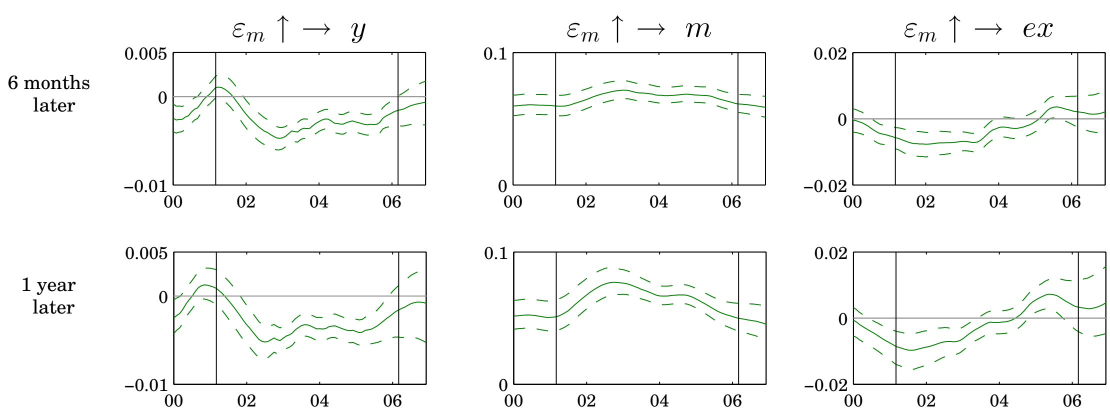


Figure 11: The impulse responses of Model 1 (Fabricated metals)

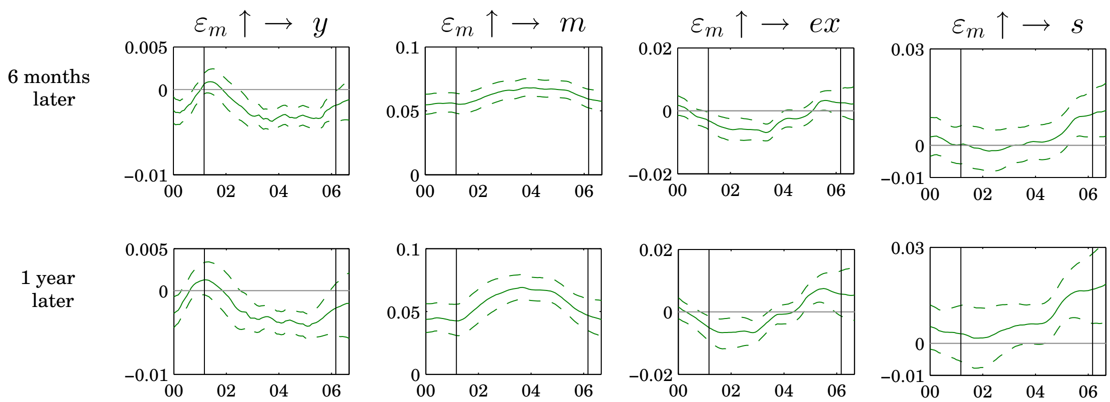


Figure 12: The impulse responses of Model 2 (Fabricated metals)

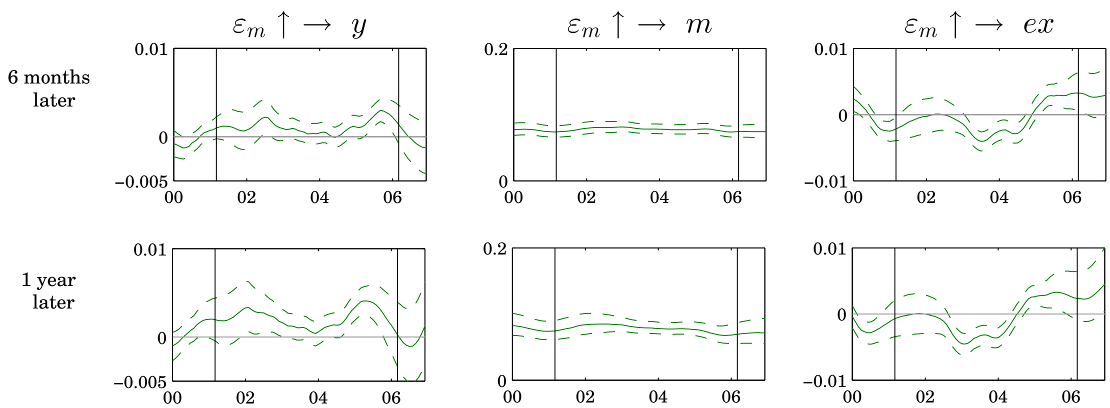


Figure 13: The impulse responses of Model 1 (Nonferrous metals)

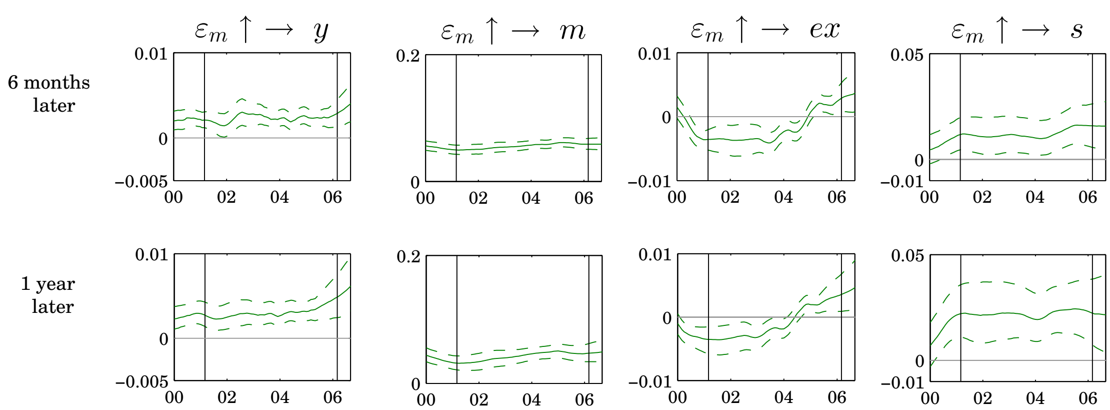


Figure 14: The impulse responses of Model 2 (Nonferrous metals)

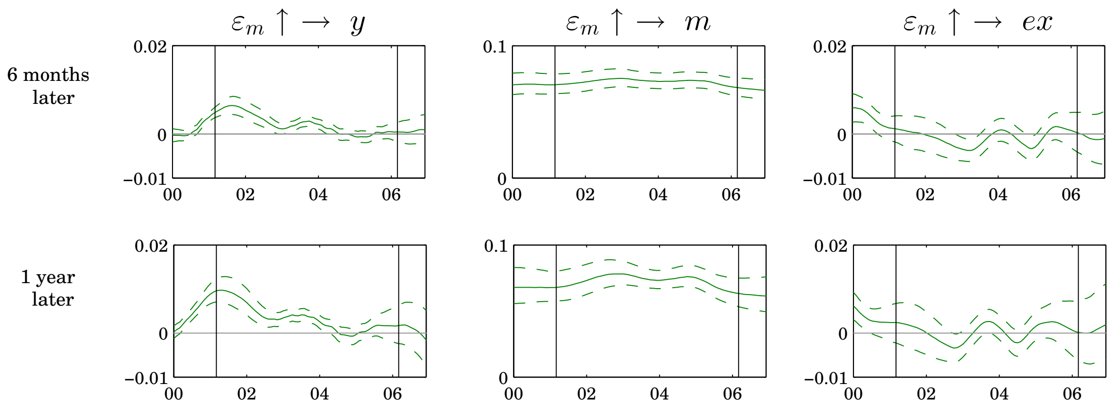


Figure 15: The impulse responses of Model 1 (Iron and steel)

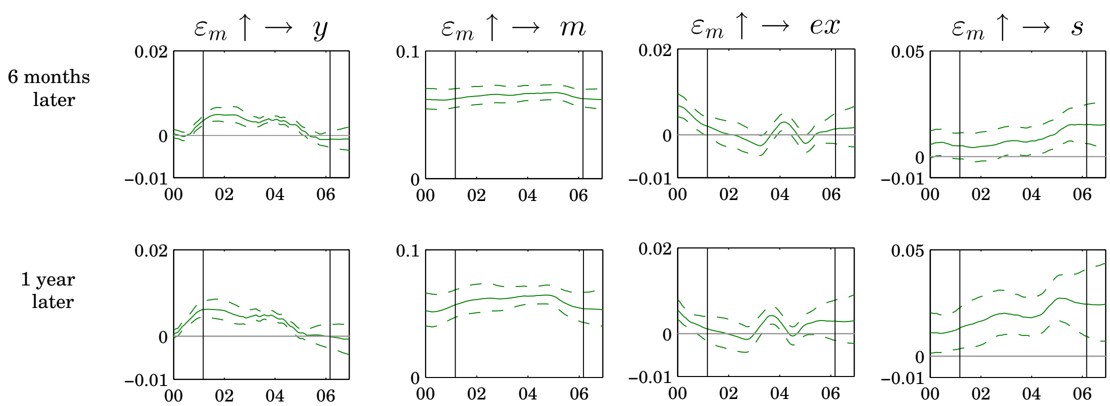


Figure 16: The impulse responses of Model 2 (Iron and steel)

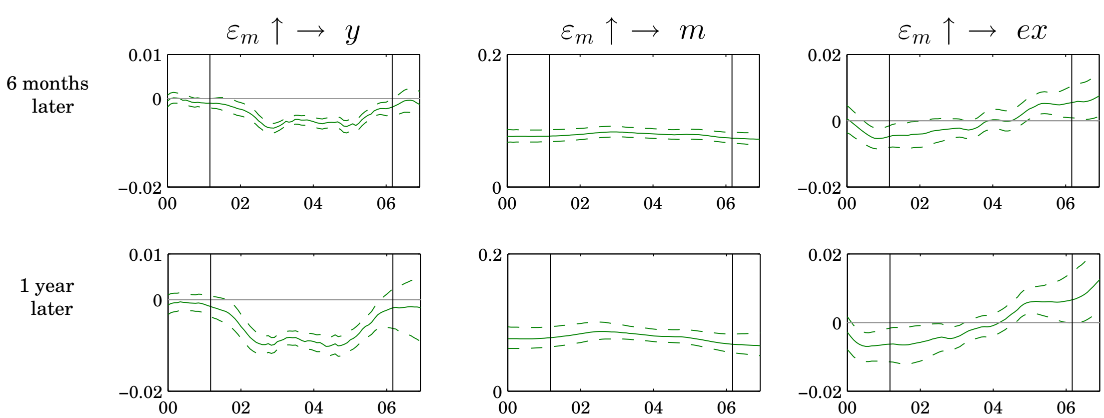


Figure 17: The impulse responses of Model 1 (Textile)

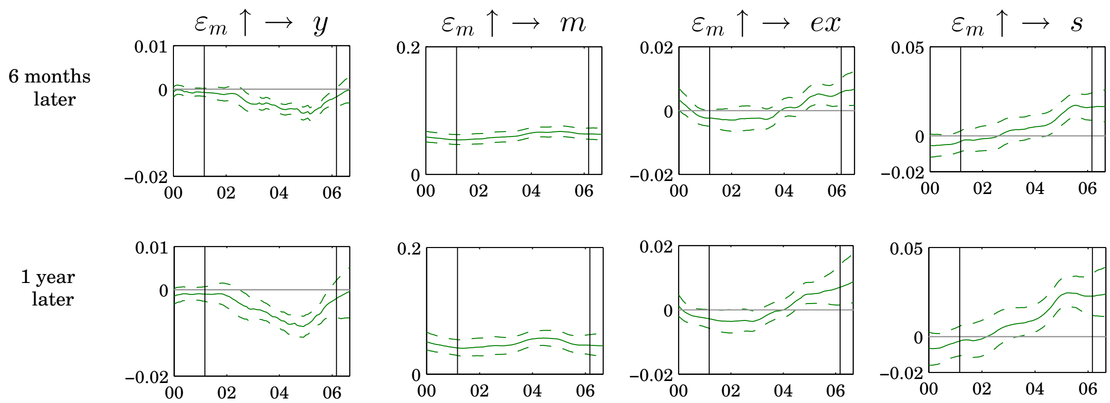


Figure 18: The impulse responses of Model 2 (Textile)

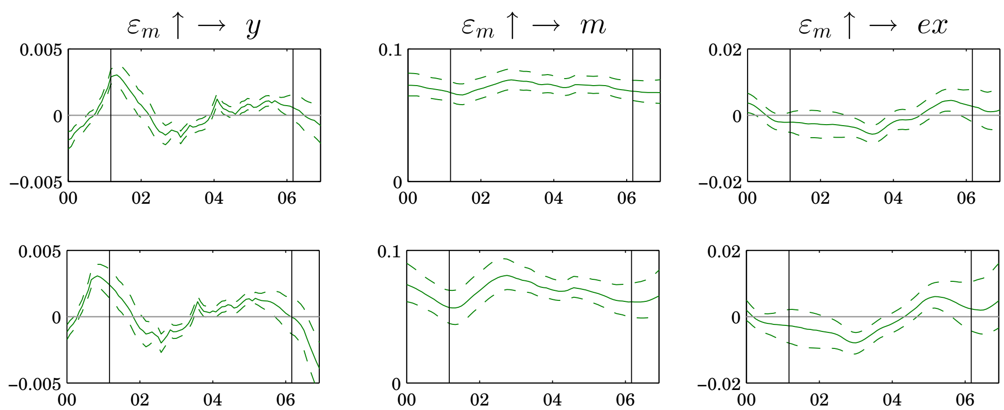


Figure 19: The impulse responses of Model 1 (Paper and pulp)

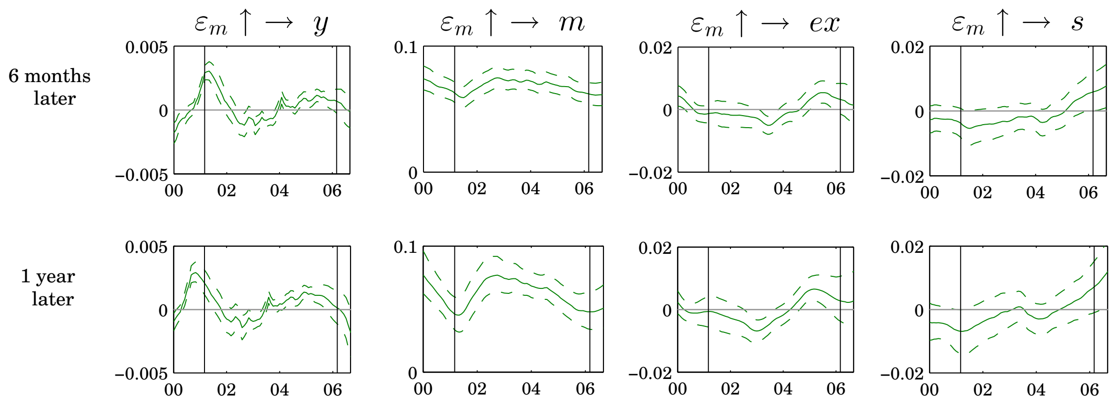


Figure 20: The impulse responses of Model 2 (Paper and pulp)

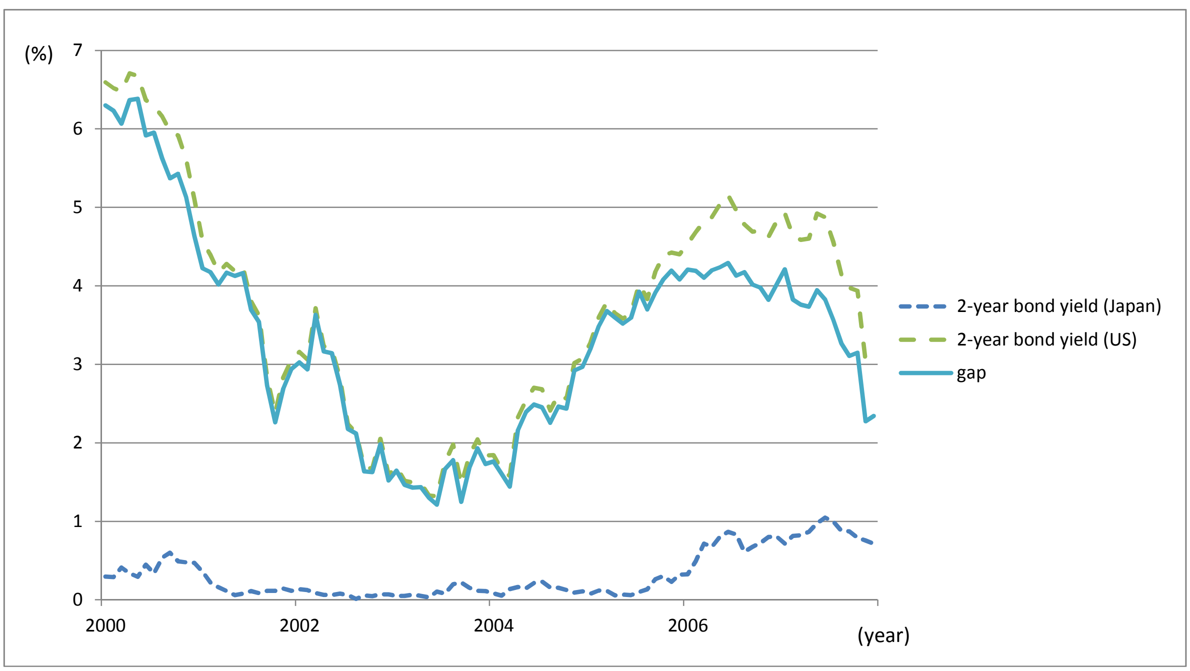


Figure 21: US-Japan interest rate (2-year bond yield)

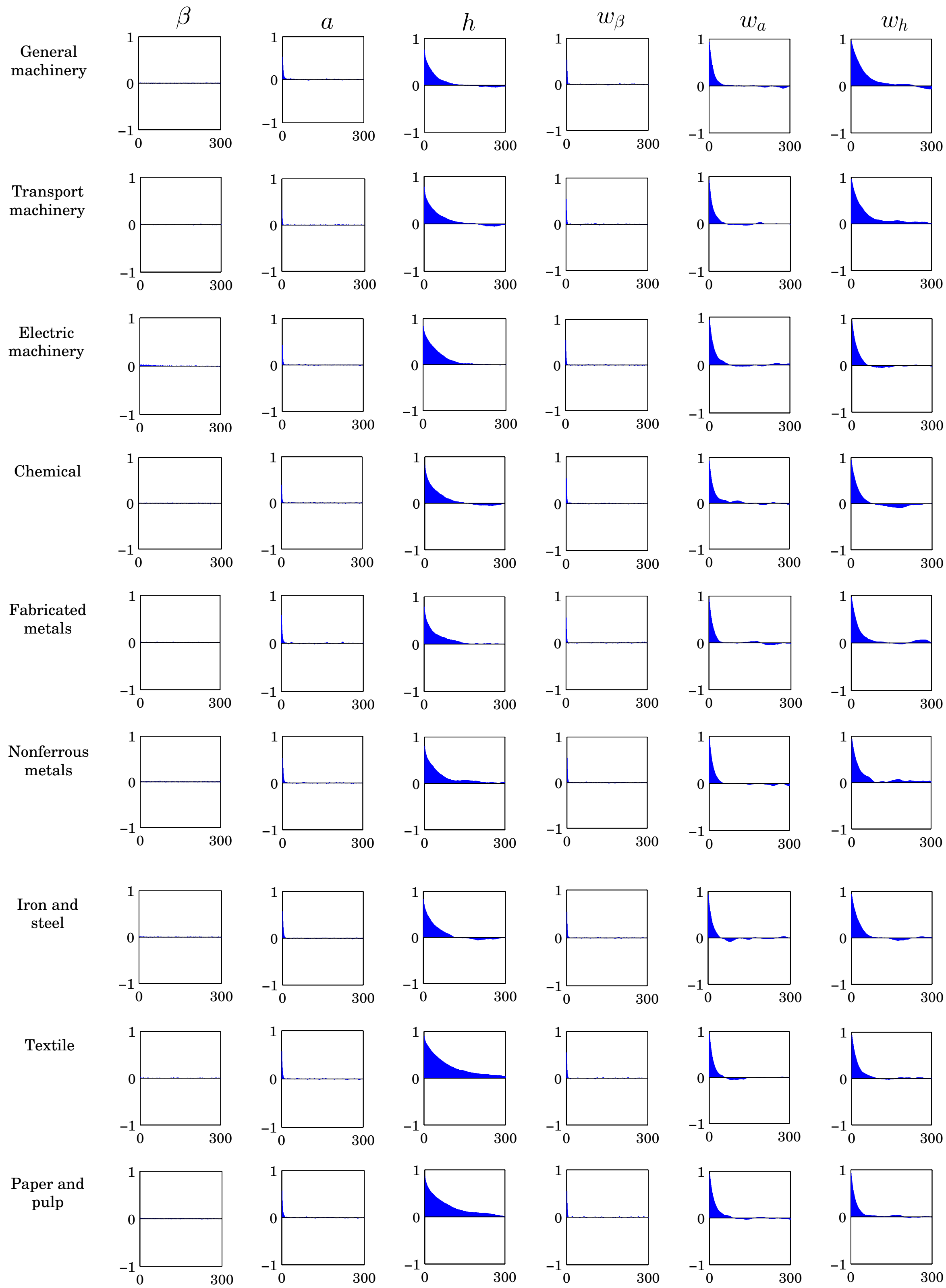


Figure 22: Estimation results of Model 1 for selected parameters

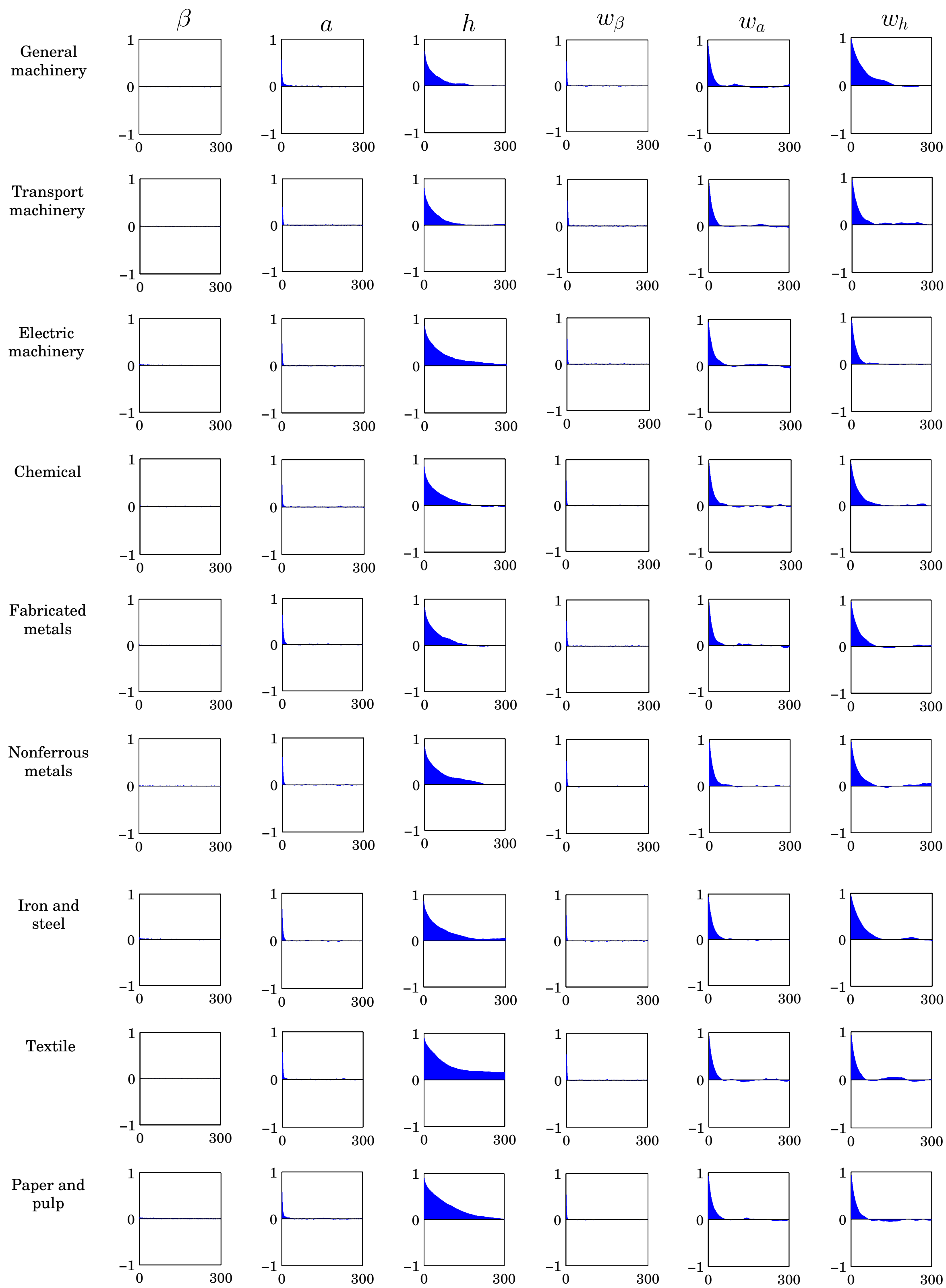


Figure 23: Estimation results of Model 2 for selected parameters

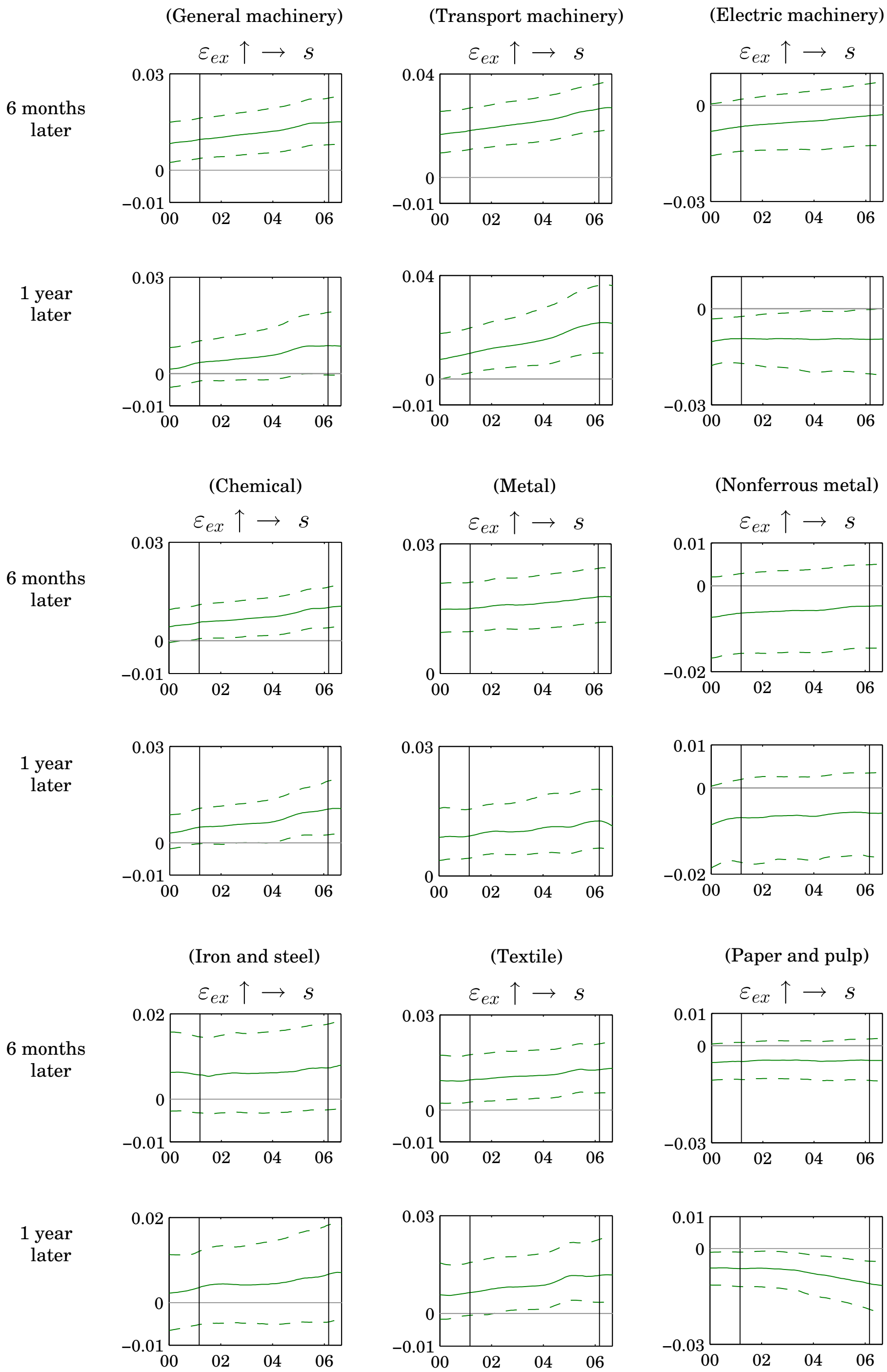


Figure 24: The response of stock prices to positive exchange rates shock