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Industry-specific Exchange Rate Fluctuations, Japanese Exports, and Financial Constraints: Evidence from Panel VAR Analysis

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Abstract

This study employs the industry-breakdown data of financial constraints obtained from the Bank of Japan, *Tankan* (*Short-Term Economic Survey of Enterprises in Japan*) to empirically investigate whether and how Japanese firms' financial constraints (internal and external) influence the response of Japanese sectoral exports to an exchange rate shock using a Panel VAR approach. Furthermore, we use the industry-specific real effective exchange rate data developed by Sato et al. (2013) to allow for different movements of real effective exchange rates across industries. It is found that financial constraints have a significant influence on Japanese exports in response to exchange rate shocks. Japanese exporters with either lower internal financial constraints (higher liquidity ratio) or external financial constraints (accommodative lending attitudes of financial institutions) are less affected by the yen's appreciation. In addition, if firms face high internal financial constraints, then reducing the external financial constraints can help them mitigate the impact of the yen's appreciation on their exports. Thus, an accommodative financial environment plays an important role in alleviating the impact that the yen's appreciation has on Japanese exports.

JEL Classification: F31, F33, F15
Keywords: Industry-specific real effective exchange rate, Internal financial constraints, External financial constraints, Japanese exports, Panel VAR

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1. Introduction

Financial constraints can play a crucial role in firms' export performance; however, only a few studies have so far investigated how financial constraints affect the impact that exchange rate fluctuations have on exports.[1] Dekle and Ryoo (2002) built a theoretical model and presented empirical results using Japanese firm-level data from 1982 to 1997.[2] They found that *keiretsu* firms, which can be characterized as having fewer financial constraints due to their strong relationship with banks, were less responsive to exchange rate fluctuations than non-*keiretsu* firms. This finding suggests that firms or industries that are less financially constrained tend to have lower exchange rate elasticities of exports. Strasser (2013) noted that the degree of exchange rate pass-through for financially constrained firms is almost twice as high as that for unconstrained firms. Moreover, the export volumes of firms with financial constraints are about twice as sensitive to exchange rate fluctuations as those of firms without financial constraints. Although interesting findings, these studies basically focus on the banks' lending attitudes, which can be characterized as external financial constraints. In the context of Japanese exporting firms, however, it is more important to consider the internal as well as external financial constraints.

Figure 1 indicates how the two types of financial constraints have changed from 2001 to 2013: one concerns the lending attitude of Japanese financial institutions (a measure of *external* financial constraints) and the other is the liquidity ratio of Japanese firms (a measure of *internal* financial constraints). In Japan, banks' lending attitudes exhibited large fluctuations from 2002 to 2003 and again from 2009 to 2010 when Japanese firms faced severe external financial constraints. Furthermore, the lending attitudes tend to fluctuate at a relatively low level (sever lending attitude) after the Lehman shock. In contrast, firms had very high liquidity ratios during the post-crisis period, which indicate that Japanese firms on average had ample internal funds. The degree of external and internal financial constraints may each differ across industries. Thus, it is interesting to examine how and to what extent financial constraints influence the response of Japanese exports to exchange rate shocks and whether the response

[1] See, among others, Amiti and Weinstein (2011) and Manova (2012).

[2] Given inadequate data on financial constraints, they conducted two empirical schemes to investigate the role of such constraints on exchange rate elasticities of exports: First, they compared the export elasticities of *non-keiretsu* firms with those of *keiretsu* firms, which can be characterized as having fewer financial constraints due to their strong relationship with banks. Further, they compare actual export elasticities with hypothetical export elasticities under the assumption that a firm hedges completely (fewer financial constraints).

varies across firms' different levels of financial constraints.

This paper differs from existing studies in three respects. First, in contrast to previous studies, the effects of both external and internal financial constraints are empirically investigated for the first time. By fully utilizing financial data from the Bank of Japan's *Tankan* (*Short-Term Economic Survey of Enterprises in Japan*) *Database*, the effects that external and internal financial constraints have upon the relationship between exchange rate fluctuations and Japanese exports are separately and jointly estimated. Second, this study uses a novel approach by focusing on differences in the short-run effect of exchange rate shocks on exports when exporters face various levels of financial constraints both internally and externally, whereas existing studies have investigated to what extent the financial constraints can affect the impact of exchange rate fluctuation on exports (Dekle and Ryoo, 2007; Stress, 2013). Third, the yen's industry-specific real effective exchange rate developed by Sato et al. (2012) is employed to consider the heterogeneity in exchange rate movements across industries as shown in Figure A1 in the Appendix. As pointed out by Byrne et al. (2008), estimates from sectoral studies may be biased by using aggregated exchange rates; using an industry-specific exchange rate can eliminate this bias.

Following the approach in Loayza and Raddatz (2007) and Towbin and Weber (2013), the present study estimates a Panel VAR and augments it with interaction terms that allow the VAR coefficients to vary with financial constraints (internal and external). This technique enables us to directly analyze how the responses of exports to exchange rate shocks vary with both internal and external financial constraints. While the literature typically uses interaction terms in a single equation regression, only a few studies employ interaction terms in a VAR model. The use of interaction terms in Panel VARs is a novel approach that will allow for deterministically varying coefficients across time and industries.

This study reports three main findings: First, Japanese exports negatively and significantly respond to exchange rate shocks. Second, financial constraints (internal and external) have significant influences on how Japanese exports respond to exchange rate changes. Japanese exporters with lower internal or external financial constraints are less affected by exchange rate shocks. Third, lowering external financial constraints can help exporters with relatively higher internal financial constraints become less affected by exchange rate shocks. This result suggests that an accommodative financial environment can help Japanese exporters alleviate the impact of the yen's appreciation on exports when facing internal financial difficulties.

The rest of the paper is organized as follows: Section 2 surveys the theoretical

relationship between exchange rates, financial constraints, and exports. Section 3 describes the data. Section 4 explains the estimation methodology. Section 5 discusses the main results, and Section 6 concludes.

2. Exchange Rate Fluctuations, Financial Constraints, and Exports

After the collapse of the Bretton Woods agreements in the early 1970s, exchange rate fluctuations have been a central concern for policymakers and academics. However, no consensus exists regarding the impact of exchange rate fluctuations on exports, though there is a growing body of literature on this issue. The traditional view holds that a change in the exchange rate may affect relative prices between domestic and foreign countries, which results in a shift in expenditures between domestic and foreign goods (Obstfeld, 2002). Thus, exchange rate appreciation may reduce exports by increasing the consumer price of export goods in the destination country. However, as shown in Figure 2, despite large fluctuations in the yen's nominal effective exchange rate, the export price index in the contract currency basis is quite stable, which suggests that Japanese exporters pursue pricing to market behavior.[3] Given such an incomplete exchange rate pass-through, Japanese exports might not be affected by exchange rate fluctuations.[4]

Accordingly, the question becomes one of how financial constraints affect the relationship between exchange rate fluctuations and exports when such an incomplete exchange rate pass-through exists. One possible mechanism is that exchange rate fluctuations affect exporters' profits, which leads to changes in working capital. For example, following appreciation of the yen, Japanese exporters do not completely pass through the exchange rate change to the price of export goods, likely due to competitive pressure in the export market. Even though neither the price of export products in the destination country nor export demand change, appreciation can cause exporters' current earnings to decline, as the price of export goods denominated in yen decreases. As shown in Table 1, most industries have a negative correlation between exchange rate changes and current profits, which supports the expectation that the yen's appreciation may cause exporters' current earnings to drop. If exporters face difficulties in financing internally or borrowing from external financial markets to produce export goods, a

[3] This pricing behavior is empirically investigated by Shimizu and Sato (2015).

[4] Existing studies have mainly explored three channels leading to incomplete pass-through, namely, pricing to market (Dornbusch, 1987; Atkeson and Burstein, 2008), local currency pricing (Engel, 2003), and local distribution margins (Campa and Goldberg, 2010).

decline in current earnings leads to a decrease in working capital and, hence, to a fall in production. Therefore, if firms can rely on easy access to external finance, exchange rate changes will have less impact on exports, a dynamic that has been empirically and theoretically examined by Dekle and Ryoo (2007), who show that less financially constrained firms tend to have lower exchange rate elasticity of exports. This mechanism is also rationalized by Aghion et al. (2009), who assume that firms' borrowing ability is proportional to their current earnings, with a higher multiplier implying a better developed financial market in the economy. When the export price is inflexible, firms' current earnings denominated in domestic currency will fall in response to exchange rate appreciation. This will reduce their ability to borrow to survive an idiosyncratic liquidity shock and thereby their ability to innovate in the longer term. Therefore, relaxing external financial constraints can weaken the negative effect of currency appreciation on their access to external finance and thereby exports.

3. Data Description

This study uses the quarterly series of the Japanese industry-breakdown data from the first quarter of 2001 through the third quarter of 2013. The industry classification is based on the International Standard Industry Classification Revision 3 (ISIC, Rev.3). Twenty-one manufacturing sectors at the two-digit level are aggregated into 13 industries, following Sato et al. (2013). The selection of industries is limited by the exchange rate data. See Table A1 in the Appendix for details.

The data used to measure the financial constraints are from *Tankan* (*Short-Term Economic Survey of Enterprises in Japan*), which is widely used in Japan.[5] The *Tankan* database reports data collected through a statistical survey by the Bank of Japan, which is performed to provide an accurate picture of business trends of enterprises in Japan. The survey is carried out quarterly in March, June, September, and December and comprises four groups: (1) "Judgment Survey," (2) "Annual Projections," (3) "Inflation Outlook of Enterprises," and (4) "Number of New Graduates Hired (surveyed only in June and December)." Sample enterprises are selected from a population (approximately two hundred and ten thousand private enterprises excluding financial institutions) based on the Ministry of Internal Affairs and Communications' "Establishment and Enterprise Census of Japan" (conducted in October 2006) having at

[5] Detail of the *Tankan* statistics can be found at:
https://www.boj.or.jp/en/statistics/outline/exp/tk/extk03.htm/#p01

least 20 million yen in capital. Manufacturing and nonmanufacturing are split into 17 and 14 categories, respectively. This study only focuses on the manufacturing sector, and 17 categories are aggregated into 13 industries as described above. Since the *Tankan* database does not provide financial data for the rubber and plastics industry, it will be excluded from the analysis.

The proxy for internal financial constraints is the liquidity ratio, which is defined as the ratio of a firm's quarter-end balance of cash, deposits, and securities listed as liquid assets to monthly average sales during the fiscal year. A higher value means the firm can access a greater amount of internal finance, which can be characterized as the firm having fewer internal financial constraints. External financial constraints are measured by the lending attitude of financial institutions, which is a diffusion index from the "Judgment Survey." In the survey, the responding enterprises are asked to choose one of three answers: 1) Accommodative, 2) Not so severe, 3) Severe, to describe the lending attitude they face from financial institutions. These responses are then compiled into a Diffusion Index (DI) by industry as follows:

> DI (%) = Percentage share of enterprises responding Answer One minus Percentage share of enterprises responding Answer Three.

Therefore, this is a direct measurement of external financial constraints, where a higher value means they experience a more accommodative lending attitude from Japanese financial institutions, which can be characterized as these firms having lower external financial constraints. As shown in Figure A2 in the Appendix, a big difference exists in liquidity ratio movements and the lending attitude of financial institutions across industries. These sectoral variations can be exploited to identify the exchange rate's effect on Japanese exports for different levels of financial constraints, both internal and external.

Regarding exchange rate data, this study uses the yen's industry-specific real effective exchange rate developed by Sato et al. (2012), which captures the difference in exchange rate fluctuations across industries. An increase in the exchange rate means appreciation. As shown in Figure A1 in the Appendix, the most striking feature of this approach is the large difference in the level of I-REER across industries, especially after the sharp appreciation following the collapse of Lehman Brothers in September 2008. If we ignore this heterogeneity in movements across industries by using aggregated REER, which is widely used by existing studies, the results will be biased as suggested by Byrne et al. (2008).

Global real income is proxied by the trade-weighted average of the partners' real GDP for each industry. Following Sato et al. (2013), 28 of Japan's trading partners are included in the calculation as shown in Table A2 in the Appendix. The GDP data are obtained from *International Financial Statistics (IFS)-IMF*. The export data used to calculate the industry-breakdown export weight of each partner are from *STAN Bilateral Trade in Goods by Industry and End-use (BTDIxE), ISIC Rev.3, OECD*.

The Japanese export data are from *Trade Statistics of Japan Ministry of Finance*, which is monthly data based on nine-digit HS classifications. Then, the export data is converted into ISIC rev.3 two-digit industries by using the concordance code from *World Integrated Trade Solution* (*WITS*) and further transformed into quarterly data for 13 industries.

4. Empirical methodology

4.1 Model

Several authors (Stress, 2013; Dekle and Ryoo, 2007) have argued that a negative relationship exists between financial constraints and the reaction of exports in response to exchange rate variability. However, most of these studies focus on the extent to which financial constraints can affect the impact that exchange rate fluctuations have on exports. By contrast, this study tries to investigate the short-run effect of an exchange rate shock at a different level of financial constraint. In addition, in contrast with existing studies, this study focuses not only on the external financial constraints but also on internal financial constraints. This study marks the first empirical investigation of the joint effect of these two types of constraints on the response of Japanese exports to an exchange rate shock.[6]

This study employs a structural Panel Vector Autoregression (Panel VAR) model augmented by adding interaction terms with financial constraints. The standard Panel VAR is as follows:

$$A_0 Y_{i,t} = \sum_{l=1}^{q} A_l Y_{i,t-l} + \lambda D_i + e_{i,t} \ , \qquad (1)$$

[6] The financial constraints defined in existing studies can be characterized as external financial constraints. For example, the financial constraints variable defined in Strasser (2013) is a judgment of credit provided by banks, with three possible answers "accommodating," "neutral," and "restrictive," which is quite similar to the proxy for external financial constraints used in this study.

where i denotes industry, t represents time, and q stands for the number of lags. $Y_{i,t}$ is a vector that contains three variables: (1) the weighted average of trading partner's GDPs is a proxy for global real income (external variable), (2) Japanese export volumes (real export), and (3) I-REER. D_i denotes industry-specific effects. To allow the coefficients to vary with both internal and external financial constraint levels, interaction terms with financial variables ($F_{i.t}$), including both internal and external financial constraints, are added into the Panel VAR model:

$$A_0 Y_{i,t} + B_0 F_{i,t} * Y_{i,t} = \sum_{l=1}^{q} A_l Y_{i,t-l} + \sum_{l=1}^{q} B_l F_{i.t} * Y_{i,t-l} + \gamma F_{i,t} + \lambda D_i + v_{i,t}\,, \quad (2)$$

which can be rewritten in a more compact form:

$$\Phi_{i,t,0} Y_{i,t} = \sum_{l=1}^{q} \Phi_{i,t,l} Y_{i,t-l} + \Gamma X_{i,t} + \varepsilon_{i,t}\,, \quad (3)$$

where $X_{i,t}$ is a vector of industry-specific effect (D_i) and single terms of financial variables ($F_{i.t}$), which contains internal financial constraints ($InF_{i.t}$), external financial constraints ($ExF_{i.t}$), and interaction terms of internal and external financial constraints ($InF_{i.t} * ExF_{i.t}$). The matrices $\Phi_{i,t,g}$ ($g = 0,1,...,q$) with time t and industry subscript i contain time-varying coefficients defined as $\phi_{i,t,g}^{jk}$, which are combinations of A_g and $B_g F_{i,t}$, $g = 0,1,...,q$. Thus, each of these coefficients is a function of financial constraints for different lags including contemporaneous ones. $\varepsilon_{i,t}$'s are the structural errors, which are i.i.d. with zero means and a diagonal variance-covariance matrix Σ.

The identification assumption used in this study is a combination of strict exogenous and contemporaneous zero restrictions. First, real global income is restricted to being exogenous with respect to two domestic variables, Japanese export volume and I-REER. Therefore, domestic shocks have neither contemporaneous nor lagged effects on real global income. Second, contemporaneous zero restrictions are imposed on two domestic variables: export volumes cannot be contemporaneously affected by an I-REER shock, but the I-REER can be contemporaneously affected by export volumes. This assumption is motivated by the fact proposed in Clark et al. (2004) that exporters

are unlikely to respond immediately to exchange rate changes but will rather take a "wait and see" approach. These assumptions are equivalent to imposing the following structures in the $\Phi_{i,t,0}$ and $\Phi_{i,t,l}$ matrices:

$$\Phi_{i,t,0} = \begin{bmatrix} 1 & 0 & 0 \\ \phi_{i,t,0}^{21} & 1 & 0 \\ \phi_{i,t,0}^{31} & \phi_{i,t,0}^{32} & 1 \end{bmatrix} \quad ; \quad \Phi_{i,t,l} = \begin{bmatrix} \phi_l^{11} & 0 & 0 \\ \phi_{i,t,l}^{21} & \phi_{i,t,l}^{22} & \phi_{i,t,l}^{23} \\ \phi_{i,t,l}^{31} & \phi_{i,t,l}^{32} & \phi_{i,t,l}^{33} \end{bmatrix}, \quad l = 1,2,...,p$$

(4)

While the exogenous restriction of real global income should be rational in studies of small economies, this might be rather controversial in studies on countries having a relatively large economy, such as Japan. In fact, a standard Granger causality test cannot reject the hypothesis that I-REERs and export volume cannot Granger cause real global income, which rationalizes the assumption for real global income.

The formula of the coefficients $\phi_{i,t,g}^{jk}$ in the matrices $\Phi_{i,t,g}$ is given by

$$\phi_{i,t,g}^{jk} = \alpha_g^{jk} + \beta_{g,1}^{jk} InF_{i,t} + \beta_{g,2}^{jk} ExF_{i,t} + \beta_{g,3}^{jk} InF_{i,t} * ExF_{i,t}, \qquad (5)$$

where internal financial constraints ($InF_{i.t}$) is proxied by the liquidity ratio, and external financial constraints ($ExF_{i.t}$) is proxied by the lending attitude of financial institutions. This structure allows Japanese exports to respond differently to exchange rate shocks for different levels of financial constraint. To control for the endogeneity problem of financial constraints in that their current value may depend on exports, all financial variables enter the estimation with a one time period lag.

For a comparison with existing studies, the first step is to examine the dynamic effects of exchange rate shocks conditional on internal financial constraints and external financial constraints separately by setting either $\beta_{g,2}^{jk} = \beta_{g,3}^{jk} = 0$ or $\beta_{g,1}^{jk} = \beta_{g,3}^{jk} = 0$. Then, the most general case in which all coefficients are unrestricted can be examined. While the domestic variables, export volumes, and I-REERs are allowed to be dependent on financial constraints (internal and external), the external variable of real global income is restricted to being independent of domestic financial constraints. Note that ϕ_l^{11} in $\Phi_{i,t,l}$, $l = 1,2,...,p$, is without time t and industry subscript *i*.

The use of Panel VARs, which allow heterogeneity in coefficients by including

interaction terms, together with the corresponding restrictions on the parameters, is common in recent literature that estimates the impact of exogenous shocks on different macroeconomic variables (Loayza and Raddatz, 2007; Towbin and Weber, 2013). This approach has the advantage of being able to test how country or industry characteristics affect the economy's response to external shocks.

4.2 Implementation

Under the identification assumptions described above, error terms are assumed to be uncorrelated across equations. Thus, the Panel VAR in (3) can be efficiently estimated equation by equation using OLS, and the finance crisis dummy is included in each equation to control for the disturbance caused by the Lehman collapse. All variables enter the Panel VAR model in terms of the first differences of the logarithmic form. The number of lags is chosen following the Schwartz information criterion, and the optimal number of lags is two. The confidence intervals for the impulse response function (IRF) are estimated by parametric bootstrapping following the procedure mentioned in Towbin and Weber (2013).

To test whether the response of Japanese exports to an exchange rate shock is affected by financial constraints (internal and/or external), three different Wald tests are applied. The first one tests for the joint significance of all interactions and triple terms. The null hypothesis is that internal and external financial constraints cannot explain the heterogeneity in the response of Japanese exports:

$$H_0 : \beta_{g,1}^{jk} = \beta_{g,2}^{jk} = \beta_{g,3}^{jk} = 0,\ g = 0,1,2$$

The second one tests for a significant role for internal financial constraints. The null hypothesis is that internal financial constraints cannot improve the overall explanatory power:

$$H_0 : \beta_{g,1}^{jk} = \beta_{g,3}^{jk} = 0,\ g = 0,1,2\ .$$

The last test determines whether external financial constraints play a significant role. The null hypothesis is that the external financial constraints cannot improve the overall explanatory power:

$$H_0 : \beta_{g,2}^{jk} = \beta_{g,3}^{jk} = 0, l = 0,1,2 .$$

As shown in Table 2, the Wald statistics of these three tests are 4.89, 4.88, and 4.50, respectively, which indicates that financial constraints (internal and external) do play a role in explaining the relationship between exchange rate fluctuations and exports.

Japanese exports are allowed to have varying responses to an exchange rate shock with internal financial constraints and external financial constraints, which are captured by $\phi_{i,t,g}^{jk}$. Although these coefficients are time-varying, we can evaluate them using a specific value of financial constraint (internal and external). To analyze the effect of financial constraints, this study compares the cumulative impact of exchange rate shocks on Japanese exports at different levels of financial constraint. Specifically, two levels of financial constraint are specified, namely, a relatively higher level of financial constraint measured at the 25th percentile value and relatively lower level of financial constraint measured at 75th percentile value.[7] Comparing a given shock's impact at these different levels provides a clear picture of the extent to which financial constraints serve to amplify or dampen the impact of exchange rate shocks.

5. Empirical Results

5.1 Response to an exchange rate shock without interactions

For comparison purposes, a three-variable Panel VAR is first estimated, which includes real global income, Japanese export volumes, and I-REERs without any interaction terms. Figure 3 shows the cumulative effect of a one unit shock in terms of exchange rate (appreciation) on Japanese export volumes. The dotted lines in the figure show 10% and 90% confidence bands estimated by parametric bootstrapping. In addition, it indicates that Japanese export volumes have a significantly negative response to an exchange rate shock, which indicates the yen's appreciation will reduce export volumes. This result differs from those of existing studies, which support the idea that exchange

[7] The higher the level of measured financial constraints (internal and external), the lower the actual financial constraints are; see Section 3.1.

rate fluctuations generally have an insignificant impact on exports for developed countries (Hooper and Kohlhagen, 1978; Grier and Smallwood, 2007). However, previous studies used an aggregated exchange rate, which may lead to some bias on the estimates, as pointed out by Byrne et al. (2008). Another explanation proposed by Dekle and Ryoo (2007) is that the negative impact of exchange rate fluctuations can be attributed to changes in financing constraints that are correlated with exchange rate fluctuations. In their working paper version, Dekle and Ryoo (2007) show that exchange rate depreciation is an average related to a relaxation of financing constraints in 10 out of 14 industries. In addition, Table 1 shows that the yen's appreciation is negatively correlated with current profit in most industries. When the exchange rate appreciates, exporters with tightened financial constraints cannot produce more goods for export even when foreign prices are inflexible. Consequently, exchange rate appreciation has a negative impact on exports.

5.2 Response to exchange rate shocks conditional on external financial constraints

Next, external financial constraints are added to the Panel VAR model. Figure 4 shows the response of Japanese exports to an exchange rate shock conditional on different levels of external financial constraints, which are proxied by the lending attitude of financial institutions. The relatively lower level of financial constraints is measured by 75 percentile point (relatively accommodative lending attitude by financial institutions), and the relatively higher level of financial constraints is measured by 25 percentile point (relatively severe lending attitude by financial institutions). We can observe the different response of Japanese export volumes to an exchange rate shock across these two levels of external financial constraint: exporters show a smaller response to an exchange rate shock when facing relatively low external financial constraints. This result is consistent with the findings of existing studies (Dekle and Ryoo, 2007; Stress, 2013) that support the view that financially constrained exporters are more sensitive to exchange rate fluctuations. However, it is surprising that the difference is negligible.

5.3 Response to an exchange rate shock conditional on internal financial constraints

Figure 5 shows the cumulative impact of exchange rates conditional on different levels of internal financial constraints, which is proxied by the liquidity ratio. Similar to previously, a relatively low level of internal financial constraint is measured by the 75 percentile point (higher liquidity ratio) and a relatively high level of internal

financial constraint is measured by the 25 percentile (lower liquidity ratio). It is very striking that, compared to external financial constraints, the difference in the response of Japanese export volumes to an exchange rate shock across the two levels of internal financial constraints is quite large. An exchange rate shock has quite a large impact on exports, and this effect continues for a long period under relatively higher internal financial constraints, while the impact is almost insignificant at relatively lower internal financial constraints. This finding may suggest that the internal financial constraints do appear to have a significant influence on the impact that exchange rate shocks have on exports.

5.4 Response to an exchange rate shock conditional on both internal and external financial constraints

The main interest of this study lies in the triple interaction term between exchange rate fluctuations, internal financial constraints, and external financial constraints. Figure 6 shows the impulse response of export volumes to an exchange rate shock for four combinations of internal financial constraints and external financial constraints, i.e.,., (1) low internal financial constraints (high liquidity ratio) and low external financial constraints (accommodative lending attitude); (2) low internal financial constraints and high external financial constraints (severe lending attitude); (3) high internal financial constraints (low liquidity ratio) and low external financial constraints; and (4) high internal financial constraints and high external financial constraints. As shown in Figure 6, an exchange rate shock has no significant effect on Japanese exports when both internal and external financial constraints are relatively low. By contrast, when both internal and external financial constraints are relatively high, an exchange rate shock has a much larger impact on Japanese exports. We can also observe that easing either internal or external financial constraints does appear to mitigate the impact of exchange rate shocks. When external financial constraints are relatively high, the negative impact of an exchange rate shock on Japanese exports becomes insignificant by easing internal financial constraints (relatively lower internal financial constraints). This result may imply that by increasing its liquidity ratio, a firm can alleviate at least some of the negative impact of exchange rate fluctuations. However, an excessively high liquidity ratio is not good for capital efficiency. As shown in the upper part of Figure 6, even when internal financial constraints are relatively high, easing external financial constraints leads to a smaller response by Japanese exports to an exchange rate shock. This suggests that an accommodative financial environment can

help firms with high internal financial constraints alleviate the impact that yen appreciation has on their exports.

6. Conclusion

This study is motivated by the fact that Japanese firms are facing a quite different financial environment from that experienced prior to the Lehman collapse. Financial institutions in Japan became relatively severe in their lending attitudes, and liquidity ratios became relatively higher after the collapse. This study employed a Panel VAR approach to empirically investigate whether and how internal and external financial constraints influence the response of Japanese exports to an exchange rate shock. Internal financial constraints are proxied by a firm's liquidity ratio, and external financial constraints are proxied by the lending attitude of financial institutions. All industry-breakdown data of financial constraints are obtained from *Bank of Japan, Tankan (Short-Term Economic Survey of Enterprises in Japan)*. To consider any possible bias that may be caused by using aggregated exchange rates, this study employs the industry-specific real effective exchange rate data developed by Sato et al. (2013) to allow for the different movements of real effective exchange rates across industries.

It is concluded that first, Japanese exports negatively and significantly respond to exchange rate shocks. Under the existence of an incomplete pass-through, one explanation for this result proposed by Dekle and Ryoo (2007) is that the responsiveness of Japanese exports to exchange rate fluctuations can be attributed to a tightening of balance sheet constraints. Second, financial constraints (both internal and external) have significant influences on the response of Japanese exports to an exchange rate shock. Japanese exporters with lower internal or external financial constraints are less affected by an exchange rate shock. Finally, an accommodative financial environment can help firms with higher internal financial constraints alleviate the impact of the yen's appreciation on their exports.

Although our finding suggests that increasing the liquidity ratio can help firms absorb some impact of an exchange rate shock, capital efficiency can be harmed if the liquidity ratio becomes excessively high. As highlighted by Sher (2014), large cash holdings may be a potential obstacle to the success of Abenomics by impeding growth in wages, investment, and dividend payments. Furthermore, it is shown that financial constraints are one of the factors contributing to positive cash accumulations by Japanese nonfinancial firms. Therefore, a policy that improves firms' access to

market-based financing (external finance) can help firms mitigate the negative impact of exchange rate shocks and also encourage them to use their cash holdings.

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Table 1 Correlations between Changes in Exchange Rate and Current Profits

Industry	Description	NEER	REER
All	Including from Industry 1 to Industry 13	-0.227	-0.233
1	Food, Beverage, and Tobabco	-0.030	-0.022
2	Textiles, Textile Products, Leather, and Footwear	-0.162	-0.222
3	Wood Products(excl. furniture)	-0.260	-0.006
4	Paper, Paper Products, and Printing and publishing	-0.135	-0.202
5	Coke, Refined Petroleum Products, and Nuclear Fuel	0.017	-0.134
6	Chemicals and Chemical Products	-0.247	-0.337
8	Non-metallic Mineral Products	-0.419	-0.390
9	Basic Metals and Fabricated Metal Products	-0.291	-0.418
10	Machinery and Equipment n.e.c.	-0.364	-0.359
11	Electrical Machinery and Apparatus n.e.c.	-0.344	-0.324
12	Optical Instruments	0.088	0.074
13	Transport Equipment	-0.268	-0.289

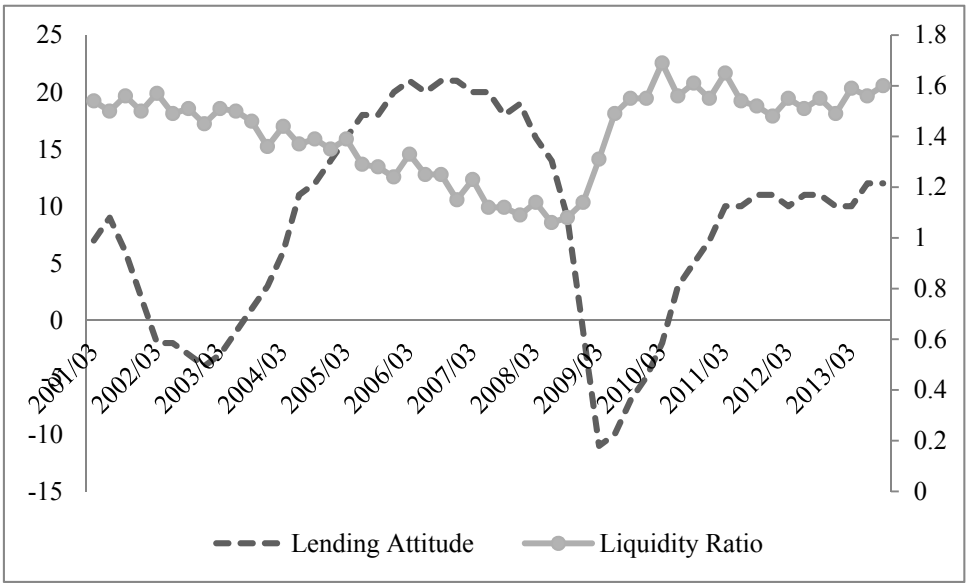
Note: All variables entered in the first difference of log terms. Current profit is the half yearly data from the first half of 2001 to the first half of 2013.

Data source: the Bank of Japan, *Tankan* (*Short-Term Economic Survey of Enterprises in Japan*).

Table 2 Results of Wald tests

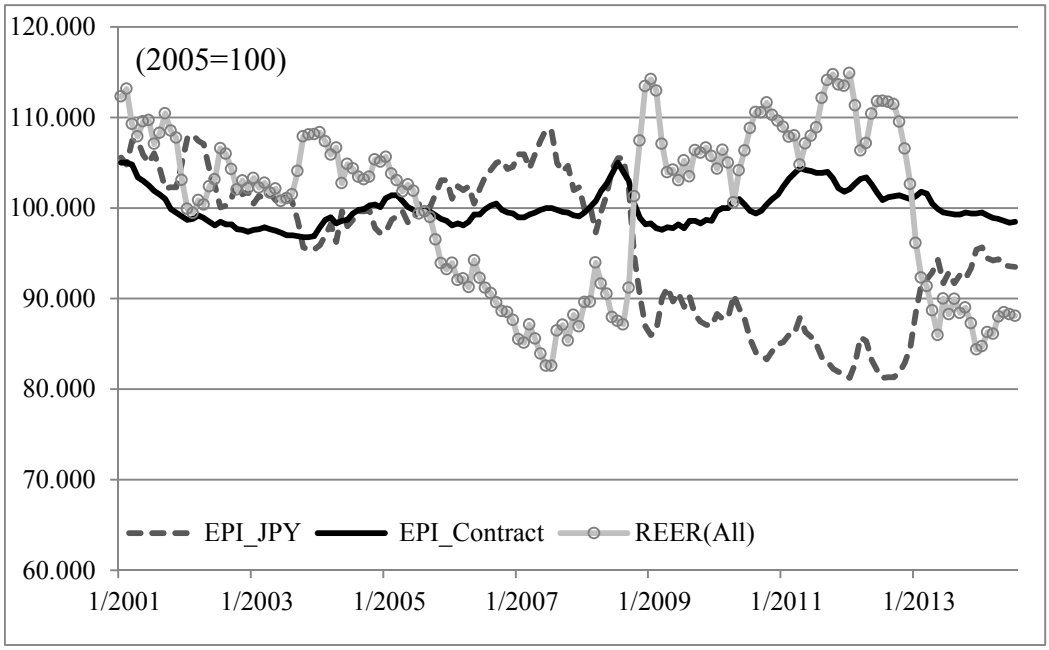
	Null hypothesis	Wald statistics
External Financial Contraints:	$H_0 : \beta_{l,2}^{jk} = \beta_{l,3}^{jk} = 0$	4.89***
Internal Financial Constraints:	$H_0 : \beta_{l,1}^{jk} = \beta_{l,3}^{jk} = 0$	4.88***
External & Internal Financial Constraints:	$H_0 : \beta_{l,1}^{jk} = \beta_{l,2}^{jk} = \beta_{l,3}^{jk} = 0$	4.50***

Figure 1 Lending Attitude of Financial Institutions and Liquidity Ratios for All Manufacturing Sectors



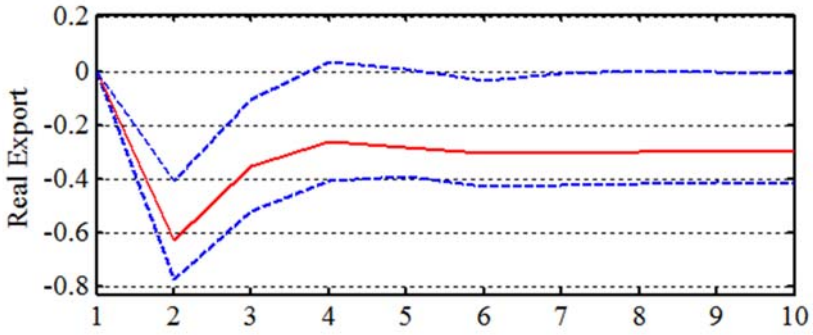
Data source: the Bank of Japan, *Tankan (Short-Term Economic Survey of Enterprises in Japan)*, 2001Q1–2013Q3.

Figure 2 Export Price Index for All Industries



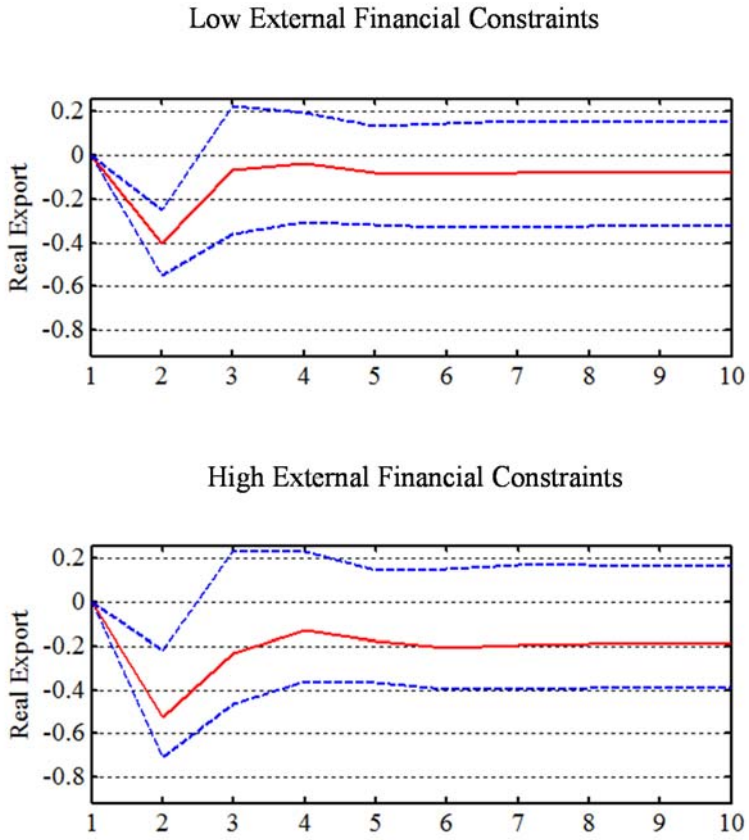
Data source: the Bank of Japan, from Jan 2001 to Oct 2014.

Figure 3 Responses to an Exchange Rate Shock Without Interactions



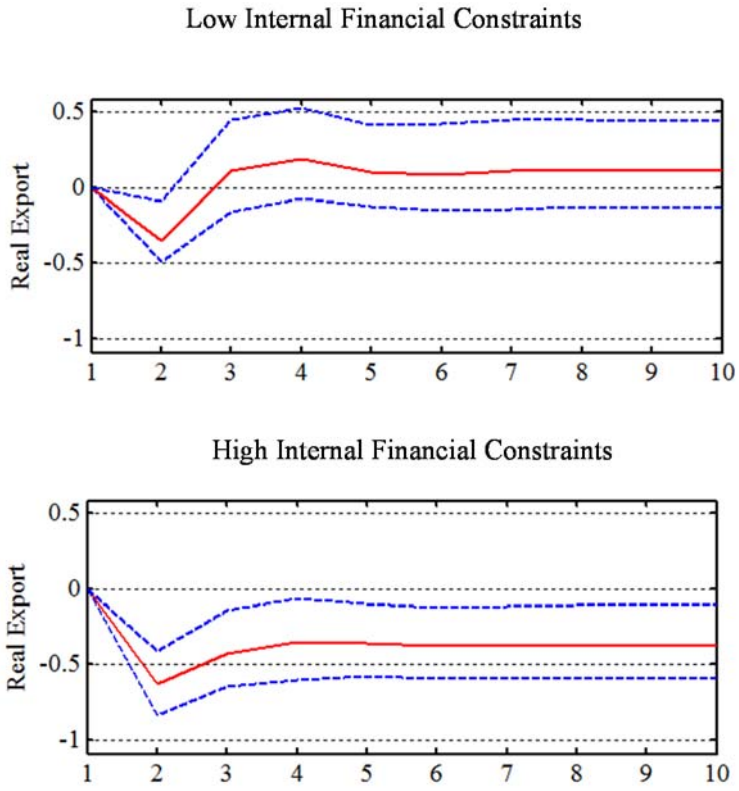
Note: Bands are 90 % confidence intervals computed by bootstrapping.

Figure 4 Response to an Exchange Rate Shock Conditional on External Financial Constraints



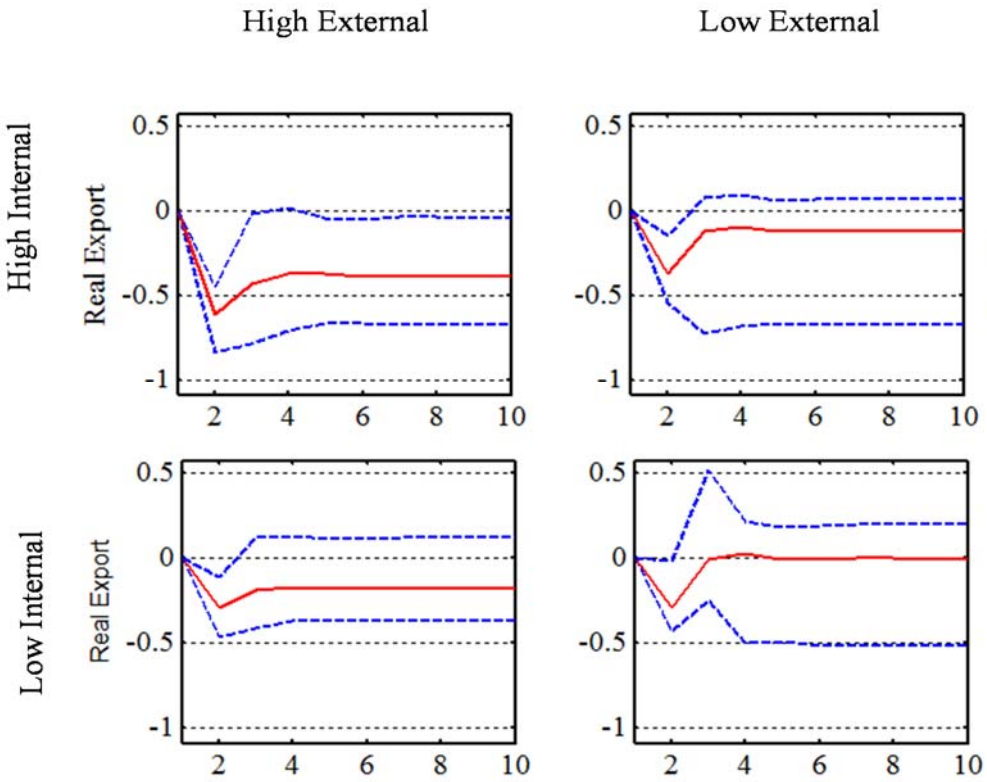
Note: Bands are 90 % confidence intervals computed by bootstrapping.

Figure 5 Response to an Exchange Rate Shock Conditional on Internal Financial Constraints



Note: Bands are 90 % confidence intervals computed by bootstrapping.

Figure 6 Response to an Exchange Rate Shock Conditional on Both Internal and External Financial Constraints



Note: Bands are 90 % confidence intervals computed by bootstrapping.

Appendix

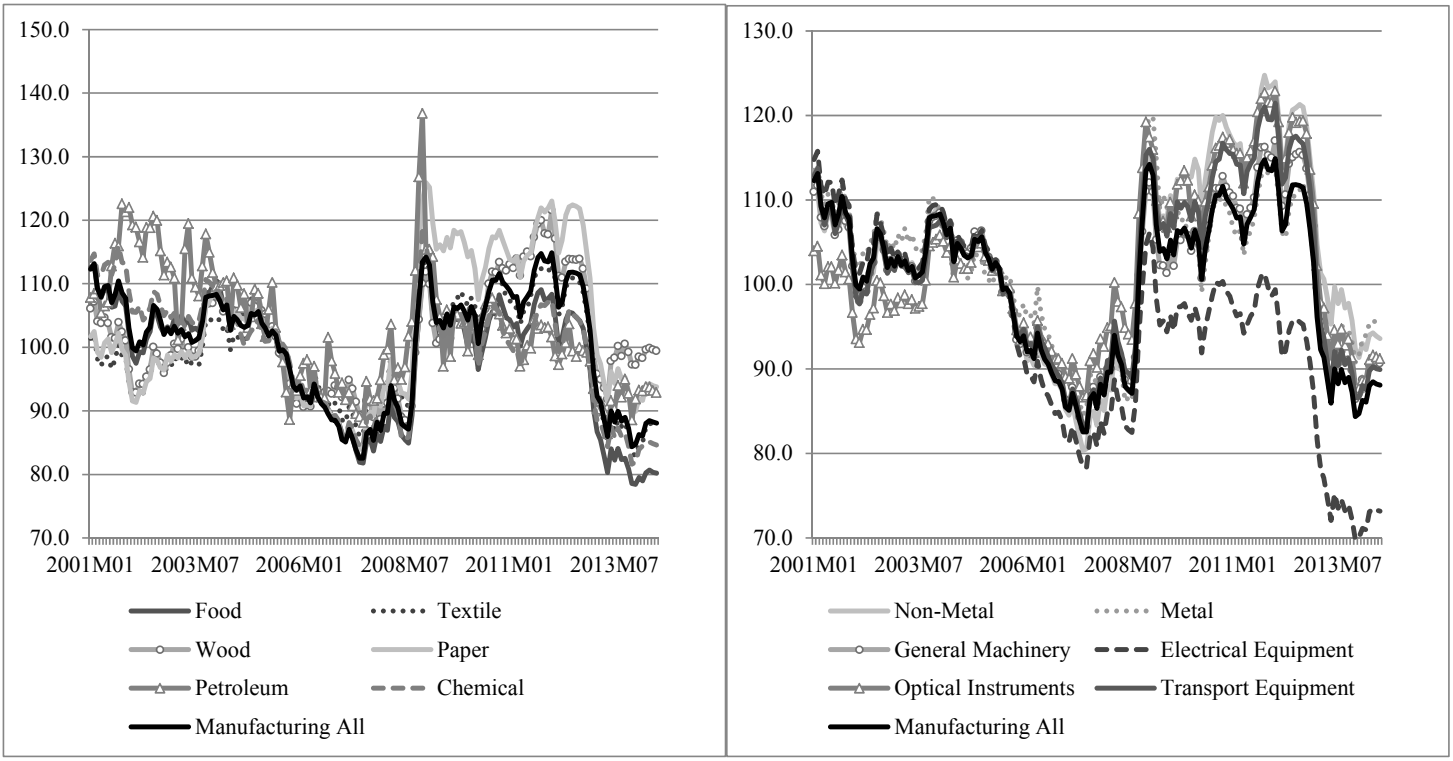
Table A1 Industry Classification

Code	ISIC.rev3	Industry Name	Description
1	15-16	Food	Food, Beverage, and Tobabco
2	17-19	Textile	Textiles, Textile Products, Leather, and Footwear
3	20	Wood	Wood Products(excl. furniture)
4	21-22	Paper	Paper, Paper Products, and Printing and publishing
5	23	Petroleum	Coke, Refined Petroleum Products, and Nuclear Fuel
6	24	Chemical	Chemicals and Chemical Products
7	25	Rubber	Rubber and Plastics Products
8	26	Non-Metal	Non-metallic Mineral Products
9	27-28	Metal	Basic Metals and Fabricated Metal Products
10	29	General Machinery	Machinery and Equipment n.e.c.
11	30-32	Electric Machinery	Electrical Machinery and Apparatus n.e.c.
12	33	Optical Instruments	
13	34-35	Transport Equipment	Transport Equipment

Table A2 Partner Countries

	Asia	8.	Taiwan	15.	German	23.	Sweden
1.	China	9.	Thailand	16.	Greece	24.	Switzerland
2.	India		***Europe***	17.	Ireland	25.	UK
3.	Indonesia	10.	Belgium	18.	Italy		***Other***
4.	Korea	11.	Canada	19.	Netherlands	26.	Australia
5.	Malaysia	12.	Denmark	20.	Norway	27.	New Zealan
6.	Philippine	13.	Finland	21.	Russia	28.	USA
7.	Singapore	14.	France	22.	Spain		

Figure A1 Industry-specific Real Effective Exchange Rates in Japan



Data source: Research Institute of Economy, Trade & Industry, IAA (RIETI), January 2001–July 2014.

Figure A2 Lending Attitude of Financial Institution and Liquidity Ratio for Each Sector

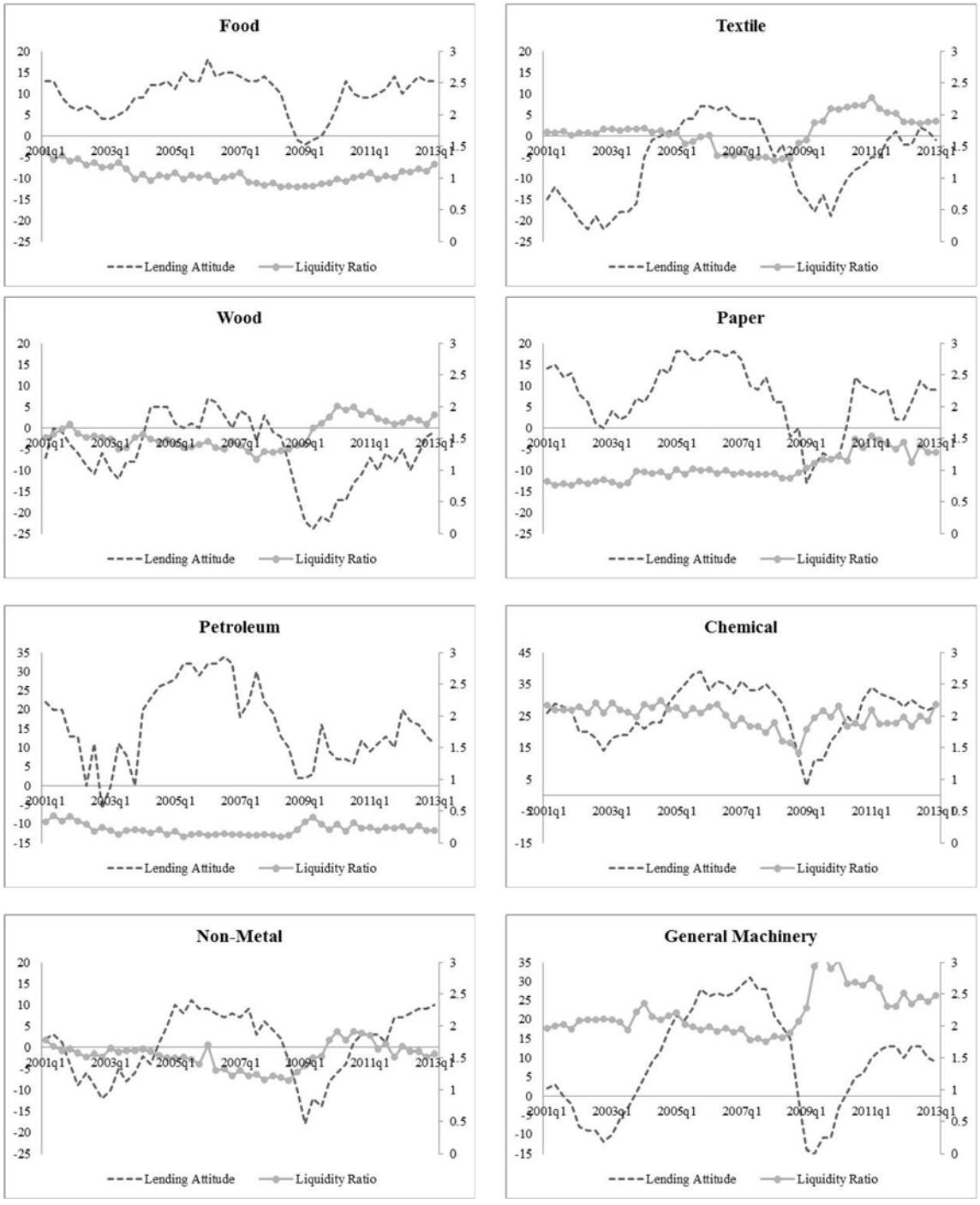
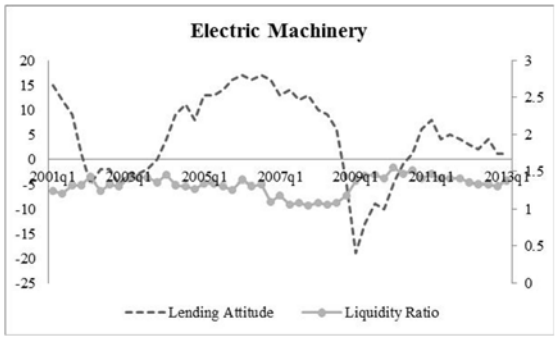
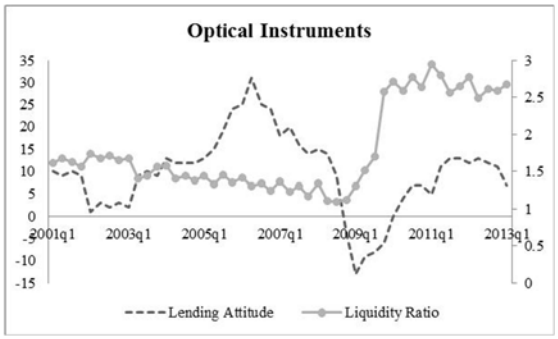
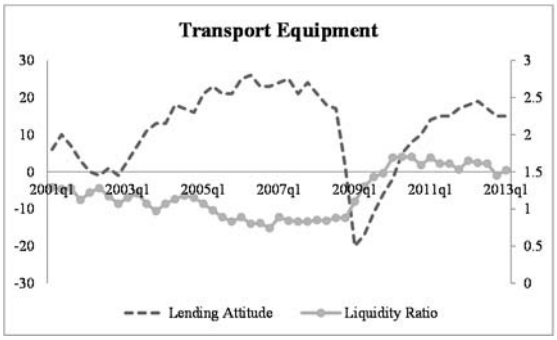


Figure A2 Lending Attitude of Financial Institution and Liquidity Ratio for Each Sector (Continued)







Data source: the Bank of Japan, *Tankan (Short-Term Economic Survey of Enterprises in Japan)*, 2001Q1–2013Q3.