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# Determinants of firm exchange rate predictions:
## Empirical evidence from survey data of Japanese firms

Thi-Ngoc Anh NGUYEN

Yokohama National University
Japan Society for the Promotion of Science

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***Center for Economic and Social Studies in Asia, Department of Economics***
***Yokohama National University***

# Determinants of firm exchange rate predictions:
## Empirical evidence from survey data of Japanese firms

Thi-Ngoc Anh NGUYEN*†

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Abstract

This letter uses Bank of Japan's *Tankan* survey data covering 10 manufacturing industries to investigate the characteristics as well as the determinants of firms' exchange rate predictions. Evidence of asymmetry is found regarding the way firms adjust their exchange rate predictions in response to different currency regimes. Japanese exporting firms are more likely to update their prediction of future exchange rates in response to unexpected yen appreciation than to unexpected yen depreciation. Furthermore, firm exchange rate prediction updating decisions are affected by other firm characteristics such as export dependency and profitability.

JEL classification: D22, D84, F31, G13

Keywords: Exchange rate pass-through (ERPT), pricing-to-market (PTM), exchange rate expectation, Japanese export, prediction adjustment speed, *Tankan* data

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† Graduate School of International Social Sciences, Yokohama National University and Research Fellow of the Japan Society for the Promotion of Science (JSPS). Email: nguyen.thingocanh208@gmail.com

## 1. Introduction

Exchange rate expectations have long been an important research topic in international macroeconomics; yet, the question of how market participants predict future exchange rate levels remains unresolved. A few studies only, such as those by Ito (1989) and Takagi (1991), have used survey data to analyze this question empirically. Accordingly, the limited data availability on expected future exchange rates has prevented further rigorous examination of this unresolved research question.

Regularly, the Bank of Japan (BOJ) publishes firm predictions of the yen/ US dollar bilateral normal exchange rate when export by firm size and by industry, which they obtain by conducting large-scale surveys of Japanese firms.[1] Figure 1 presents the exchange rate prediction error for both large-size and small-size firms as well as the actual (quarterly averaged) yen/ US dollar bilateral nominal exchange rate, where the prediction error is defined as the differences between the actual and predicted exchange rate. It can be observed that the magnitude of the prediction error is larger with a longer duration in shaded yen depreciation periods than in non-shaded yen appreciation periods.[2] In addition, in most periods, the graph of large-size firms (black x marked line) is above that of small-size firms (red dotted line) implying that prediction errors by large-size firms are larger (smaller) than those of small-size firms during yen depreciation (appreciation) periods. Thus, questions are raised about why the degree of prediction errors differs (1) between yen appreciation and depreciation periods, and (2) depending on firm size.

This letter aims to use the BOJ's *Tankan* survey data to reveal the characteristic as well as the determinants of firm-level exchange rate predictions. The analysis revealed that, first, Japanese firms adjust their exchange rate prediction errors more quickly (slowly) in yen appreciation (depreciation) period. Second, the adjustment speed of exchange rate prediction is positively correlated with a firm's degree of export dependency in the yen depreciation period. Third, in contrast, the adjustment speed is found to have negative relationship with a firm's profitability performance in the yen depreciation period, with small-size firms tending to increase the adjustment speed in response to an unanticipated depreciation of the yen.

The letter is organized as follows. Section 2 investigates the characteristics of exchange rate prediction and adjustment speed. The relationship between the adjustment speed and firm

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[1] BOJ's *Short-Term Economic Survey of Enterprises in Japan* (*TANKAN*) is published in every quarter. As of March 2018, for example, the BOJ sent out questionnaires to 10,020 firms and presents the averaged results by three types of firm size (large, medium-sized, and small firms) and by industry (17 manufacturing and 14 non-manufacturing industries).

[2] In this letter, the criteria of dividing currency regimes are based on prediction errors of exchange rates, i.e., the period is counted as yen depreciation period if the yen depreciates more than firms' expectation (prediction error >0) and yen appreciation otherwise. In fact, this currency regime specification is reasonable when comparing with the movement of actual yen/ US dollar exchange rate (blue solid line) in Figure 1.

characteristics is analyzed empirically in Section 3. Section 4 concludes.

## 2. Adjustment speed of exchange rate prediction

The adjustment speed ( $\alpha_t$ ) of exchange rate prediction is calculated by dividing the change in firm's predicted exchange rate by the exchange rate prediction error in the previous period: $\alpha_t = (E_t s_{t+1} - E_{t-1} s_t)/(s_t - E_{t-1} s_t)$, where $s_t$ is the natural log of bilateral nominal exchange rate at $t$ period, and $E_t$ is an expectation operator conditional on all available information at $t$ period. Although firms use all the available information to predict the future exchange rate, it is impossible to establish perfect expectations. Thus, the hypothesis proposed here is that firms tend to determine the predicted exchange rate conservatively when making an export plan. The additional hypothesis is that the magnitude of prediction errors depends on firm characteristics such as export dependency and profitability.

To test the above hypothesis, the adjustment speed, $\alpha_t$, which measures how quickly firms update their predicted exchange rate by observing current (realized) exchange rate, is estimated. To allow for possible asymmetric prediction of future exchange rates, the following threshold regression model is established:

$$E_t s_{t+1} - E_{t-1} s_t = I \times \alpha_1 (s_t - E_{t-1} s_t) + (1 - I) \times \alpha_2 (s_t - E_{t-1} s_t) + v_{t+1} \quad (1)$$

where the dummy $I$ takes the value of 1 (yen depreciation regime) if the prediction error is positive, and takes 0 (yen appreciation regime) otherwise.

Quarterly data from 1997Q2 to 2016Q1 for three firm sizes in 10 manufacturing industries are used for the above estimation.[3] Table 1 presents the results of $\alpha_1$ and $\alpha_2$ as well as the results for the Wald-test for the null hypothesis $\alpha_1 = \alpha_2$. An asymmetric pattern of adjustment speeds can be observed among almost all large and medium enterprises and in four out of 10 industries for small enterprises, where the adjustment speed is higher in the yen appreciation regime than in the yen depreciation regime.

One explanation for regime-dependent adjustment speed could be that exporting firms might need to revise their export plan quickly in response to an unexpected appreciation of the

[3] Following Nguyen and Sato (2017), this letter constructs the dataset from BOJ's *Tankan* data. Although data on 17 manufacturing sectors are available, as footnote 1 shows, we finally chose "all manufacturing" and nine manufacturing industries. See the footnote of Table 1 for industry information. Actual yen/ US dollar bilateral nominal exchange rate (quarterly average) $s_t$ is taken from the IFS.

yen, especially when they use foreign currency invoicing in their exports.[4] In contrast, during the yen depreciation regime, Japanese firms could enjoy unexpected exchange gains, which provides less incentive to change their export plan and, hence, to revise their predicted exchange rate.

## 3. Determinants of adjustment speed

Next, we investigate what factors determine the adjustment speed. The BOJ provides notable data of forecasted (planned) export amounts, total sales, and ordinary profits as obtained from their *Tankan* surveys. These data are used to calculate the "forecasted export ratio" as well as the "forecasted profit ratio".[5] To investigate the effect of firm size on adjustment speed, firm-size dummies and their interactions with explanatory variables are included in the following fixed-effect model estimation:

$$\begin{aligned} spd_{ijt} &= c + \sum_i S_i + \alpha \cdot \exp\_ratio_{ijt-1} + \sum_i \alpha_i \cdot S_i \times \exp\_ratio_{ijt-1} + \\ &+ \beta \cdot profit\_ratio_{ijt-1} + \sum_i \beta_i \cdot S_i \times profit\_ratio_{ijt-1} + \gamma_{ij} + \eta_t + \varepsilon_{ijt} \end{aligned} \quad (2)$$

where $spd_{ijt}$, $\exp\_ratio_{ijt}$, and $profit\_ratio_{ijt}$ denote the adjustment speed, export ratio, and profit ratio of *i* firm-size-level in industry *j* at time *t*, respectively. $S_i$ denotes dummies for large or small enterprises. Fixed effects of industry-firm-size and time are captured by $\gamma_{ij}$ and $\eta_t$, respectively. Prediction error, $er_t$, is used to distinguish currency regimes. The sample period ranges from 1999Q2 to 2016Q1.

A firm's export ratio has two conflicting effects on its adjustment speed. One effect is an "exposure effect" that occurs when the export ratio is treated as a proxy for firms' exchange rate exposure. Given the assumption of a positive relationship between the adjustment speed and ERPT, the sign on $\alpha$ is expected to be positive.[6] The other effect is a "market share

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[4] As shown by Ito et al. (2018), Japanese firms tend to invoice exports in the destination currency (mainly in US dollars) when exporting products to advanced countries. Even for exports to Asian countries, the share of US-dollar-invoiced exports is higher than the share of yen-invoiced exports. Given such a large share of foreign currency invoicing in exports, Japanese firms shoulder foreign exchange loss when the yen appreciates unexpectedly.

[5] Export (profit) ratio is calculated as the ratio of firm's export (ordinary profit) amount compared with total sales amount. The two ratios' correlation coefficient is 0.33.

[6] Floden et al. (2008) shows that higher exchange rate exposure leads to a higher ERPT level.

effect" that arises when the export ratio is considered as a proxy for firms' sales dependency on the international market. The fact that firms depend heavily on overseas sales might give them an incentive to maintain (boost) their market share by decreasing (increasing) the level of ERPT and hence to slowly (quickly) revise exchange rate predictions when the yen appreciates (depreciates).[7] Therefore, taken together, $\alpha$ is expected to be positive when the yen depreciates, but remains ambiguous when the yen appreciates.

The profit ratio is used to proxy for firms' business performance and is highly related to a firm's mark-up level. Depending on that firm's export competitiveness, the relationship between firm profitability and adjustment speed can be either positive or negative.[8]

Columns (4)–(6) in Table 2 reports the results of regression (2).[9] The coefficients of both the export and profit ratios are found to be significant in the regime-free as well as yen depreciation regime, but not in the yen appreciation regime.

In the yen depreciation regime, the coefficient of the export ratio is significantly positive as expected, with 1% increase in the export ratio leading to a 11% higher adjustment speed. However, firm size itself does not have a significant effect on adjustment speed, indicating a linear effect of the export ratio on adjustment speed among all types of enterprises. Meanwhile, the profit ratio shows a strongly significant nonlinear relationship with the adjustment speed in the yen depreciation regime. For benchmark medium-size enterprises, profitability negatively affects adjustment speed, whereas the interaction between firm size and profitability is significantly positive for small-size enterprises, making the point estimate 34.004. Thus, the smaller the firm size, the more likely it is that firms with high profitability will increase their adjustment speed in the yen depreciation regime.

As discussed earlier, firms with high profits tend not to revise their predictions of future exchange rates quickly in response to an unexpected depreciation of the yen. However, the small-size firms, often regarded as "less competitive," are likely to have a stronger incentive to update their predicted exchange rate to decrease their export price, thereby improving their export price competitiveness during the yen depreciation regime. This finding is consistent with the empirical results of Berman et al. (2012) and Nguyen and Sato (2017), which demonstrated an asymmetric relationship between firm business performance and ERPT.

## 4. Concluding remarks

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[7] Krugman (1987) and Knetter (1993) discuss possible ERPT asymmetry due to market power.

[8] Berman et al. (2012), Nguyen and Sato (2017) suggest a nonlinear relationship between firm performance (or industry competitiveness) and ERPT.

[9] For reference, the results of the model without firm-size dummies (model (3)) are reported in column (1)–(3) of Table 2. Only the export ratio coefficients are found to be significant in regime-free and yen depreciation regime. $spd_{ijt} = c + \alpha \cdot \exp\_ratio_{ijt-1} + \beta \cdot profit\_ratio_{ijt-1} + \gamma_{ij} + \eta_t + \varepsilon_{ijt}$ (3)

Using the BOJ's *Tankan* data, we have investigated empirically the characteristic and determinants of firm exchange rate predictions. The novel findings are three-fold. First, Japanese exporting firms are more likely to update their exchange rate predictions in response to unexpected yen appreciation than in response to unexpected yen depreciation. Second, the performed panel estimation demonstrated that a firm's export dependency, as well as its profitability, has significant effect on the speed of updating predicted exchange rates in response to an unexpected yen depreciation. Finally, unlike the negative effect of profitability on prediction updating found among large- and medium-size firms, small-size firms tend to update their prediction of future exchange rates in response to unexpected yen depreciation, which suggests that firm size, often associated with firm export competitiveness, does matter in the prediction of future exchange rates. These empirical findings will motivate further research on firm-level predictions of future exchange rates.

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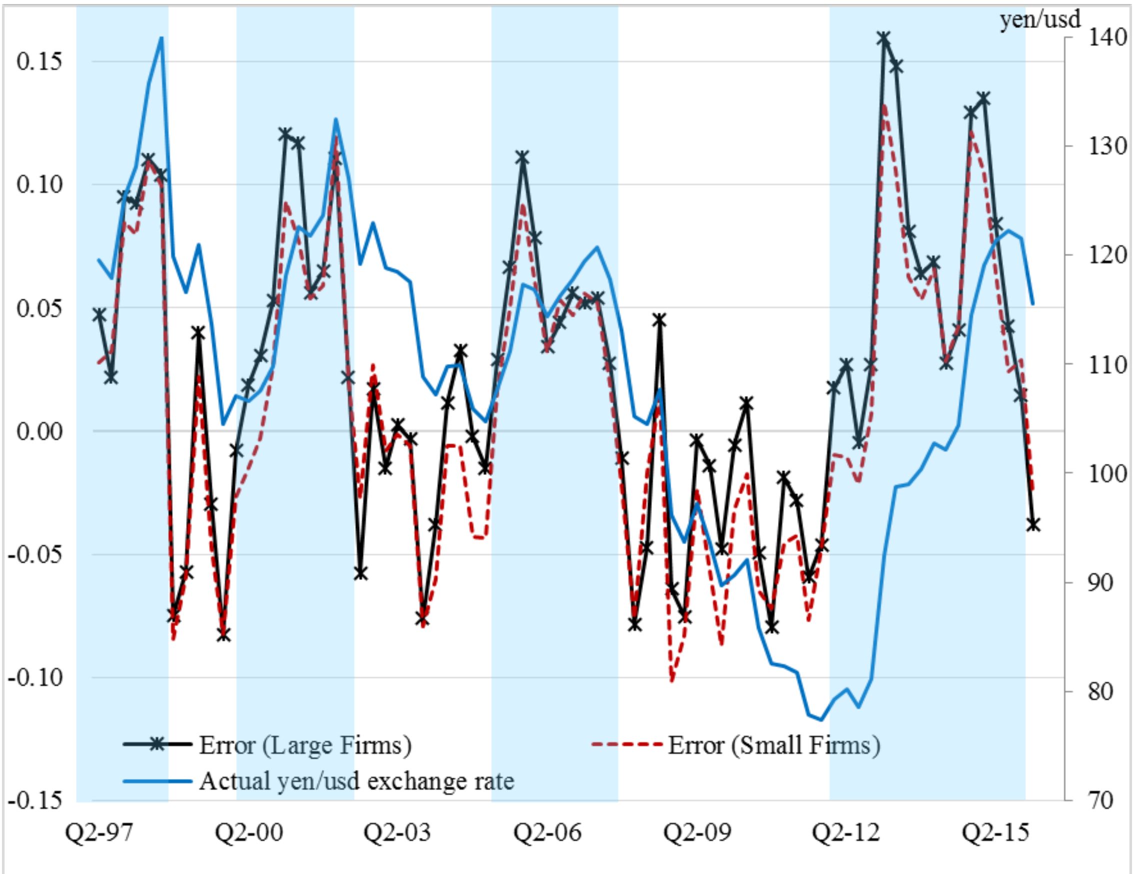
Figure 1: Prediction error of large and small Japanese manufacturing exporters




*Note:* Prediction error is calculated as the difference between natural log of the actual exchange rate and natural log of the predicted exchange rate, $er_t = \ln s_t - \ln E_{t-1} s_t$, indicating the deviation rate of the realized exchange rate from the expected one. "Error (Large Firms)," "Error (Small Firms)" are calculated using the expected exchange rate for large- and small-size firms, respectively. The shaded (non-shaded) yen depreciation (appreciation) periods are periods in which the prediction errors are larger (smaller) than 0.

*Source*: Bank of Japan, *Short-Term Economic Survey of Enterprises in Japan* (*TANKAN*); IMF, *International Financial Statistics*.

Table 1: Adjustment speed of exchange rate predictions to an error in the previous period

| Industry \ Firm-size level | Large enterprise | | | Medium enterprise | | | Small enterprise | | |
|---|---|---|---|---|---|---|---|---|---|
| | Depre. | Appre. | Symmetry | Depre. | Appre. | Symmetry | Depre. | Appre. | Symmetry |
| Manufacturing | 0.351*** | 0.632*** | 0.000*** | 0.357*** | 0.542*** | 0.000*** | 0.397*** | 0.480*** | 0.104 |
| | *(0.026)* | *(0.052)* | | *(0.023)* | *(0.037)* | | *(0.030)* | *(0.041)* | |
| Textile | 0.431*** | 0.573*** | 0.031** | 0.442*** | 0.578*** | 0.011** | 0.509*** | 0.611*** | 0.187 |
| | *(0.038)* | *(0.527)* | | *(0.031)* | *(0.042)* | | *(0.046)* | *(0.062)* | |
| Chemical | 0.381*** | 0.573*** | 0.001*** | 0.386*** | 0.565*** | 0.006*** | 0.345*** | 0.510*** | 0.015** |
| | *(0.030)* | *(0.049)* | | *(0.034)* | *(0.053)* | | *(0.032)* | *(0.058)* | |
| Iron and steel | 0.478*** | 0.621*** | 0.014** | 0.354*** | 0.543*** | 0.017** | 0.480*** | 0.532*** | 0.539 |
| | *(0.045)* | *(0.063)* | | *(0.040)* | *(0.066)* | | *(0.053)* | *(0.065)* | |
| Non-ferrous metal | 0.377*** | 0.590*** | 0.011** | 0.419*** | 0.613*** | 0.001*** | 0.500*** | 0.586*** | 0.241 |
| | *(0.041)* | *(0.071)* | | *(0.032)* | *(0.049)* | | *(0.047)* | *(0.056)* | |
| Processed metal | 0.370*** | 0.523*** | 0.036** | 0.278*** | 0.673*** | 0.000*** | 0.256*** | 0.771*** | 0.000*** |
| | *(0.039)* | *(0.060)* | | *(0.031)* | *(0.077)* | | *(0.047)* | *(0.109)* | |
| General | 0.335*** | 0.656*** | 0.000*** | 0.345*** | 0.573*** | 0.000*** | 0.380*** | 0.628*** | 0.001*** |
| | *(0.032)* | *(0.069)* | | *(0.025)* | *(0.046)* | | *(0.034)* | *(0.063)* | |
| Electric | 0.251*** | 0.651*** | 0.007*** | 0.312*** | 0.623*** | 0.000*** | 0.396*** | 0.513*** | 0.041** |
| | *(0.049)* | *(0.137)* | | *(0.027)* | *(0.054)* | | *(0.031)* | *(0.047)* | |
| Transport | 0.326*** | 0.699*** | 0.000*** | 0.256*** | 0.536*** | 0.000*** | 0.373*** | 0.352*** | 0.784 |
| | *(0.034)* | *(0.076)* | | *(0.025)* | *(0.051)* | | *(0.054)* | *(0.052)* | |
| Other | 0.367*** | 0.534*** | 0.014** | 0.410*** | 0.370*** | 0.518 | 0.328*** | 0.275*** | 0.527 |
| | *(0.034)* | *(0.057)* | | *(0.041)* | *(0.045)* | | *(0.058)* | *(0.060)* | |

*Note*: (a) “Manufacturing,” “General,” “Electric,” “Transport,” and “Other” denotes “All manufacturing industries,” “General machinery” (including the three sectors of “General-purpose machinery,” “Production machinery,” and “Business oriented machinery”), “Electrical machinery,” “Transportation machinery,” and “Other manufacturing,” respectively. (b) “Depre.” and “Appre.” denote the yen depreciation and appreciation regimes, respectively. (c) “Symmetry” indicates *p*-values of the Wald test for the hypothesis of equality in adjustment speed ($\alpha_1 = \alpha_2$) in the two regimes.

Table 2: Relationship of adjustment speed with other firm characteristics.

| dependent var: adjustment speed | no regime (1) | depreciation (2) | appreciation (3) | no regime (4) | depreciation (5) | appreciation (6) |
|---|---|---|---|---|---|---|
| exp_ratio | 5.462** | 9.532*** | -2.788 | 6.955** | 11.152*** | -1.590 |
| | *(2.543)* | *(2.982)* | *(4.187)* | *(3.472)* | *(4.145)* | *(5.657)* |
| profit_ratio | -8.624 | -7.355 | -1.378 | -17.628** | -25.715** | -6.280 |
| | *(5.589)* | *(6.503)* | *(9.297)* | *(8.252)* | *(10.183)* | *(12.942)* |
| large*exp_ratio | | | | -1.592 | -1.325 | -3.406 |
| | | | | *(5.098)* | *(5.937)* | *(8.463)* |
| small*exp_ratio | | | | -2.079 | 0.390 | 1.427 |
| | | | | *(6.858)* | *(9.024)* | *(10.011)* |
| large*profit_ratio | | | | 10.383 | 19.538 | 7.562 |
| | | | | *(9.694)* | *(12.063)* | *(15.004)* |
| small*profit_ratio | | | | 25.820** | 59.719*** | 8.647 |
| | | | | *(12.122)* | *(16.058)* | *(17.962)* |
| Constant | -0.590 | -1.482* | 2.378 | 0.073 | -0.504 | 4.025 |
| | *(0.841)* | *(0.899)* | *(3.378)* | *(0.840)* | *(0.878)* | *(3.417)* |
| large enterprise | | | | -0.681 | -0.889 | -1.430 |
| | | | | *(1.066)* | *(1.211)* | *(1.823)* |
| small enterprise | | | | -1.099 | -1.440 | -3.061* |
| | | | | *(1.031)* | *(1.294)* | *(1.585)* |
| time-fixed effect | YES | YES | YES | YES | YES | YES |
| cross-section fixed effect | YES | YES | YES | YES | YES | YES |
| degree of freedoms | 1908 | 1074 | 771 | 1904 | 1070 | 767 |
| R-squared | 0.067 | 0.232 | 0.128 | 0.069 | 0.242 | 0.129 |
| No. of obs | 2006 | 1159 | 847 | 2006 | 1159 | 847 |

*Note*: */**/*** denotes significance at 10%, 5% and 1%, respectively.