Firm’s Predicted Exchange Rate and Nonlinearities in Pricing-to-Market

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1. Introduction: Motivation and Literature Review

2. Empirical Analysis: Model and Data

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INTRODUCTION

— Motivation and Literature Review —
Motivation 1: Asymmetric ERPT

Japanese Export Price and Nominal Yen/USD Exchange Rate (2005=100)

- **Yen Appreciation**
  - Export price (contract) did not decline.
  - PTM (??)

- **Yen Depreciation**
  - Export price (contract) Index fell considerably.
  - ERPT↑ (??)

*Note: 2000M1-2016M7.*
*Source: BOJ and IMF.*
Motivation 1: Asymmetric ERPT

Japanese Export Price and Nominal Yen/USD Exchange Rate (2005=100)

Yen Appreciation
→ Export price (contract) increased.
→ ERPT↑ (??)

Yen Depreciation
→ Export Price Index did not fall.
→ PTM (??)

Source: BOJ.
Motivation 1: Asymmetric ERPT

- **ERPT/PTM behavior of Japanese firms:**
  - Likely different across industries.
  - May differ between yen appreciation and depreciation periods.

- **Object**
  - To analyze possible differences in ERPT/PTM between yen appreciation and depreciation periods

How to distinguish between yen appreciation and depreciation periods?
Motivation 2: Threshold Specification


\[ \Delta E > 0 \text{ } \rightarrow \text{ Exchange rate \textit{depreciation} period} \]
\[ \Delta E < 0 \text{ } \rightarrow \text{ Exchange rate \textit{appreciation} period} \]

However, …

Changes in the monthly exchange rate series do not correctly capture the yen appreciation/depreciation periods.
Motivation 2: Threshold Specification

Even in the yen appreciation period, these S-R responses will be regarded as the yen depreciation period.

Source: BOJ and IMF.
Motivation 2: Threshold Specification

- Balke and Fomby (1997), Belke et al. (2009), Belke et al. (2012)

\[
\begin{align*}
\Delta E > c & \quad \text{Exchange rate depreciation period} \\
-c < \Delta E < c & \quad \text{Inaction band} \\
\Delta E < -c & \quad \text{Exchange rate appreciation period}
\end{align*}
\]

The method to choose critical value \( c \) remains ambiguous.
Motivation 2: Threshold Specification

- Firms predict exchange rate and use it as a reference when setting export price.

- Use expected exchange rates as a threshold specification
  - rarely used in the literature because of its unavailability.
  - Bank of Japan conducts Tankan survey quarterly, including a question about firms predicted exchange rate
Predicted exchange rate – *Tankan* data

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<tbody>
<tr>
<td>Japan calendar</td>
<td>2014-1\textsuperscript{st} half</td>
<td>2014-2\textsuperscript{nd} half</td>
<td>2015-1\textsuperscript{st} half</td>
<td>2015-2\textsuperscript{nd} half</td>
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<tr>
<td>Mar-2015</td>
<td>Actual result</td>
<td>Estimated</td>
<td>Forecast</td>
<td>Forecast</td>
<td>Forecast</td>
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<tr>
<td>Jun-2015</td>
<td>Actual result</td>
<td>Actual result</td>
<td>Forecast</td>
<td>Forecast</td>
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<tr>
<td>Sep-2015</td>
<td>Sep-14</td>
<td>Mar-15</td>
<td>Sep-15</td>
<td>Mar-16</td>
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<td>Dec-2015</td>
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Survey time

- 3/2014
- 9/2014
- 3/2015
- 9/2015
- 3/2016

Survey time:
- Mar-2015
- Jun-2015
- Sep-2015
- Dec-2015

Exchange rate:
- Actual result
- Estimated
- Forecast

Calendar:
- Japan calendar
- 2014-1\textsuperscript{st} half
- 2014-2\textsuperscript{nd} half
- 2015-1\textsuperscript{st} half
- 2015-2\textsuperscript{nd} half
Predicted and actual exchange rate

Nominal Yen/USD Exchange Rate: Actual and Predicted 1997Q2-2015Q4

Source: BOJ and IMF
To test the possible nonlinearity of PTM level in Japanese export using a new threshold specification method.

**Model**: Nonlinear Autoregressive Distributed Lag (NARDL)

**Data**: World IPI, NEER, Input price, Yen-based export price

**Threshold data**: JPY/USD actual and predicted exchange rate

**Sample period**: From 1997M4 to 2015M12.
Empirical Analysis
— Model and Data—
ARDL Model

- PTM in long- and short-run

\[ \Delta ex_t = \pi + \theta_1 ex_{t-1} + \theta_2 er_{t-1} + \theta_4 dp_{t-1} + \theta_5 ipi_{t-1} \]

\[ + \sum_{j=1}^{n} \alpha_j \Delta ex_{t-j} + \sum_{k=0}^{o} \beta_k \Delta er_{t-k} + \sum_{l=0}^{p} \gamma_l \Delta dp_{t-l} + \sum_{m=0}^{q} \delta_m \Delta ipi_{t-m} + \mu_t \]

- Cointegration test

  **\( F \)-test**  \( H_0 : \theta_1 = \theta_2 = \theta_3 = \theta_4 = 0 \)

  **\( t \)-test**  \( H_0 : \theta_1 = 0 \)
**NARDL Model**

\[
\Delta e_{xt} = \pi + \theta_1 e_{xt-1} + \theta_2^+ e_{rt-1}^+ + \theta_3^- e_{rt-1}^- + \theta_4 d_{pt-1} + \theta_5 i_{pi t-1} + \sum_{j=1}^{n} \alpha_j \Delta e_{xt-j} + \sum_{k=0}^{o} \left( \beta_k^+ \Delta e_{rt-k}^+ + \beta_k^- \Delta e_{rt-k}^- \right) + \sum_{l=0}^{p} \gamma_l \Delta d_{pt-l} + \sum_{m=0}^{q} \delta_m \Delta i_{pi t-m} + \mu_t
\]

Where \( e_{r^+} \) captures the depreciation regime

\( e_{r^-} \) captures the appreciation regime

<table>
<thead>
<tr>
<th>Cointegration test</th>
<th>Asymmetry test</th>
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<tbody>
<tr>
<td><strong>F-test</strong> ( H_0 : \theta_1 = \theta_2^+ = \theta_3^- = \theta_4 = \theta_5 = 0 )</td>
<td><strong>LR</strong> ( H_0 : -\theta_2^+ / \theta_1 = -\theta_3^- / \theta_1 )</td>
</tr>
<tr>
<td><strong>t-test</strong> ( H_0 : \theta_1 = 0 )</td>
<td><strong>SR</strong> ( H_0 : \beta_k^+ = \beta_k^- ) for ( k=0,\ldots,o )</td>
</tr>
<tr>
<td>or ( H_0 : \sum_{k=0}^{o} \beta_k^+ = \sum_{k=0}^{o} \beta_k^- )</td>
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Regime specification

• Conventional threshold

\[ er_t^+ = \sum_{i=1}^{t} \Delta er_i^+ = \sum_{i=1}^{t} \max( \Delta er_i, 0) \]

\[ er_t^- = \sum_{i=1}^{t} \Delta er_i^- = \sum_{i=1}^{t} \min( \Delta er_i, 0) \]

• Using prediction error as a threshold

\[ er_t^+ = \sum_{i=1}^{t} \Delta er_i^+ = \sum_{i=1}^{t} \Delta er_i I\{\text{error} > \text{mean} \ (\text{error}) \} \]

\[ er_t^- = \sum_{i=1}^{t} \Delta er_i^- = \sum_{i=1}^{t} \Delta er_i I\{\text{error} < \text{mean} \ (\text{error}) \} \]

with error = actual ER – predict ER
Why \textit{mean(error)} as a threshold?

Nominal Yen/USD Exchange Rate: Actual and Predicted

1997Q2-2015Q4

Source: BOJ and IMF.
NEER change in conventional threshold
NEER change in new threshold

![Graph showing depreciation and appreciation over time.](image)
Nominal JPY/USD Exchange Rate

Source: IMF.

1997M01-2015M12
Data Description

1. World demand: World IPI

- Choose destination countries (areas) which account for 1% or more in Japan’s total exports as of 2005 and 2010.
  - => 20 countries are chosen. (Source: IMF, DOT.)

- Re-calculate Japanese export weight using the “20-country-world”.
  - Export weight is revised every year from 1997 to 2014. The weight in 2015 is assumed to be equal to the weight in 2014.

- World IPI at year $t$ is:

$$\text{World IPI}_t = \sum_{i=1}^{20} IPI_i^t \times \text{weight}_i^t$$
2. Contract Currency Based NEER (C-NEER)

- C-NEER is calculated by industry from the Export Price Index published from Bank of Japan (1997M4-2015M12).

3. Domestic Input Price (DIP)

4. Export Price Index (EXP)

- Source: Bank of Japan (from 1997M4 to 2015M12).
- Industry-specific data: All manufacturing and 7 industries.
- All data is in natural logarithm.
- First-difference series to ensure the stationarity of variables.
Contract currency based NEER (1)

Two types of BOJ export price index:

(1) Contract currency based export price index ($P_{con}^{EX}$):

$$P_{con}^{EX} = (P_{yen})^\alpha (P_\$)^\beta (P_{euro})^\gamma \quad \alpha + \beta + \gamma = 1$$

(2) Yen based export price index ($P_{yen}^{EX}$):

$$P_{yen}^{EX} = (P_{yen})^\alpha (P_\$ \cdot E_{yen/$})^\beta (P_{euro} \cdot E_{yen/euro})^\gamma$$

$$= (P_{yen})^\alpha (P_\$)^\beta (P_{euro})^\gamma \cdot (E_{yen/$})^\beta \cdot (E_{yen/euro})^\gamma$$

$$= P_{con}^{EX} \cdot (E_{yen/$})^\beta \cdot (E_{yen/euro})^\gamma$$
Two types of BOJ export price index:

\[
P^\text{EX}_\text{yen} = (P_{\text{yen}})^\alpha (P_\$ \cdot E_{\text{yen} / \$})^\beta (P_{\text{euro}} \cdot E_{\text{yen} / \text{euro}})^\gamma
\]

\[
P^\text{EX}_{\text{con}} = (P_{\text{yen}})^\alpha (P_\$)^\beta (P_{\text{euro}})^\gamma
\]

Contract currency based NEER by industry:

\[
\text{NEER}^\text{Contract} = \frac{P^\text{EX}_{\text{yen}}}{P^\text{EX}_{\text{con}}} = (1)^\alpha \cdot (E_{\text{yen} / \$})^\beta \cdot (E_{\text{yen} / \text{euro}})^\gamma
\]

Increase in NEER => Yen Depreciation
Decrease in NEER => Yen Appreciation
Contract currency based NEER (2)

Advantage:

- Able to calculate industry-specific contract-NEER.
- Reflect the degree of exchange rate risk that exporters face in each industry
Bilateral exchange rate of yen vis-à-vis USD

- Predicted yen/usd exchange rate:
  - Industry level, all size firm data
  - Metal = Iron and steel, Nonferrous metal and Processed metal with weight
  - Prediction is fixed for 3 months in the same quarter
- Period: 1997M4 – 2015M12
- Actual yen/usd exchange rate: IFS
- $error = \ln(\text{actual yen/usd}) - \ln(\text{predict yen/usd})$
Empirical Result
Result and Interpretation

\[ \Delta e_x_t = \pi + \theta_1 e_{x_{t-1}} + \theta_2^+ e_{r_{t-1}}^+ + \theta_3^- e_{r_{t-1}}^- + \theta_4 d_{p_{t-1}} + \theta_5 i_{p_{t-1}} \]

\[
+ \sum_{j=1}^{n} \alpha_j \Delta e_x_{t-j} + \sum_{k=0}^{o} \left( \beta_k^+ \Delta e_{r_{t-k}}^+ + \beta_k^- \Delta e_{r_{t-k}}^- \right) + \sum_{l=0}^{p} \gamma_l \Delta d_{p_{t-l}} + \sum_{m=0}^{q} \delta_m \Delta i_{p_{t-m}} + \mu_t
\]

- **Model:** NARDL
- Long-run relationship among variables (\(F\)-test and \(t\)-test)
- Long-run asymmetry of PTM level \[- \frac{\theta_2^+}{\theta_1} \neq - \frac{\theta_3^-}{\theta_1}\]
- **Sample period:** full sample 1997-2015
  sub sample 1997-2006 and 2007-2015
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<thead>
<tr>
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<tbody>
<tr>
<td>All manufacturing</td>
<td>0.497</td>
<td>0.900</td>
<td>a***</td>
</tr>
<tr>
<td>Textile</td>
<td>0.534</td>
<td>0.456</td>
<td>***</td>
</tr>
<tr>
<td>Chemical</td>
<td>0.504</td>
<td>0.135</td>
<td>0.010</td>
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<tr>
<td>Metal</td>
<td>0.465</td>
<td>0.238</td>
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<tr>
<td>Machinery</td>
<td>0.725</td>
<td>0.825</td>
<td>0.222</td>
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<tr>
<td>Electric</td>
<td>2.175</td>
<td>-1.611</td>
<td>0.737</td>
</tr>
<tr>
<td>Transport</td>
<td>0.828</td>
<td>0.617</td>
<td>0.828</td>
</tr>
<tr>
<td>Other</td>
<td>-0.448</td>
<td>0.127</td>
<td>a</td>
</tr>
</tbody>
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Notes: */**/*** denote the significance of cointegration test for 10%, 5% and 1%, respectively. a/b/c denote the significance of long-run symmetry test for 1%, 5% and 10%, respectively.
Cointegration and asymmetry in long-run

- Full sample (1997-2015) and first sub-sample (1997-2006)
  - No cointegration and PTM asymmetry in most cases

  - Strong evidence (5/8 industries) of cointegration and PTM asymmetry in the long-run

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<thead>
<tr>
<th></th>
<th>Yen depreciation</th>
<th>Yen appreciation</th>
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<tbody>
<tr>
<td>Competitive (Machinery, Transport)</td>
<td>Almost full PTM</td>
<td>Incomplete PTM (57-73% PTM)</td>
</tr>
<tr>
<td>Less competitive (Metal, Textile, Chemical)</td>
<td>Closer to full ERPT</td>
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</tbody>
</table>
Concluding Remarks
1. ERPT (PTM) behavior of Japanese exporters differs between the yen appreciation and depreciation regimes.
   ✓ Clear evidence cannot be found before 2007.
   ✓ Strong evidence for nonlinearities in PTM strategy from 2007.

2. Different PTM behavior across industries.
   ✓ Yen appreciation: Incomplete PTM in all industries except Electric and Other manufacturing.
   ✓ Yen depreciation:
     • Almost full PTM in competitive industries
     • Closer to full ERPT in less competitive industries.
Contribution

• Employ a new threshold specification method using firms’ predicted exchange rate

• Explain the unresponsiveness of Japanese trade balance to the yen depreciation from 2012

✓ 45% of Japanese export are Transportation and General Machinery, who conduct full PTM in yen depreciation
References


