REITI-IWEP-CESSA Joint-Workshop
Exchange Rate and International Currency: Perspective from China and Japan
Beijing, 19 November 2016

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

Thi-Ngoc-Anh Nguyen (*Yokohama National University and JSPS*)
Kiyotaka Sato (*Yokohama National University*)

Outline

1. Introduction: Motivation and Literature Review

2. Empirical Analysis: Model and Data

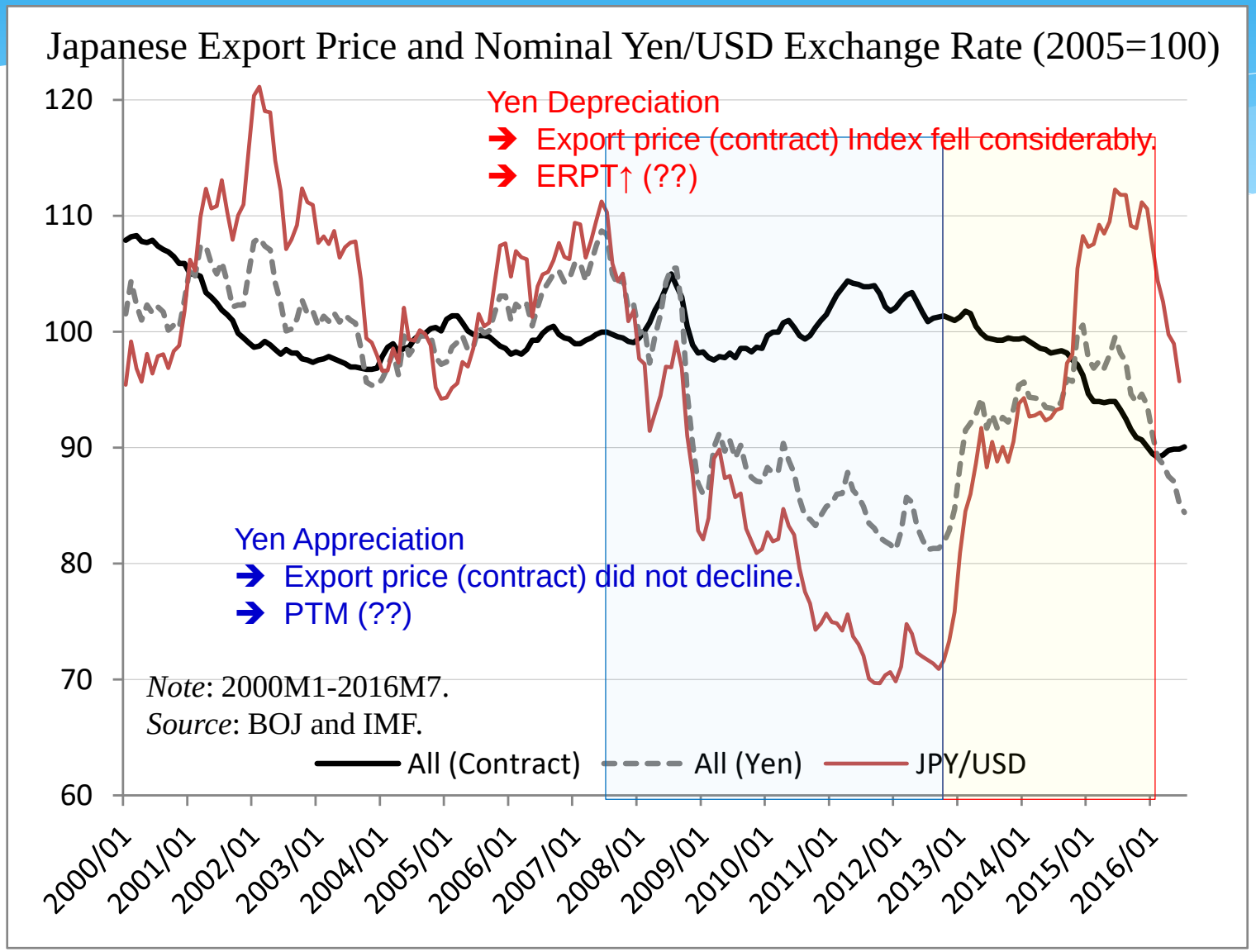
3. Results

4. Concluding Remarks

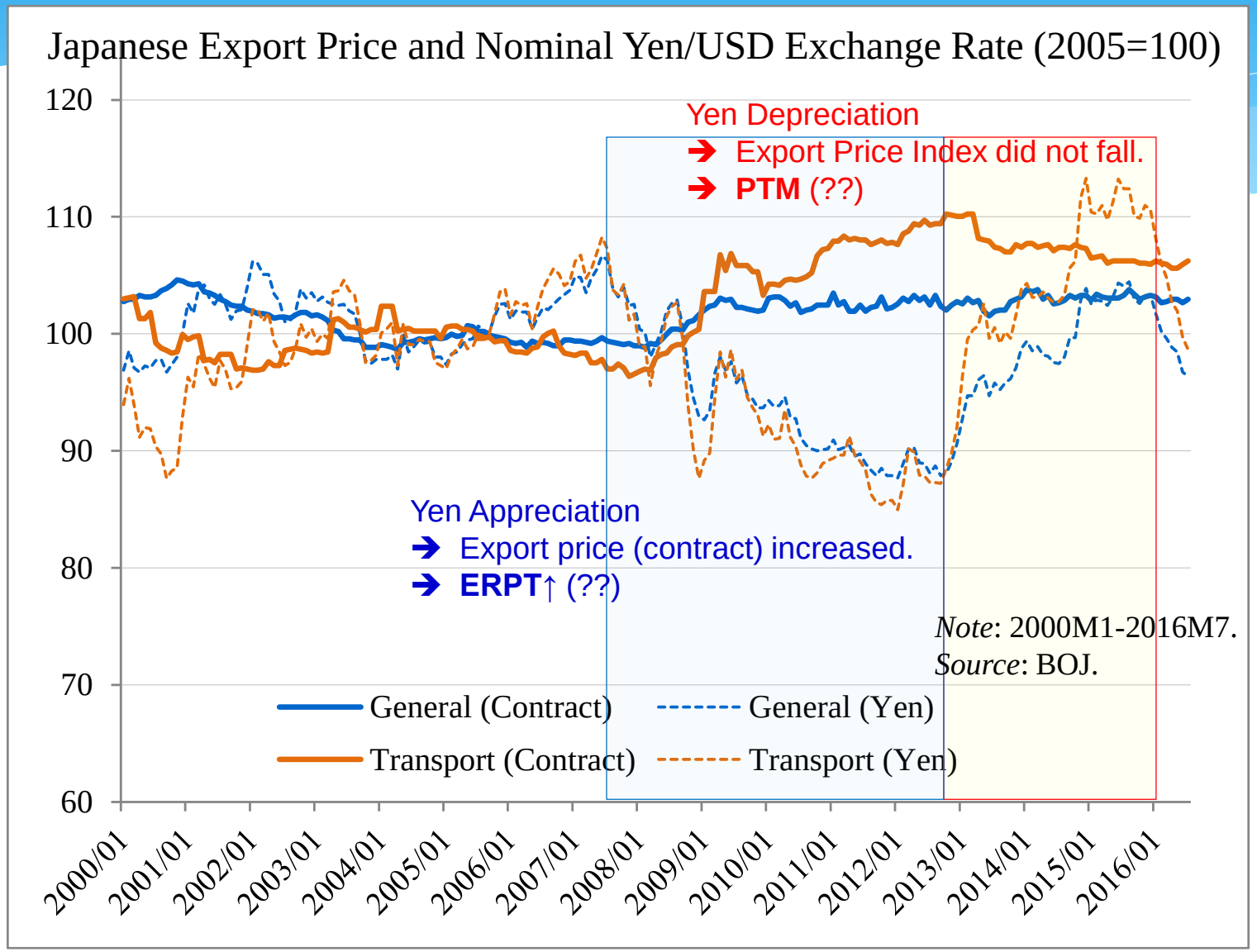
INTRODUCTION

— Motivation and Literature Review —

Motivation 1: Asymmetric ERPT



Motivation 1: Asymmetric ERPT



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

- Knetter (1994), Mahdavi (2002), Pollard and Coughlin (2004)

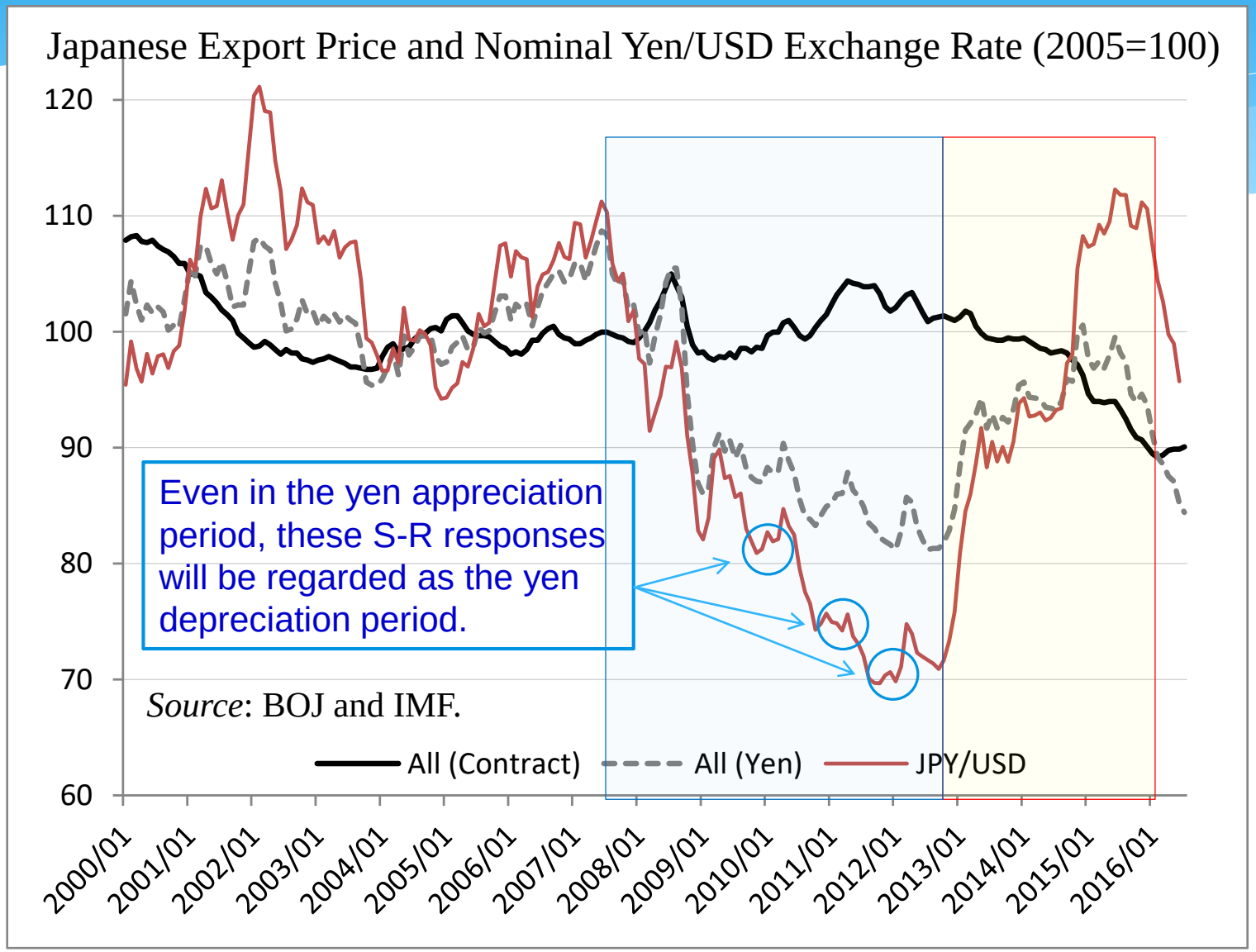
$\Delta E > 0$ ⇒ Exchange rate depreciation period

$\Delta E < 0$ ⇒ Exchange rate appreciation period

However, …

Changes in the monthly exchange rate series do not correctly capture the yen appreciation/depreciation periods.

Motivation 2: Threshold Specification



Motivation 2: Threshold Specification

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

$\Delta E > c$ ⇒ Exchange rate depreciation period

$-c < \Delta E < c$ ⇒ Inaction band

$\Delta E < -c$ ⇒ Exchange rate appreciation period

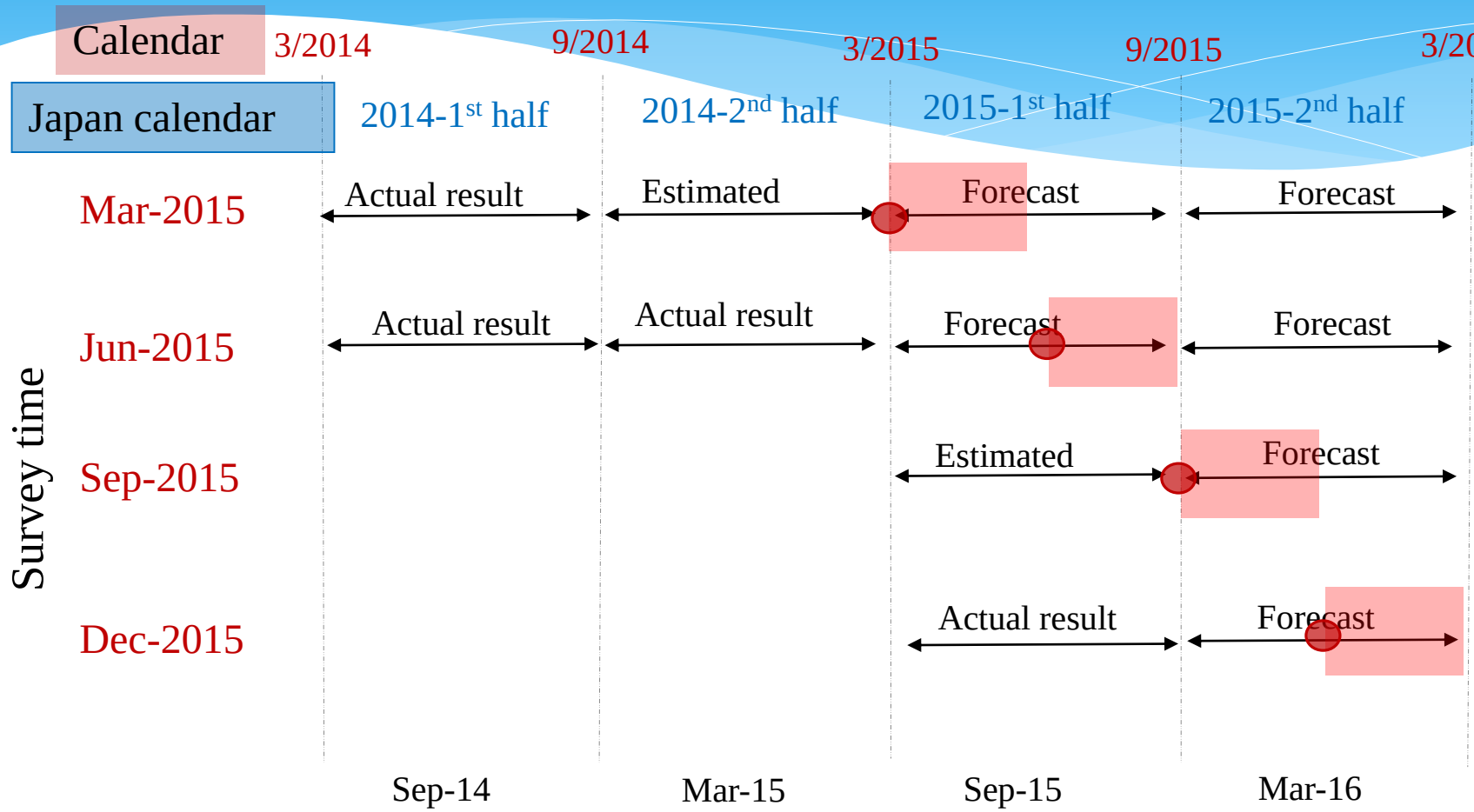
The method to choose critical value c remains ambiguous.

Motivation 2: Threshold Specification

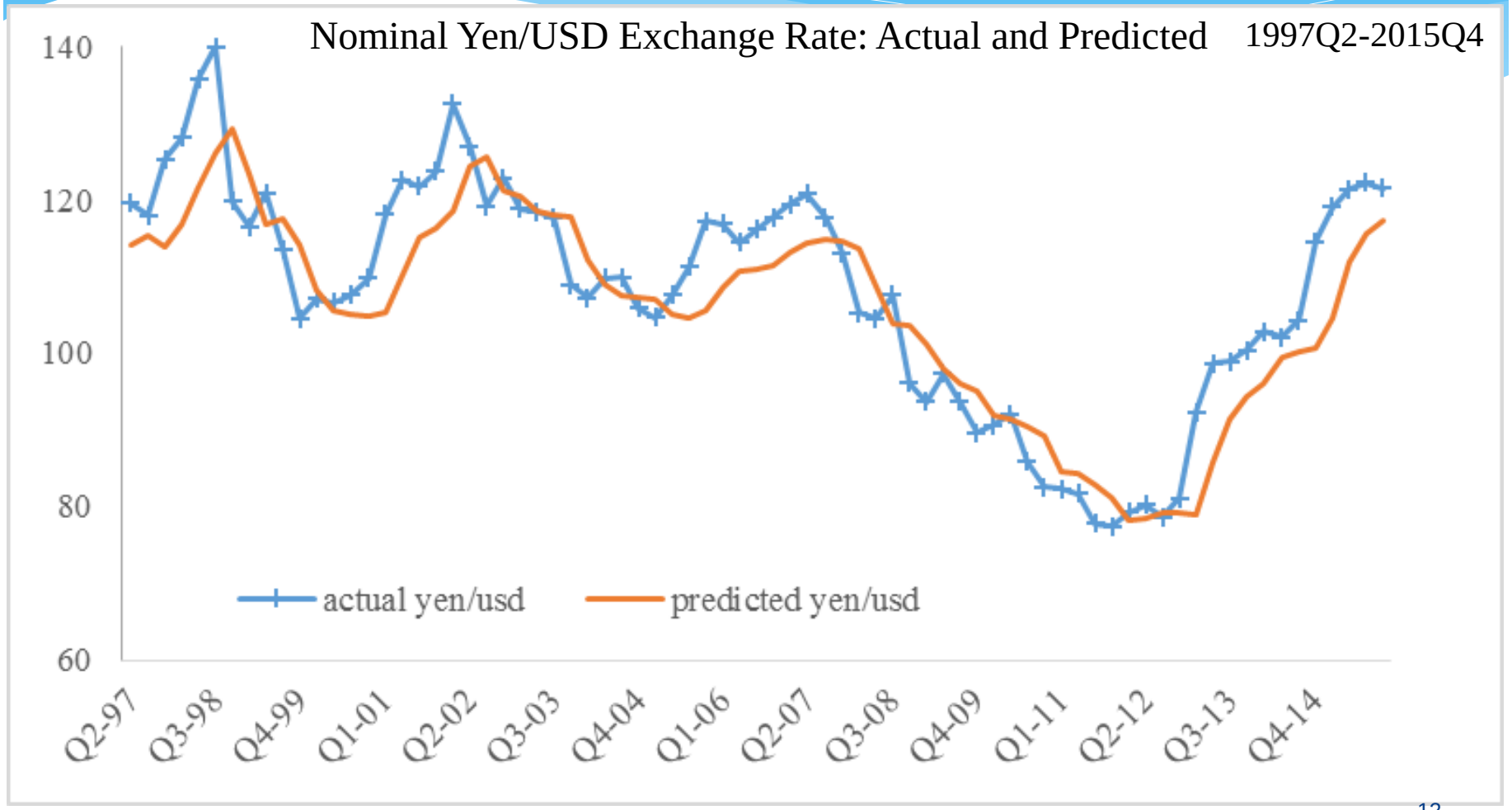
- Firms predict exchange rate and use it as a reference when setting export price.

- 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



Predicted and actual exchange rate



Source: BOJ and IMF.

Research motivation

- 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

$$\Delta ex_t = \pi + \theta_1 ex_{t-1} + \theta_2 er_{t-1} + \theta_4 dp_{t-1} + \theta_5 ipi_{t-1} + \sum_{j=1}^{n} \alpha_j \Delta ex_{t-j} + \sum_{k=0}^{o} \beta_k \Delta er_{t-k} + \sum_{l=0}^{p} \gamma_l \Delta dp_{t-l} + \sum_{m=0}^{q} \delta_m \Delta ipi_{t-m} + \mu_t$$

- Cointergration test

F-test $H_0 : \theta_1 = \theta_2 = \theta_3 = \theta_4 = 0$

t-test $H_0 : \theta_1 = 0$

NARDL Model

$$\Delta ex_t = \pi + \theta_1 ex_{t-1} + \theta_2^+ er_{t-1}^+ + \theta_3^- er_{t-1}^- + \theta_4 dp_{t-1} + \theta_5 ipi_{t-1}$$
$$+ \sum_{j=1}^{n} \alpha_j \Delta ex_{t-j} + \sum_{k=0}^{o} \left(\beta_k^+ \Delta er_{t-k}^+ + \beta_k^- \Delta er_{t-k}^- \right) + \sum_{l=0}^{p} \gamma_l \Delta dp_{t-l} + \sum_{m=0}^{q} \delta_m \Delta ipi_{t-m} + \mu_t$$

Where er^+ captures the depreciation regime

er^- captures the appreciation regime

Cointegration test

F-test $H_0 : \theta_1 = \theta_2^+ = \theta_3^- = \theta_4 = \theta_5 = 0$

t-test $H_0 : \theta_1 = 0$

Asymmetry test

LR $H_0 : -\theta_2^+ / \theta_1 = -\theta_3^- / \theta_1$

SR $H_0 : \beta_k^+ = \beta_k^-$ for $k=0,\ldots,o$

or $H_0 : \sum_{k=0}^{o} \beta_k^+ = \sum_{k=0}^{o} \beta_k^-$

Regime specification

- Conventional threshold

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

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

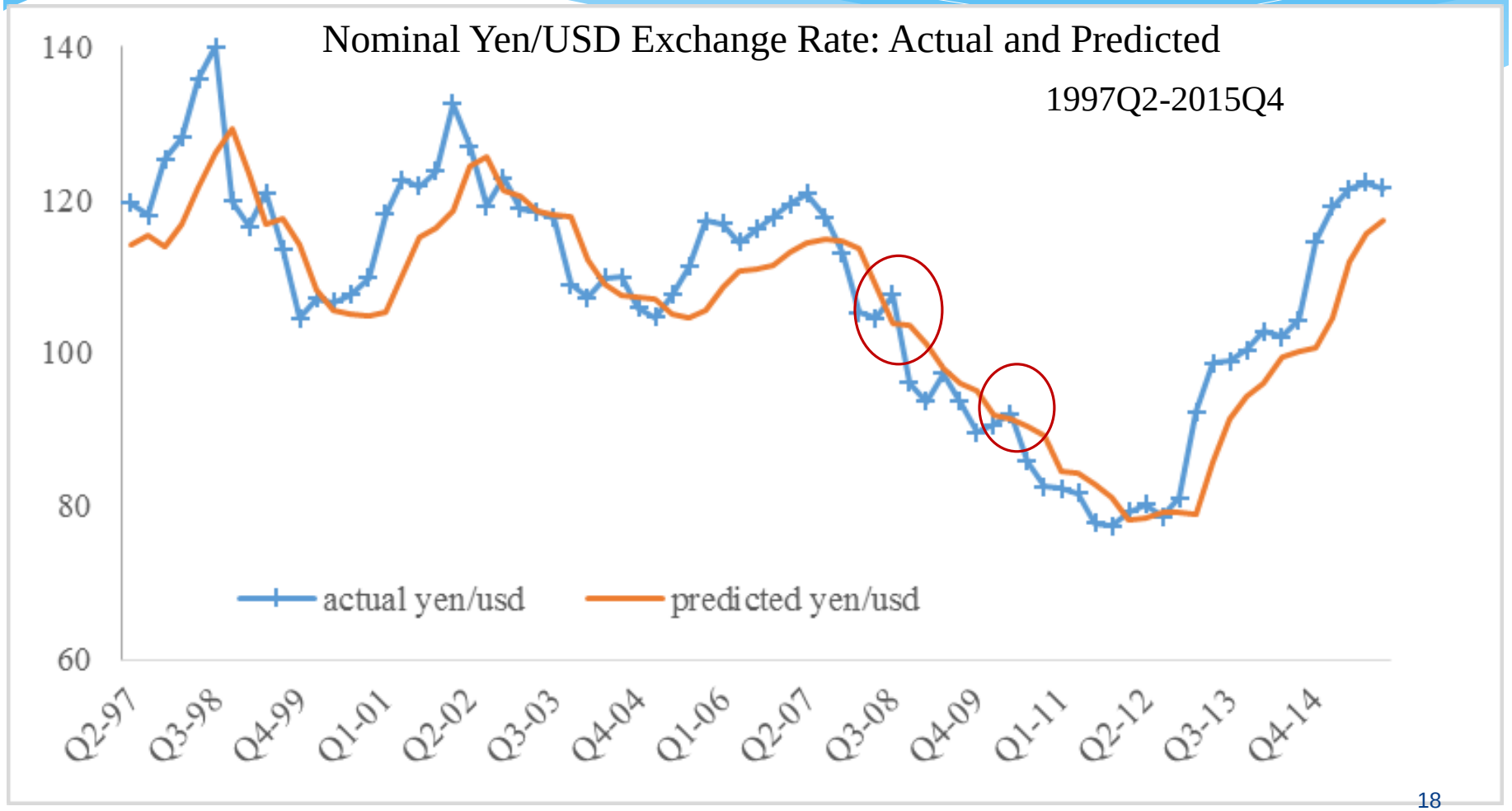
- Using prediction error as a threshold

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

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

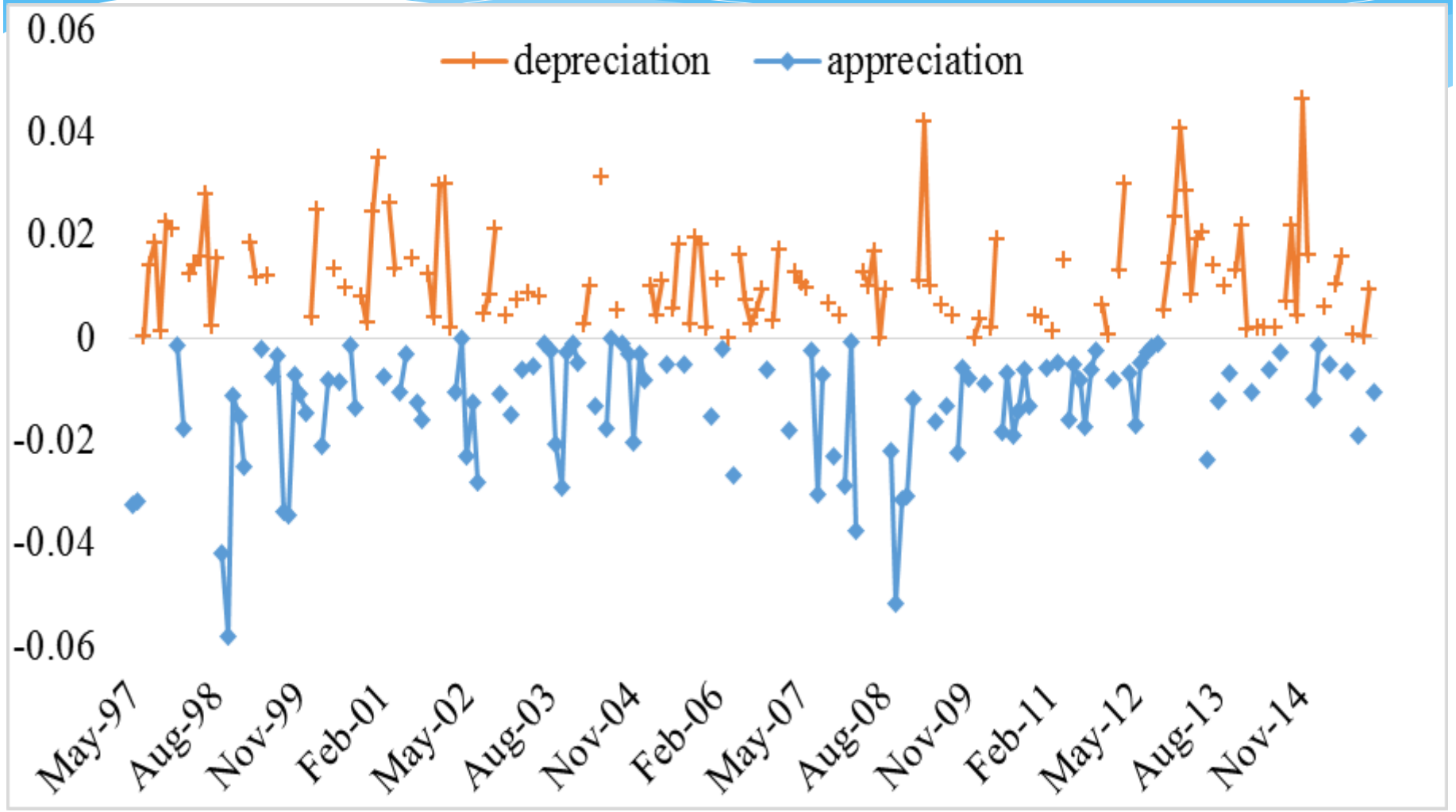
with *error* = actual ER – predict ER

Why mean(*error*) as a threshold?

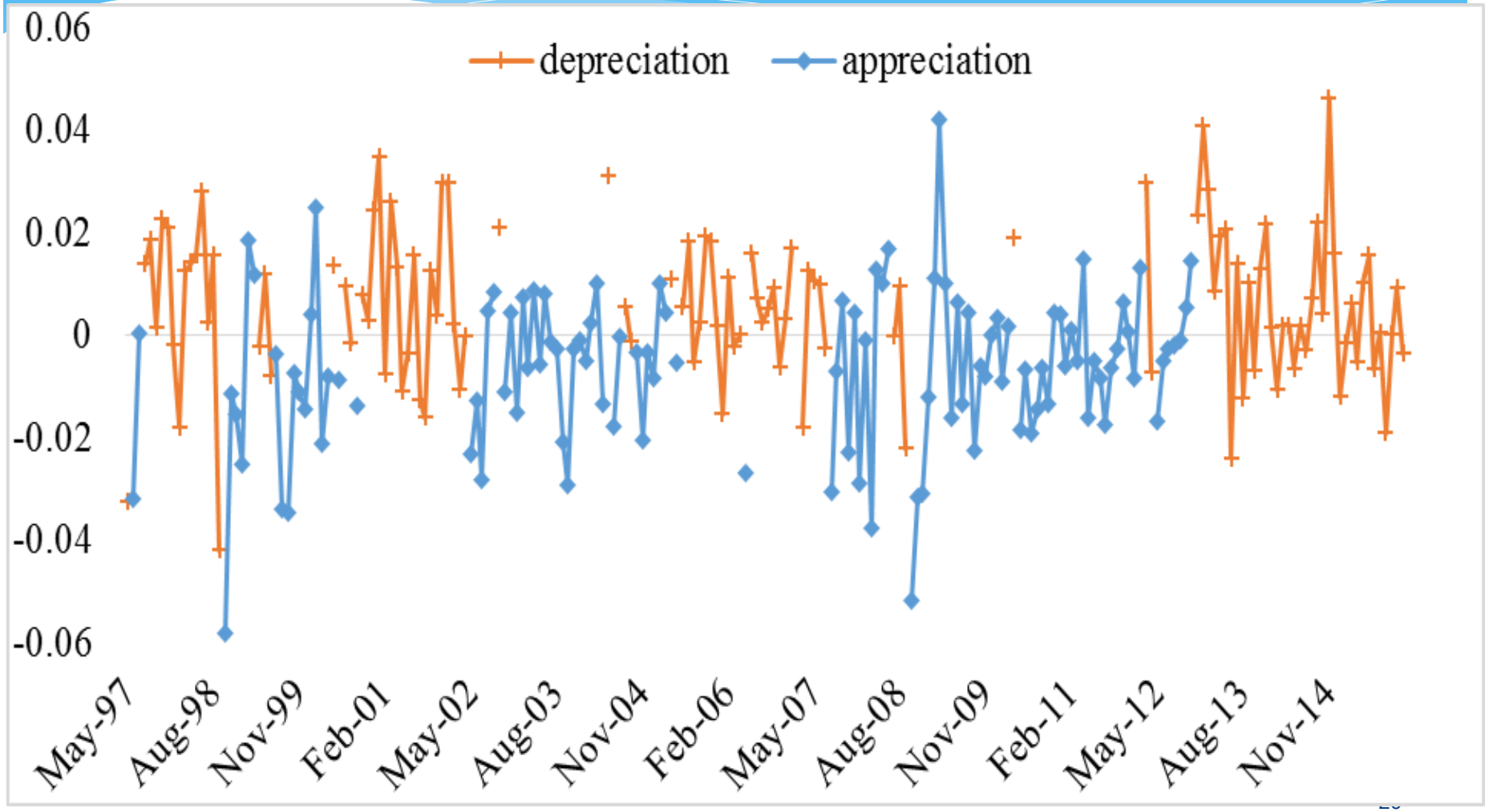


Source: BOJ and IMF.

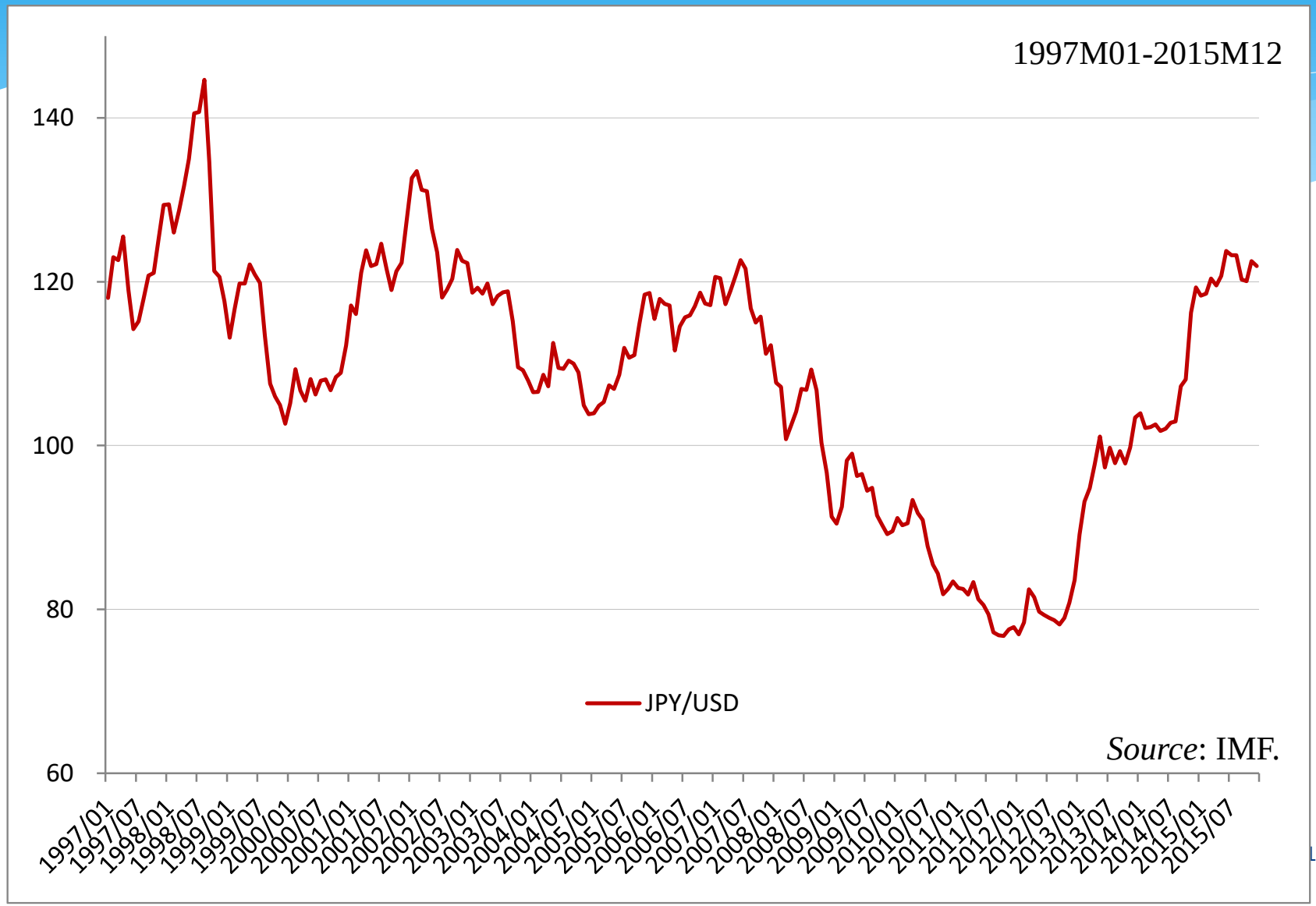
NEER change in conventional threshold



NEER change in new threshold



Nominal JPY/USD Exchange Rate



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:

$$World\quad IPI_t = \sum_{i=1}^{20} IPI_t^i \times weight_t^i$$

Data Description (cont'd)

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}):

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

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

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

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

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

Contract currency based NEER (2)

Two types of **BOJ export price index**:

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

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

Contract currency based NEER *by industry*:

$$NEER_{yen}^{Contract} = \frac{P_{yen}^{EX}}{P_{con}^{EX}} = (1)^{\alpha} \cdot (E_{yen/\$})^{\beta} \cdot (E_{yen/euro})^{\gamma}$$

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

Prediction error

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(*actual yen/usd*) – ln(*predict yen/usd*)

Empirical Result

Result and Interpretation

$$\Delta ex_t = \pi + \theta_1 ex_{t-1} + \theta_2^+ er_{t-1}^+ + \theta_3^- er_{t-1}^- + \theta_4 dp_{t-1} + \theta_5 ipi_{t-1}$$
$$+ \sum_{j=1}^{n} \alpha_j \Delta ex_{t-j} + \sum_{k=0}^{o} \left(\beta_k^+ \Delta er_{t-k}^+ + \beta_k^- \Delta er_{t-k}^- \right) + \sum_{l=0}^{p} \gamma_l \Delta dp_{t-l} + \sum_{m=0}^{q} \delta_m \Delta ipi_{t-m} + \mu_t$$

- 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

NARDL model (prediction error with mean threshold)

Industry	Full sample (1997-2015)			First half sample (1997-2006)			Second half sample (2007-2015)		
	LR^+ coeff.	LR^- coeff.	sign.	LR^+ coeff.	LR^- coeff.	sign.	LR^+ coeff.	LR^- coeff.	sign.
All manufacturing	0.497	0.900	a***	0.466	0.856	a	0.584	0.858	a***
Textile	0.534	0.456	***	0.536	0.331	a	0.412	0.574	***
Chemical	0.504	0.135		0.010	-0.023		0.291	0.670	c
Metal	0.465	0.238	a	0.358	-0.038	a	0.142	0.635	a***
Machinery	0.725	0.825		0.222	0.146		1.137	0.726	a**
Electric	2.175	-1.611		0.737	-0.605		0.875	1.584	
Transport	0.828	0.617		0.828	0.617		0.923	0.601	a***
Other	-0.448	0.127	a	0.597	0.328	a***	-3.720	0.865	

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
- Second sub-sample (2007-2015)
  - ✓ Strong evidence (5/8 industries) of cointegration and PTM asymmetry in the long-run

	Yen depreciation	**Yen appreciation**
Competitive (Machinery, Transport)	Almost full PTM	Incomplete PTM (57-73% PTM)
Less competitive (Metal, Textile, Chemical)	Closer to full ERPT	

Concluding Remarks

Findings

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

- Balke N.S, Fomby T.B., 1997, Threshold cointegration, International Economic Review 38(3), 627-645
- Belke A., Goecke M., Guenther M., 2009, When does it hurt? The exchange rate "pain threshold" for German exports, Ruhr Economic Paper No. 148, University of Duisburg-Essen, ruhr University Bochum, Technical University Dortmund and RWI Essen, Essen.
- Belke A., Goecke M., Guenther M., 2012, Exchange rate bands of inaction and play-hysteresis in German exports – sectoral evidence for some OECD destinations, DIW Discussion Paper No. 1203, German Institute for Economic Research (DIW), Berlin.
- Knetter, M.M., 1994, "Is export price adjustment asymmetric?: evaluating the market share and marketing bottlenecks hypotheses", *Journal of International Money and Finance* (13), pp. 55-70
- Mahdavi, Saeid, 2002, "The Response of the US Export Prices to Changes in the Dollar's Effective Exchange Rate: Further Evidence from Industry Level Data," *Applied Economics*, 34(17), pp.2115-2125.
- Pollard, Patricia S. and Cletus C. Coughlin, 2004, "Size Matters: Asymmetric Exchange Rate Pass-Through at the Industry Level," Federal Reserve Bank of St. Louis Working Paper Series 2003-029C (revised July 2004).
- Shin, Y., Yu, B., Greenwood-Nimmo, M., 2013, "Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework, Electric copy available at http://ssm.com/abstract=1807745