The Yen Exchange Rate and the Hollowing-out of the Japanese Manufacturing Industry

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Outline

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- Literature review
- Empirical approach & findings
- Conclusions

Introduction

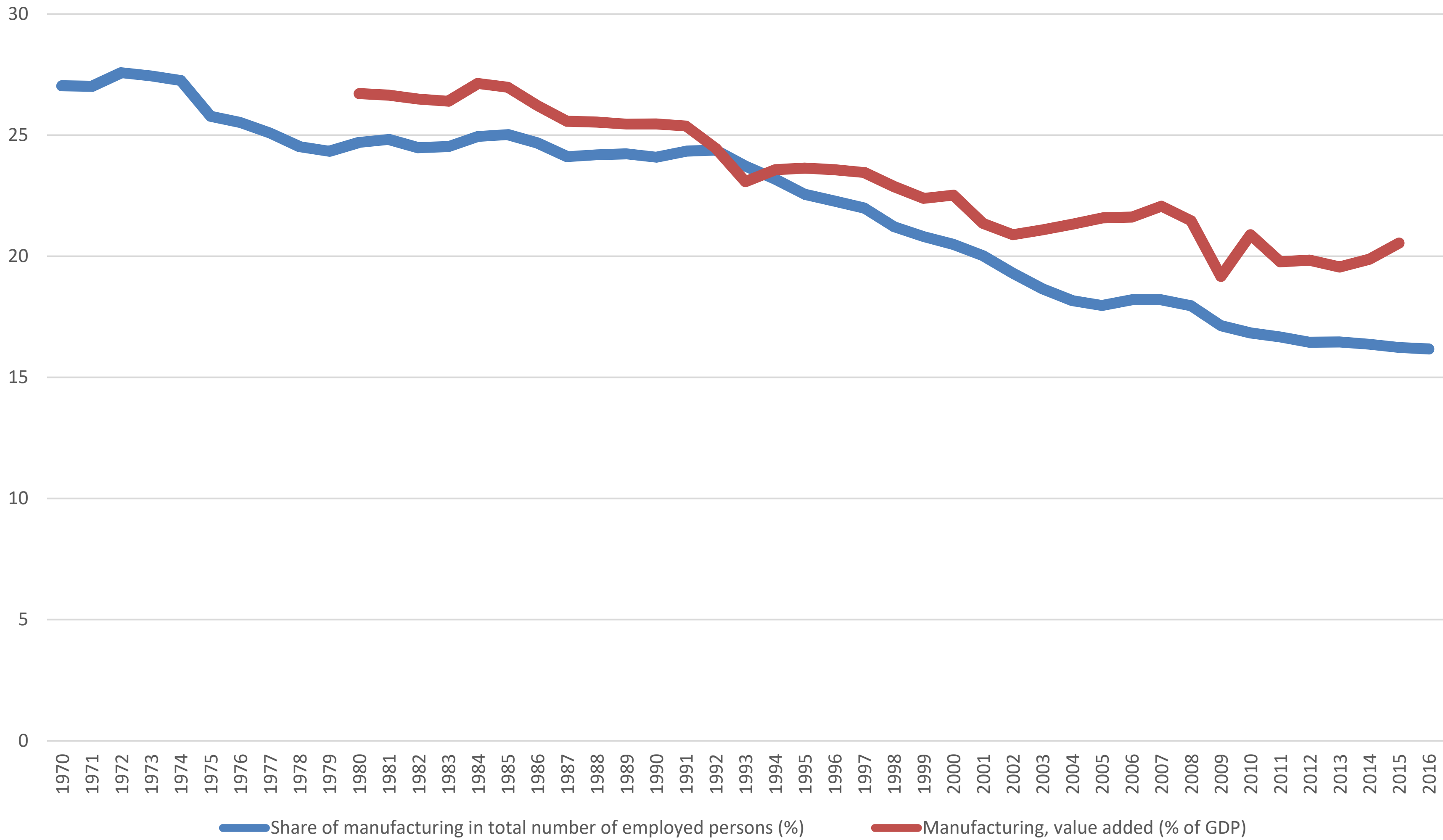
- A strong yen—endaka (円高) in Japanese—has repeatedly cause distress among Japanese policymakers and manufacturers.
- Since the demise of the Bretton Woods system in 1971, the yen has seen several episodes of strong appreciation, including in the late 1970s, after the 1985 Plaza Agreement, the early and late 1990s and after 2008.

Real effective exchange rate of the Japanese yen, 1964-2017 (2010=100)

Source: BIS Effective Exchange Rate Indices (updated 17 August 2017), www.bis.org/statistics/eer.htm

- These appreciations have not only been associated with “expensive yen recessions”—endaka fukyo (円高不況) in Japanese—resulting from negative effects on exports.
- Since the late 1980s the strong yen has also raised concern about a de-industrialisation of the Japanese economy.
- The share of manufacturing in total output has declined from 26.7% in 1980 to 20.5% in 2015, while the share of manufacturing in total number of employed persons has declined from 27.0% to 16.2% between 1970 and 2016.

Value added in manufacturing as share of GDP and share of manufacturing in total number of employed persons



Sources: Compiled with data from the Japan Labor Force Survey and WDI.

- While the strong yen and its potentially de-industrialising effect has received much attention in the political and economic policy discourse in Japan, there has been surprisingly little research in the academic literature.
  - Hamada and Okada (2009: 200): most research on Japan’s “lost decade” and hollowing out of the Japanese industry “have been broadly focused on its real and domestic aspects, such as total factor productivity (TPF), growth decline, non-performing loans, and governance.”
- But arguably monetary and exchange rate policy have played an important role in this.
  - Hamada and Okada (2009: 200): “Japanese industries endured a heavy burden” due to a greatly overvalued real exchange rate.

Research question

- What has been the impact of the yen exchange rate on industrial production and the 'hollowing out' of Japanese manufacturing?
  - Hollowing out / de-industrialisation defined as "a secular decline in the share of manufacturing in national employment" (Rowthorn & Coutts, 2004: 767)

Literature review

- It is well established that depreciated real exchange rates can help to stimulate industrial development and economic growth (Rodrik, 2008).
- Despite a “fear of appreciation” (Levy-Yeyati et al., 2013), relatively little research has been conducted on the effect of overvalued exchange rates on economies.

- The first systematic empirical cross-country analysis to investigate the effects of large exchange rate appreciation on current account balances and on real output was conducted by Kappler et al. (2013).
  - Find that episodes of strong exchange rate appreciations are associated with deteriorating current account balances and a slow-down of real export growth, but no significant effects on output
- Likewise, Bussière et al. (2015) examine to what extent large and rapid real exchange rate appreciations impact on economic growth.
  - Using a sample of 53 emerging and advanced economies they find that while large appreciations dampen export growth and boost import growth, output growth is higher on average.
- Thorbecke & Kato (2017) examine effect of Swiss franc exchange rate on the Swiss economy.
  - Find differences related to sophistication of exports

- The literature on de-industrialisation has focused less on exchange rate valuations than on changes in specialisation, consumption, technological progress and productivity, international trade and investment patterns (Rowthorn & Coutts, 2004).
- The major exemption is the US economy, for which the effect of the dollar exchange rate on the US industry has been studied widely (e.g., Glick & Hutchison, 1990; Goldberg, 1993; Campa & Goldberg, 1995; Kletzer, 2000).

- Surprisingly few studies have looked into the potentially de-industrialising effect of endaka, even though Obstfeld (2010) pointed out that Japan’s real economic growth rate has been strongly negatively correlated with the level of the yen’s real effective exchange rate.
- Only few studies can be found that systematically try to verify the hypothesis that the strong yen has contributed to de-industrialisation and outsourcing of industry in Japan.

- BOJ (1989): long-term structural adjustment in the export sector by increased outward direct investment
  - Temporary surge in the export of capital goods and parts to overseas production bases of Japanese companies
  - Seen as transitional effect
- Dekle (1996) & Dekle at al. (2013): Yen appreciations of 1985 and 1995 significantly hurt the ability of Japan to compete with the US by raising the relative production costs of Japanese industries
- Sato et al. (2013): Strong yen after 2007 destroyed the electronics sector
- Yamashita (2015): Outward FDI and yen appreciation contributed to deindustrialization

Empirical approach and findings

- Econometric analysis using **both aggregate and industry-specific data** to gauge the effects of changes of the real effective yen exchange rate.
  - Annual data from 1970 to 2016
  - Monthly data from 2001:M01 to 2017:M06

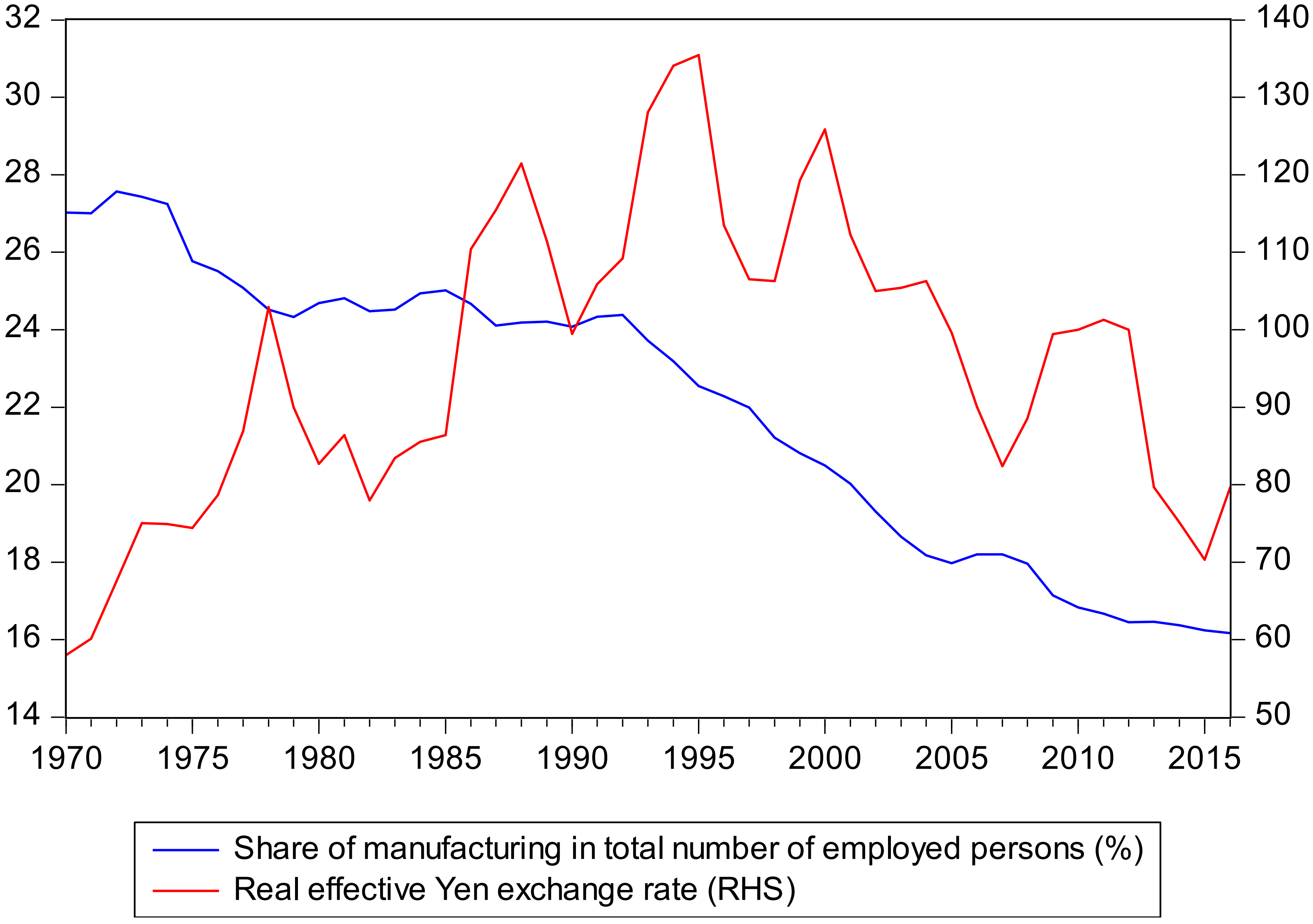
Analysis with annual data, 1970-2016

Building on Rowthorn and Ramaswamy (1997) and Rowthorn and Coutts (2004, 2013), we estimate the following model for Japan:

$EMPMAN = \beta_0 + \beta_1 EMPMAN_{t-1} + \beta_2 CAP + \beta_3 EXPMAN + \beta_4 OFDI + \beta_5 TFP + \beta_6 EXPCHIN + \beta_7 EXR + \varepsilon$

where

- *EMPMAN* = Share of manufacturing in total number of employed persons (%) [Source: Japan Labor Force Survey]
- *CAP* = Gross domestic fixed capital formation (% of GDP) [Source: WDI]
- *EXPMAN* = Manufacturing exports [Source: WDI]
- *OFDI* = Outward direct investment [Source: JETRO]
- *TFP* = Total factor productivity at constant national prices [Source: Penn World Table 9.0]
- *EXPCHIN* = Chinese exports [Source: WDI]
- *EXR* = Real effective exchange rate [Source: Bank of Japan]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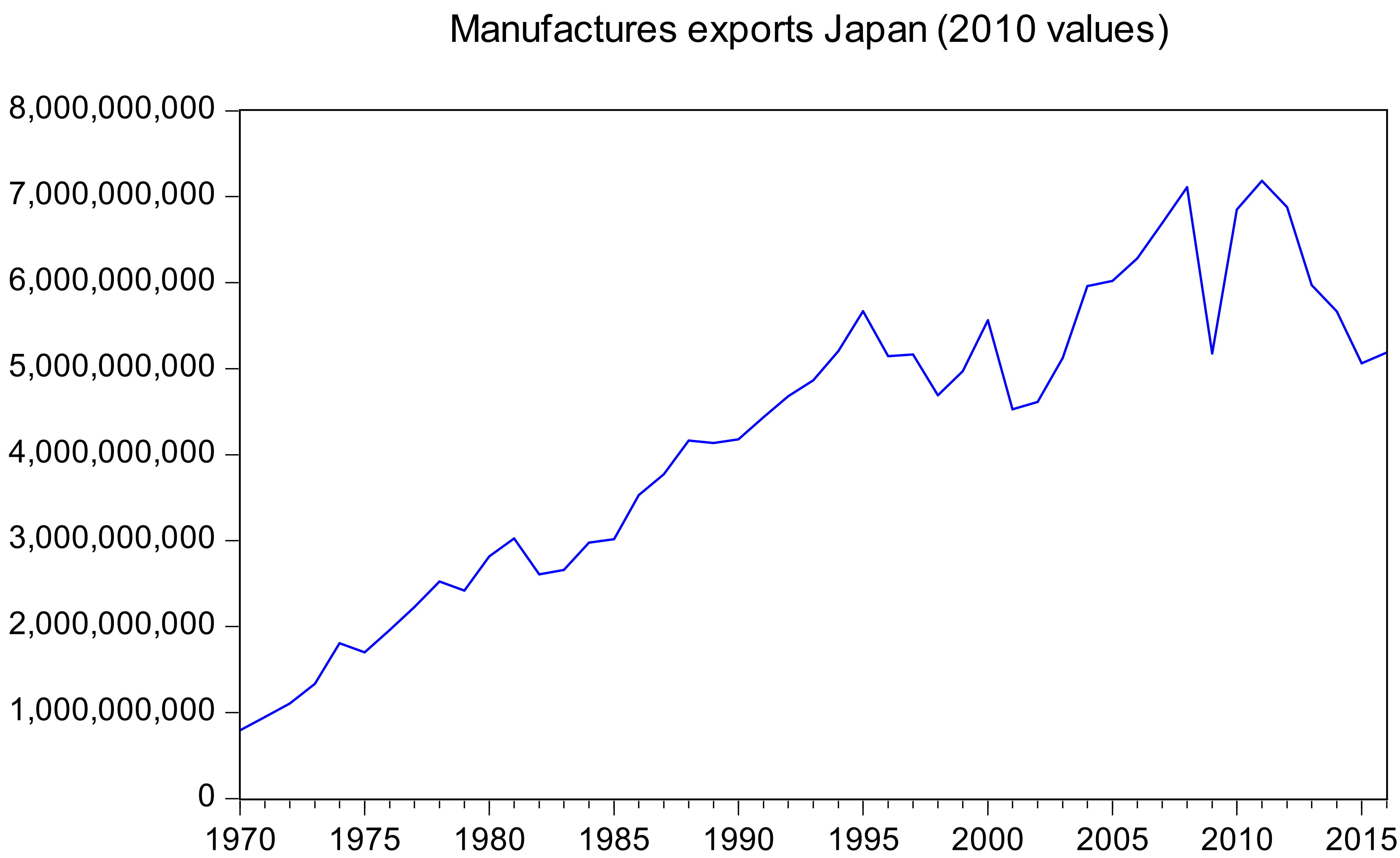
Share of manufacturing in total number of employed persons (%)
Real effective Yen exchange rate (RHS)


Manufactures exports Japan (2010 values)
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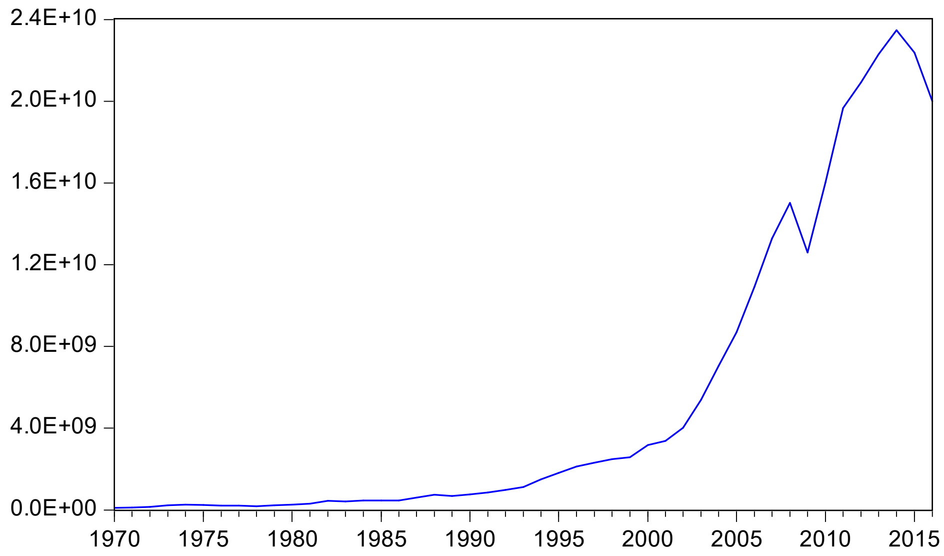
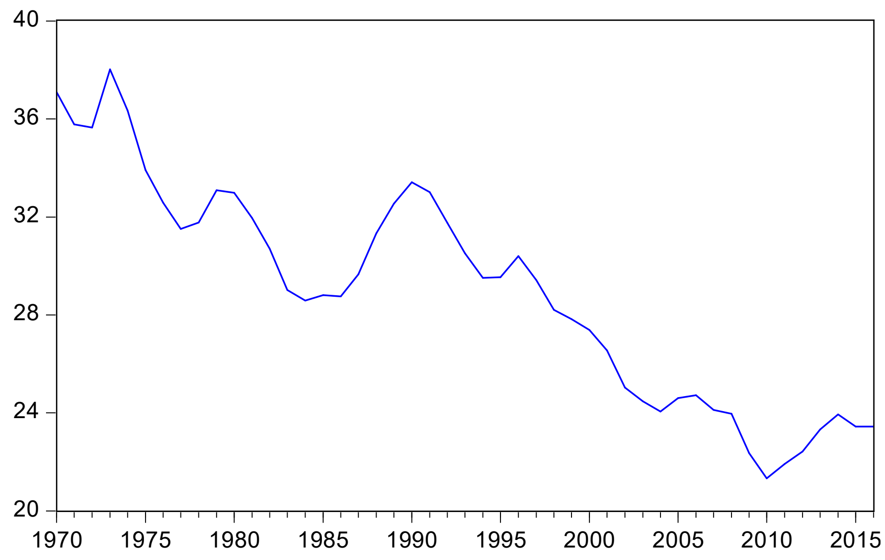
2000
2005
2010
2015

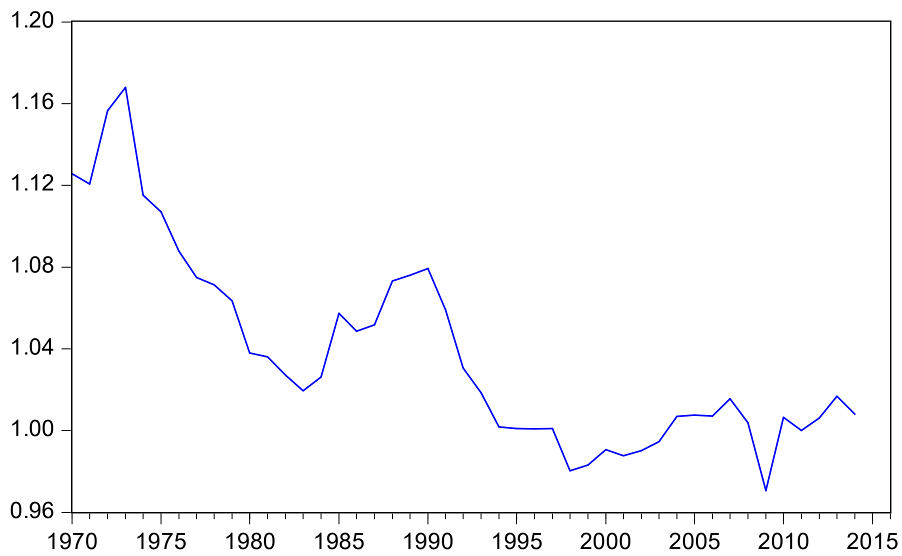
Chinese exports of goods and services (2010 values)



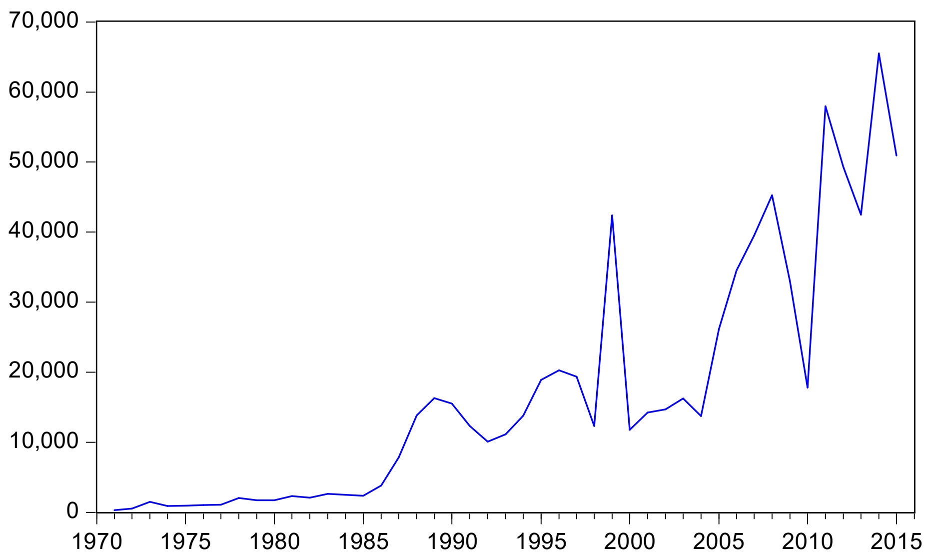
Gross fixed capital formation Japan (% of GDP)



Total Factor Productivity at Constant National Prices for Japan,



Outward FDI Manufacturing Japan (total)



Ordinary correlations

	CAP	EMPMAN	EXPCHIN	EXPMAN	EXR	OFDI	TFP
CAP	1.000000	0.946907	-0.796667	-0.846322	-0.239863	-0.730577	0.807738
EMPMAN	0.946907	1.000000	-0.868595	-0.890158	-0.216322	-0.833582	0.762477
EXPCHIN	-0.796667	-0.868595	1.000000	0.726566	-0.114324	0.879415	-0.450889
EXPMAN	-0.846322	-0.890158	0.726566	1.000000	0.496410	0.796646	-0.783812
EXR	-0.239863	-0.216322	-0.114324	0.496410	1.000000	0.116064	-0.531790
OFDI	-0.730577	-0.833582	0.879415	0.796646	0.116064	1.000000	-0.545285
TFP	0.807738	0.762477	-0.450889	-0.783812	-0.531790	-0.545285	1.000000

Unit root tests
(ADF test statistics and probabilities)

Variable	Level	First difference	Integration order of variable
CAP	-1.33 (0.6087)	-4.96 (0.0002)	I(1)
EMPMAN	-0.56 (0.8680)	-4.69 (0.0004)	I(1)
EXPCHIN	2.52 (1.0000)	-0.59 (0.9735)	I(1)/I(2)
EXPMAN	-1.92 (0.3195)	-8.10 (0.0000)	I(1)
EXR	-2.75 (0.0088)	-5.20 (0.0001)	I(1)
OFDI	0.45 (0.9827)	-8.23 (0.0000)	I(1)
TFP	-1.83 (0.3629)	-6.17 (0.0000)	I(1)

Note: Table displays empirical realisations of the Augmented Dickey-Fuller test with a constant (MacKinnon (1996) one-sided p-values).

- As a robustness check, we also conducted Dickey-Fuller GLS tests, Phillips-Perron tests, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) and Ng-Perron unit root tests.
- The results stayed the same.

- All variables are I(1), except EXPCHIN which appears borderline I(2).
- For the real effective yen exchange rate, all unit root tests we conducted (such as the Dickey-Fuller GLS (ERS) test, the Phillips-Perron test and the Kwiatowski-Phillips-Schmidt-Shin test) except the AFD-test point into the direction of an I(1) process.
  - The results are available on request.
- Hence, we feel legitimized to proceed with a cointegration approach.

Estimation of cointegrating equation (Dynamic Ordinary Least Squares, DOLS)

- DOLS allows to test for **unequivocal causality** running from the independent to the dependent variables.
- DOLS estimation technique **controls for endogeneity** of explanatory variables (Stock & Watson, 1993; Wooldridge, 2009).
- Endogeneity in the form of feedback effects or reverse causality between the dependent and independent variables would lead to a misspecification of our estimated models.
- Specifically, DOLS procedure controls for endogeneity of all explanatory variables by inserting **leads and lags** of the changes of all exogenous variables.
- DOLS is a **powerful estimation technique**, where standard errors are corrected for heteroscedasticity and cross-section correlation (Saikkonen, 1991; Stock & Watson, 1993).
- By inserting the leads and lags of the exogenous variables in first differences, the **explanatory variables** in levels become **(super-) exogenous** and the **regression results unbiased** (Wooldridge, 2009).

First DOLS estimation for fully specified model

Dependent Variable: EMPMAN				
Method: Dynamic Least Squares (DOLS)				
Sample (adjusted): 1973 2013				
Included observations: 41 after adjustments				
Cointegrating equation deterministics: C				
Fixed leads and lags specification (lead=1, lag=1)				
Long-run variance estimate (Bartlett kernel, Newey-West fixed bandwidth				
= 4.0000)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
TFP	-10.49578	6.642659	-1.580057	0.1337
CAP	1.108099	0.135792	8.160269	0.0000
EXPCHIN	2.20E-10	8.54E-11	2.572967	0.0204
EXPMAN	1.42E-09	3.67E-10	3.879566	0.0013
OFDI	-0.000192	3.60E-05	-5.325351	0.0001
EXR	**-0.051424**	**0.016242**	**-3.166034**	**0.0060**
C	2.783452	5.976907	0.465701	0.6477
R-squared	0.992483	Mean dependent var		22.11307
Adjusted R-squared	0.981208	S.D. dependent var		3.295862
S.E. of regression	0.451804	Sum squared resid		3.266036
Long-run variance	0.175494			

- Since EXPCHIN and EXPMAN are obviously multicollinear (both indicators of world business cycle, global factor), we leave out EXPCHIN

Dependent Variable: EMPMAN				
Method: Dynamic Least Squares (DOLS)				
Sample (adjusted): 1973 2013				
Included observations: 41 after adjustments				
Cointegrating equation deterministics: C				
Fixed leads and lags specification (lead=1, lag=1)				
Long-run variance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
TFP	-4.949611	8.354137	-0.592474	0.5602
CAP	0.930860	0.140335	6.633109	0.0000
EXPMAN	1.10E-09	4.76E-10	2.309287	0.0317
OFDI	-0.000122	3.54E-05	-3.440251	0.0026
EXR	**-0.055554**	**0.020831**	**-2.666873**	**0.0148**
C	3.580114	8.186393	0.437325	0.6666
R-squared	0.988524	Mean dependent var		22.11307
Adjusted R-squared	0.977048	S.D. dependent var		3.295862
S.E. of regression	0.499324	Sum squared resid		4.986488
Long-run variance	0.337452			

DOLS with Newey-West correction

Dependent Variable: EMPMAN
Method: Dynamic Least Squares (DOLS)
Sample (adjusted): 1973 2013
Included observations: 41 after adjustments
Cointegrating equation deterministics: C
Fixed leads and lags specification (lead=1, lag=1)
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TFP	-10.49578	5.232113	-2.006031	0.0621
CAP	1.108099	0.110067	10.06753	0.0000
EXPCHIN	2.20E-10	9.38E-11	2.343780	0.0323
EXPMAN	1.42E-09	3.24E-10	4.395452	0.0005
OFDI	-0.000192	3.71E-05	-5.161301	0.0001
EXR	**-0.051424**	**0.015851**	**-3.244239**	**0.0051**
C	2.783452	5.467176	0.509121	0.6176

R-squared	0.992483	Mean dependent var	22.11307
Adjusted R-squared	0.981208	S.D. dependent var	3.295862
S.E. of regression	0.451804	Sum squared resid	3.266036

Dependent Variable: EMPMAN				
Method: Dynamic Least Squares (DOLS)				
Sample (adjusted): 1973 2013				
Included observations: 41 after adjustments				
Cointegrating equation deterministics: C				
Fixed leads and lags specification (lead=1, lag=1)				
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
TFP	-4.949611	7.467324	-0.662836	0.5150
CAP	0.930860	0.100093	9.299968	0.0000
EXPMAN	1.10E-09	4.34E-10	2.532957	0.0198
OFDI	-0.000122	4.22E-05	-2.881250	0.0092
EXR	**-0.055554**	**0.011886**	**-4.673997**	**0.0001**
C	3.580114	7.497427	0.477512	0.6382
R-squared	0.988524	Mean dependent var		22.11307
Adjusted R-squared	0.977048	S.D. dependent var		3.295862
S.E. of regression	0.499324	Sum squared resid		4.986488

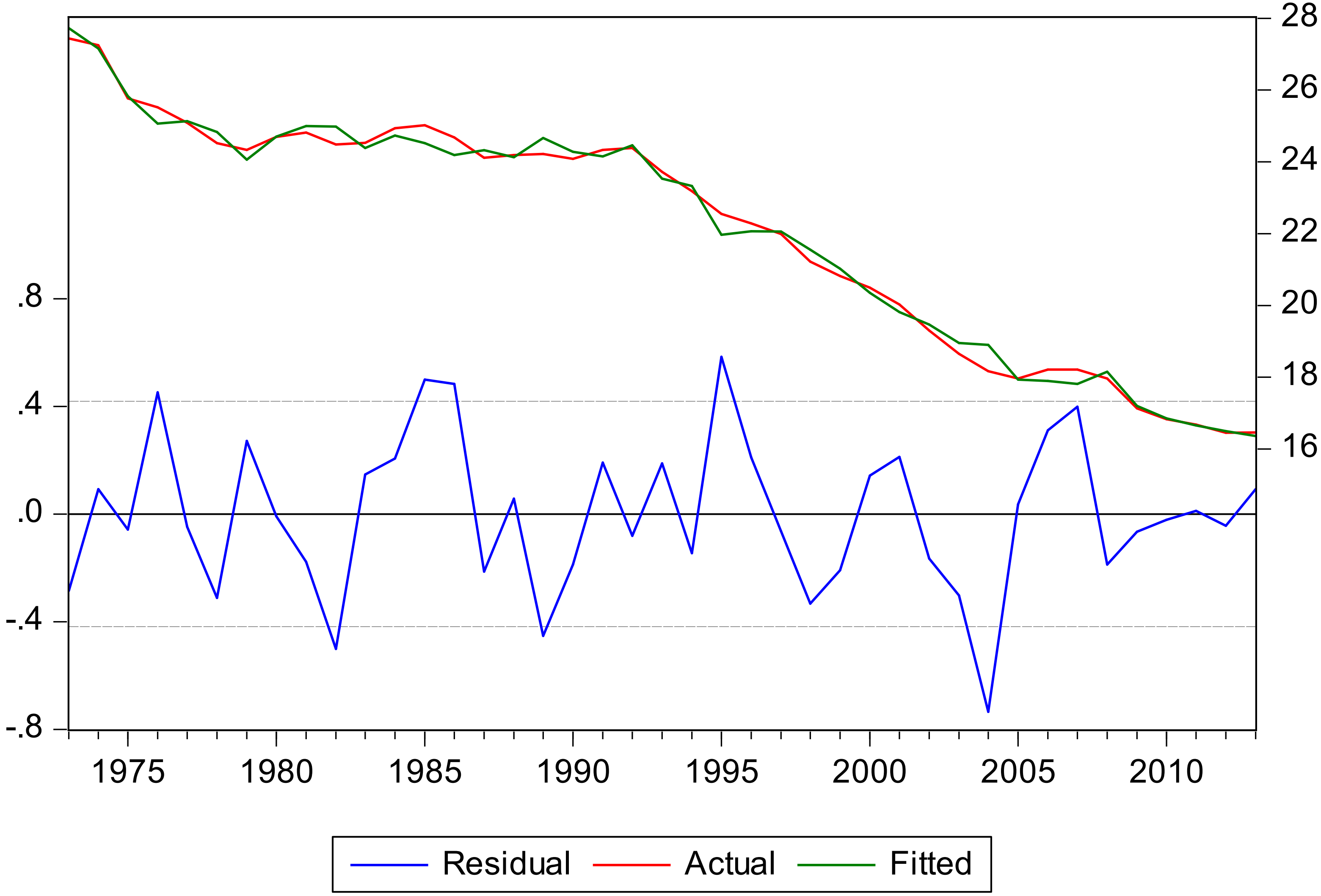
DOLS with White correction

Dependent Variable: EMPMAN				
Method: Dynamic Least Squares (DOLS)				
Sample (adjusted): 1973 2013				
Included observations: 41 after adjustments				
Cointegrating equation deterministics: C				
Fixed leads and lags specification (lead=1, lag=1)				
White heteroskedasticity-consistent standard errors & covariance				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
TFP	-10.49578	6.116778	-1.715900	0.1055
CAP	1.108099	0.114299	9.694747	0.0000
EXPCHIN	2.20E-10	8.05E-11	2.728241	0.0149
EXPMAN	1.42E-09	3.44E-10	4.133799	0.0008
OFDI	-0.000192	3.68E-05	-5.205931	0.0001
EXR	**-0.051424**	**0.016735**	**-3.072769**	**0.0073**
C	2.783452	6.037110	0.461057	0.6510
R-squared	0.992483	Mean dependent var		22.11307
Adjusted R-squared	0.981208	S.D. dependent var		3.295862
S.E. of regression	0.451804	Sum squared resid		3.266036

Dependent Variable: EMPMAN				
Method: Dynamic Least Squares (DOLS)				
Sample (adjusted): 1973 2013				
Included observations: 41 after adjustments				
Cointegrating equation deterministics: C				
Fixed leads and lags specification (lead=1, lag=1)				
White heteroskedasticity-consistent standard errors & covariance				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
TFP	-4.949611	6.434338	-0.769249	0.4507
CAP	0.930860	0.101876	9.137229	0.0000
EXPMAN	1.10E-09	3.70E-10	2.974161	0.0075
OFDI	-0.000122	3.25E-05	-3.746083	0.0013
EXR	**-0.055554**	**0.014164**	**-3.922160**	**0.0008**
C	3.580114	6.497678	0.550984	0.5877
R-squared	0.988524	Mean dependent var		22.11307
Adjusted R-squared	0.977048	S.D. dependent var		3.295862
S.E. of regression	0.499324	Sum squared resid		4.986488

- Application of the DOLS procedure requires time series to be non-stationary and to be cointegrated over time.
- Both conditions are satisfied in our case.
  - For the results of our unit root tests see above, and for those of our cointegration tests see next slide

Test for cointegration
(for basic DOLS estimation)



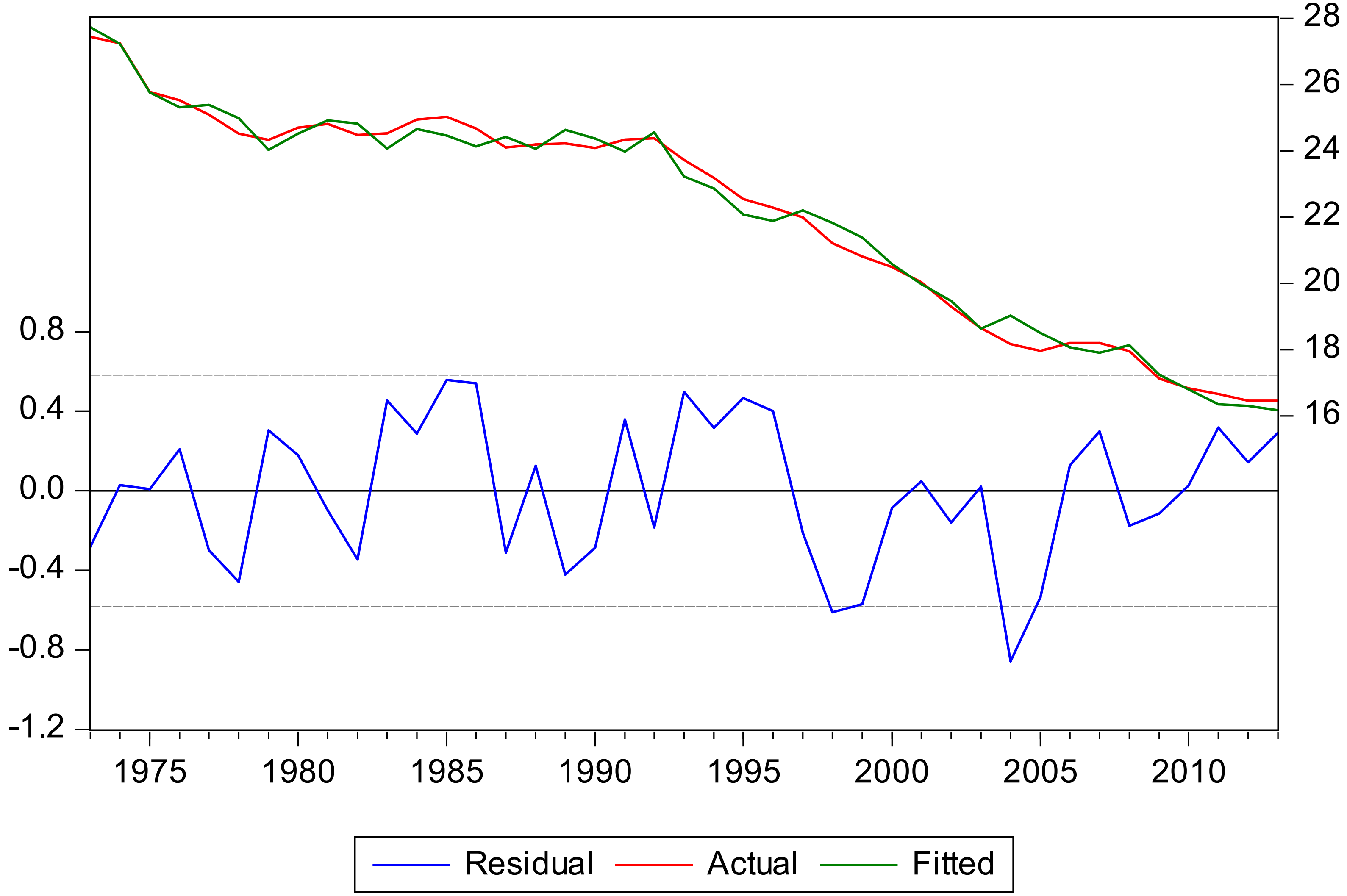
Cointegration Test - Engle-Granger
Equation: EQ01
Specification: EMPMAN TFP CAP EXPCHIN EXPMAN OFDI EXR C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated

Engle-Granger Test Equation:
Dependent Variable: D(RESID)
Method: Least Squares
Date: 10/20/17 Time: 16:34
Sample (adjusted): 1972 2014
Included observations: 43 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.282619	0.107162	-2.637302	0.0117

R-squared	0.141977	Mean dependent var	0.005944
Adjusted R-squared	0.141977	S.D. dependent var	0.559905
S.E. of regression	0.518638	Akaike info criterion	1.547760
Sum squared resid	11.29738	Schwarz criterion	1.588718
Log likelihood	-32.27683	Hannan-Quinn criter.	1.562864
Durbin-Watson stat	1.855124		

Test for cointegration
(for DOLS estimation without EXPCHIN)



Cointegration Test - Engle-Granger				
Equation: EQ01				
Specification: EMPMAN TFP CAP EXPMAN OFDI EXR C				
Cointegrating equation deterministics: C				
Null hypothesis: Series are not cointegrated				
Engle-Granger Test Equation:				
Dependent Variable: D(RESID)				
Method: Least Squares				
Sample (adjusted): 1972 2014				
Included observations: 43 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
RESID(-1)	-0.367846	0.119751	-3.071757	0.0037
R-squared	0.183441	Mean dependent var		-0.001782
Adjusted R-squared	0.183441	S.D. dependent var		0.677695
S.E. of regression	0.612390	Akaike info criterion		1.880087
Sum squared resid	15.75091	Schwarz criterion		1.921045
Log likelihood	-39.42186	Hannan-Quinn criter.		1.895191
Durbin-Watson stat	1.861195			

Autoregressive distributed lag-estimations for first differences

- ARDLs are standard least squares regressions that include lags of both the dependent variable and explanatory variables as regressors (Greene, 2008).
- Require data to be stationary
- Estimation of intertemporal dynamics
- ARDL model selection process uses the same sample for each estimation and selects the final model according to the empirical realisation of information criteria (Akaike).

Dependent Variable: D(EMPMAN)
Method: ARDL
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): D(TFP) D(CAP) D(EXPMAN)
D(EXPCHIN) D(OFDI) D(EXR)
Fixed regressors: C
Number of models evalulated: 1458
Selected Model: ARDL(1, 2, 0, 1, 1, 0, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
D(EMPMAN(-1))	0.391195	0.141019	2.774061	0.0094
D(TFP)	-3.808531	4.248908	-0.896355	0.3772
D(TFP(-1))	2.768530	3.802030	0.728171	0.4722
D(TFP(-2))	-6.491839	3.288327	-1.974207	0.0576
D(CAP)	0.109411	0.071213	1.536395	0.1349
D(EXPMAN)	4.35E-10	1.70E-10	2.564722	0.0156
D(EXPMAN(-1))	-2.45E-10	1.18E-10	-2.081662	0.0460
D(EXPCHIN)	-1.47E-10	1.01E-10	-1.456282	0.1557
D(EXPCHIN(-1))	1.50E-10	8.89E-11	1.683592	0.1026
D(OFDI)	2.83E-07	5.12E-06	0.055276	0.9563
D(EXR)	**-0.016393**	**0.006865**	**-2.387858**	**0.0234**
C	-0.175573	0.068215	-2.573808	0.0152

R-squared	0.486519	Mean dependent var	-0.266650
Adjusted R-squared	0.298243	S.D. dependent var	0.362367
S.E. of regression	0.303559	Akaike info criterion	0.688472
Sum squared resid	2.764433	Schwarz criterion	1.184949
Log likelihood	-2.457906	Hannan-Quinn criter.	0.870450
F-statistic	2.584071	Durbin-Watson stat	1.718422
Prob(F-statistic)	0.019257		

Summary of findings for annual data analysis

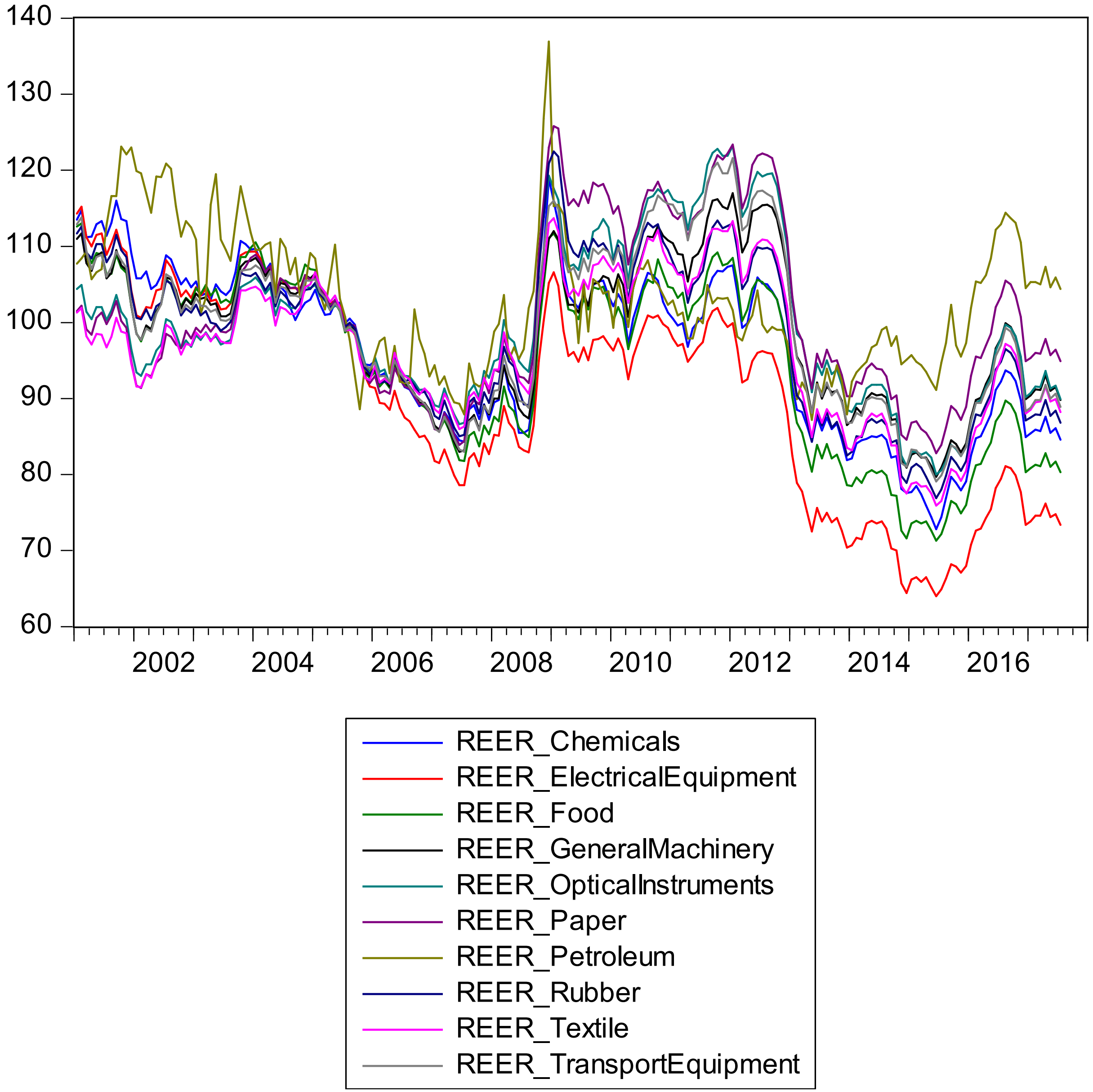
- DOLS and ARDL estimations provide robust results which indicate that changes to the real effective yen exchange rate did have significant effects on the share of manufacturing in total employment.
- This is despite the fact that the yen also experiences longer periods of real effective depreciation.
  - Indicative of hysteresis effects.
- DOLS estimations also find a negative and significant effect of outward FDI.

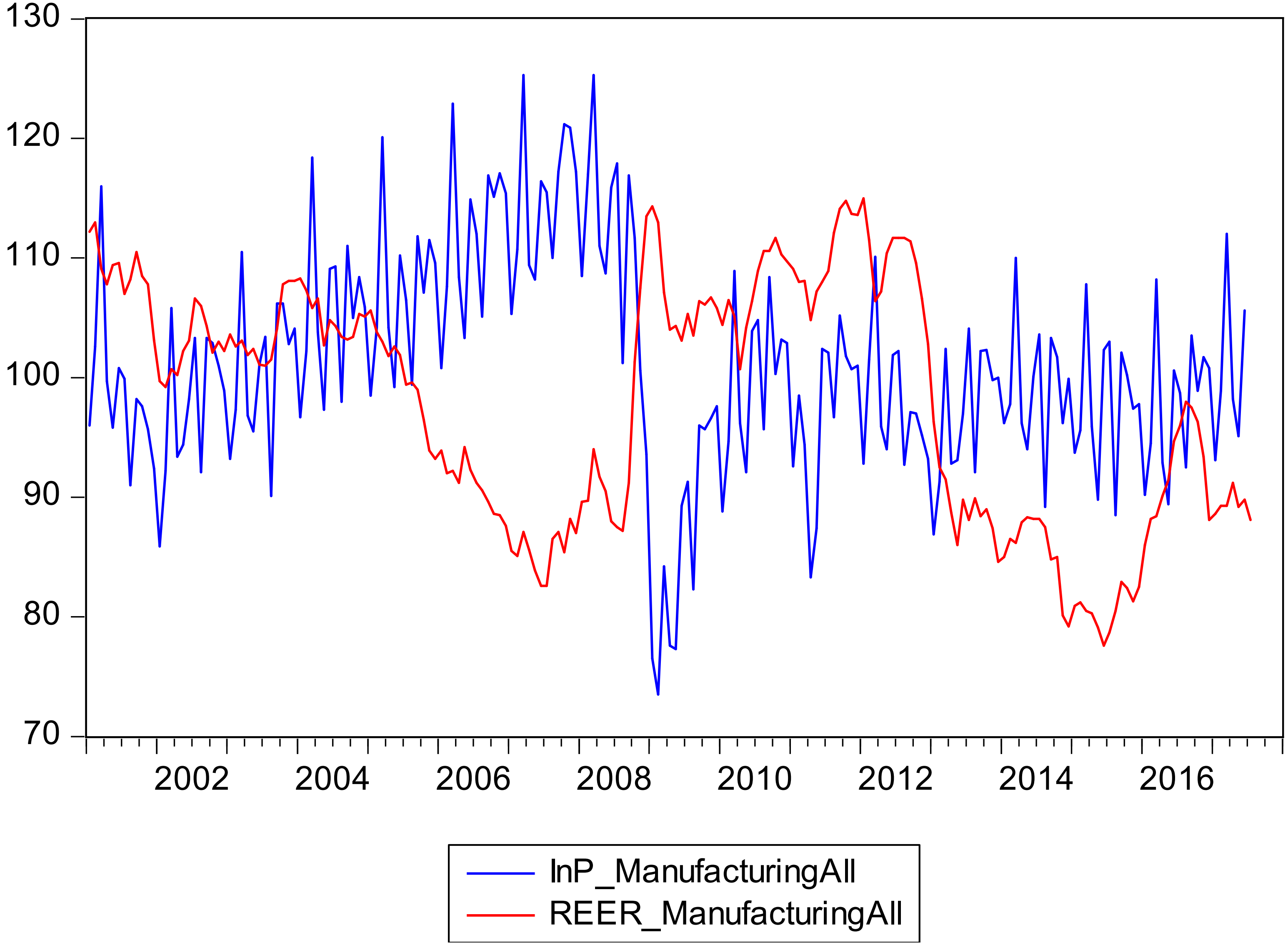
Analysis with monthly data, 1991-2017

Real exchange rate effects on industrial production

- REER_X: Industry-specific real effective exchange rate of industry X for 13 different industries [Source: Sato et al., 2013; RIETI, 2017]
- INP_X: Industrial production by industry X [Source: METI Survey of Production]
- EX_X: Exports by industry X [Source: Global Trade Atlas]
- Non-industry-specific variables:
  – INDINPUTPRICE: Industrial input price [Source: IMF Primary Commodity Prices]
  – INPUSA: Industrial production USA [Source: Global Economic Monitor]

Real effective exchange rates for different sectors

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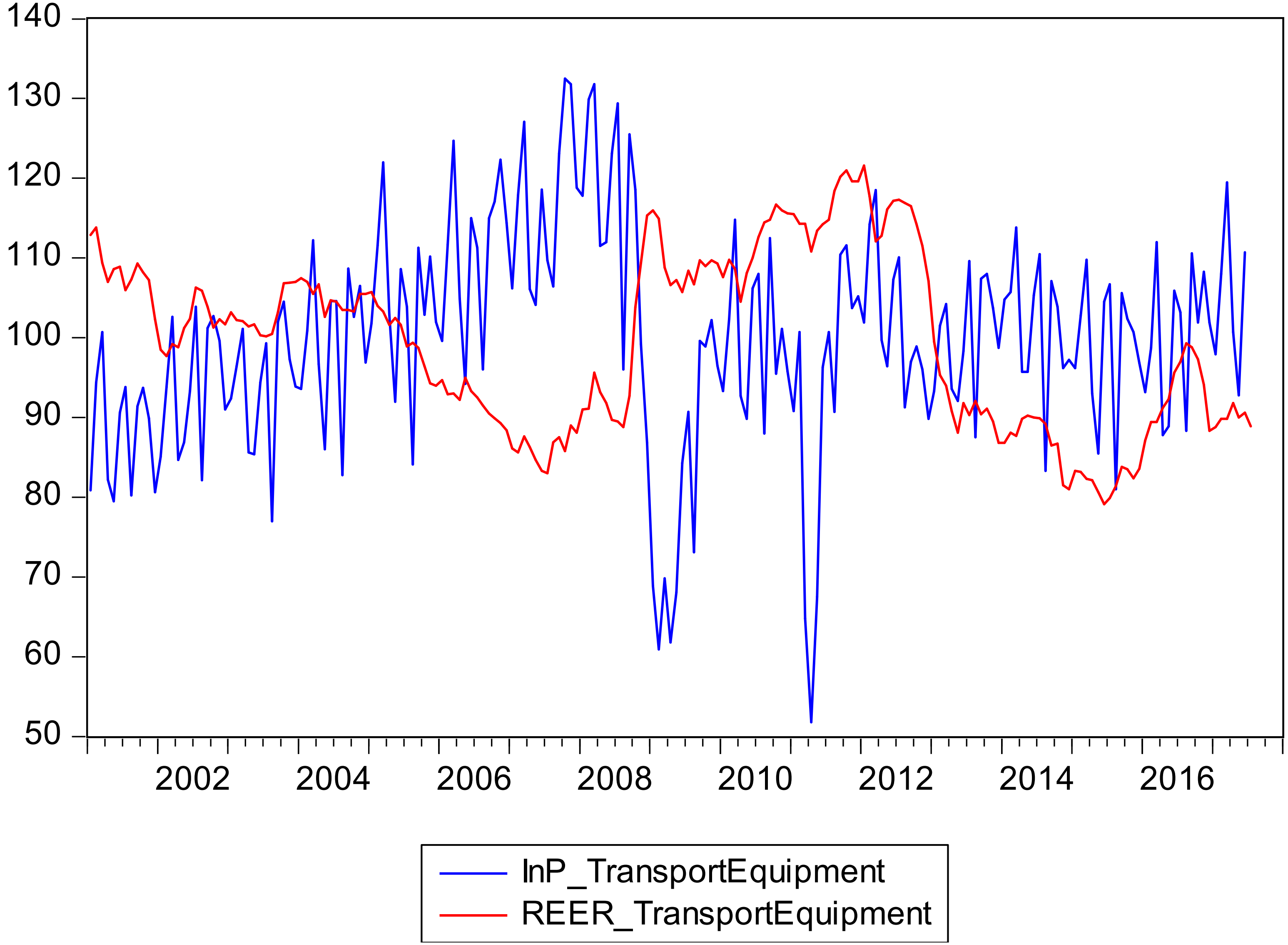
2016
InP_ManufacturingAll
REER_ManufacturingAll


140
130
120
110
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90
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70
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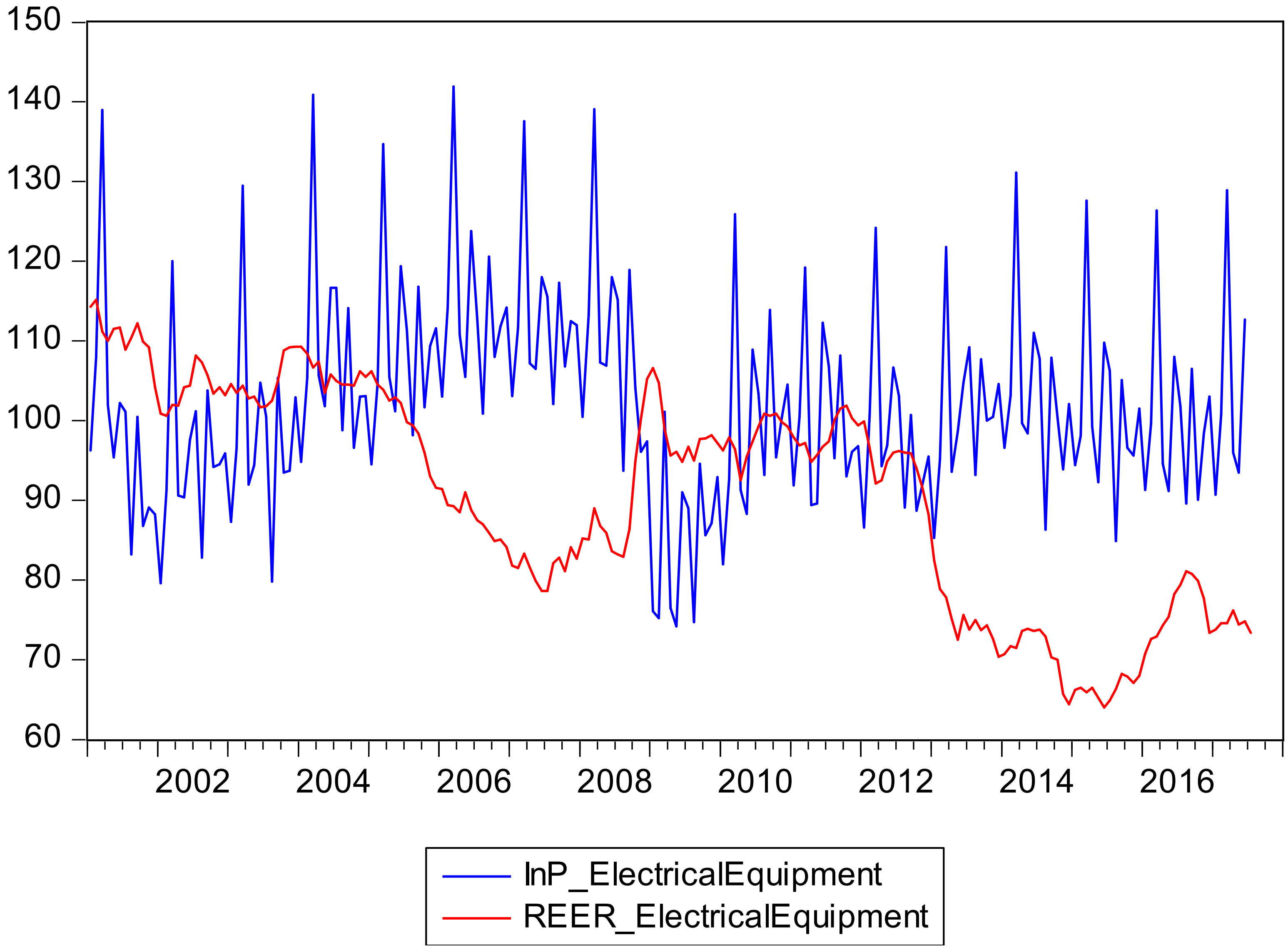
50
2002
2004
2006
2008
2010
2012
2014
2016
InP_TransportEquipment
REER_TransportEquipment


150
140
130
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2002
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2006
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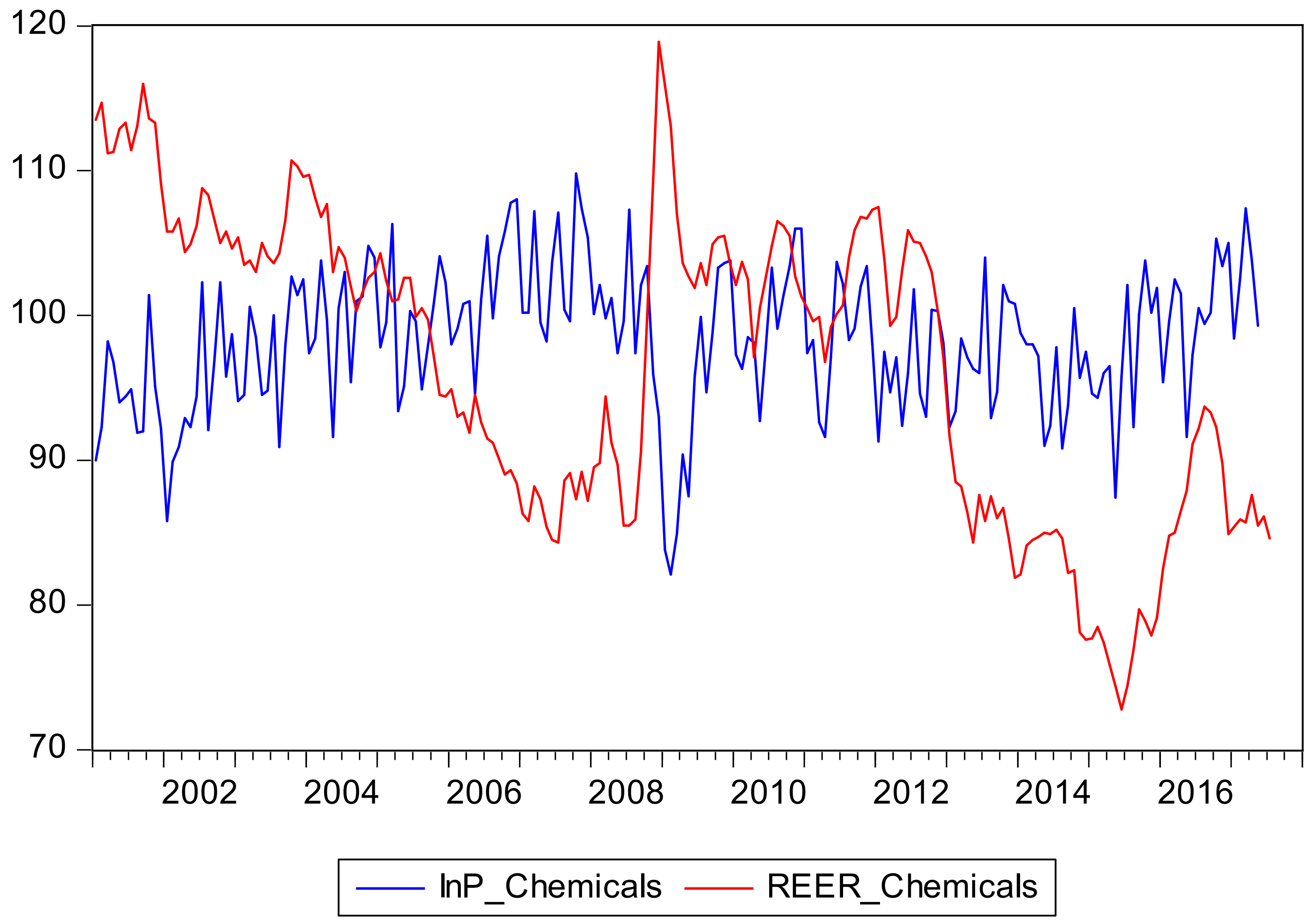
lnP_ElectricalEquipment
REER_ElectricalEquipment


120
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80
70
2002
2004
2006
2008
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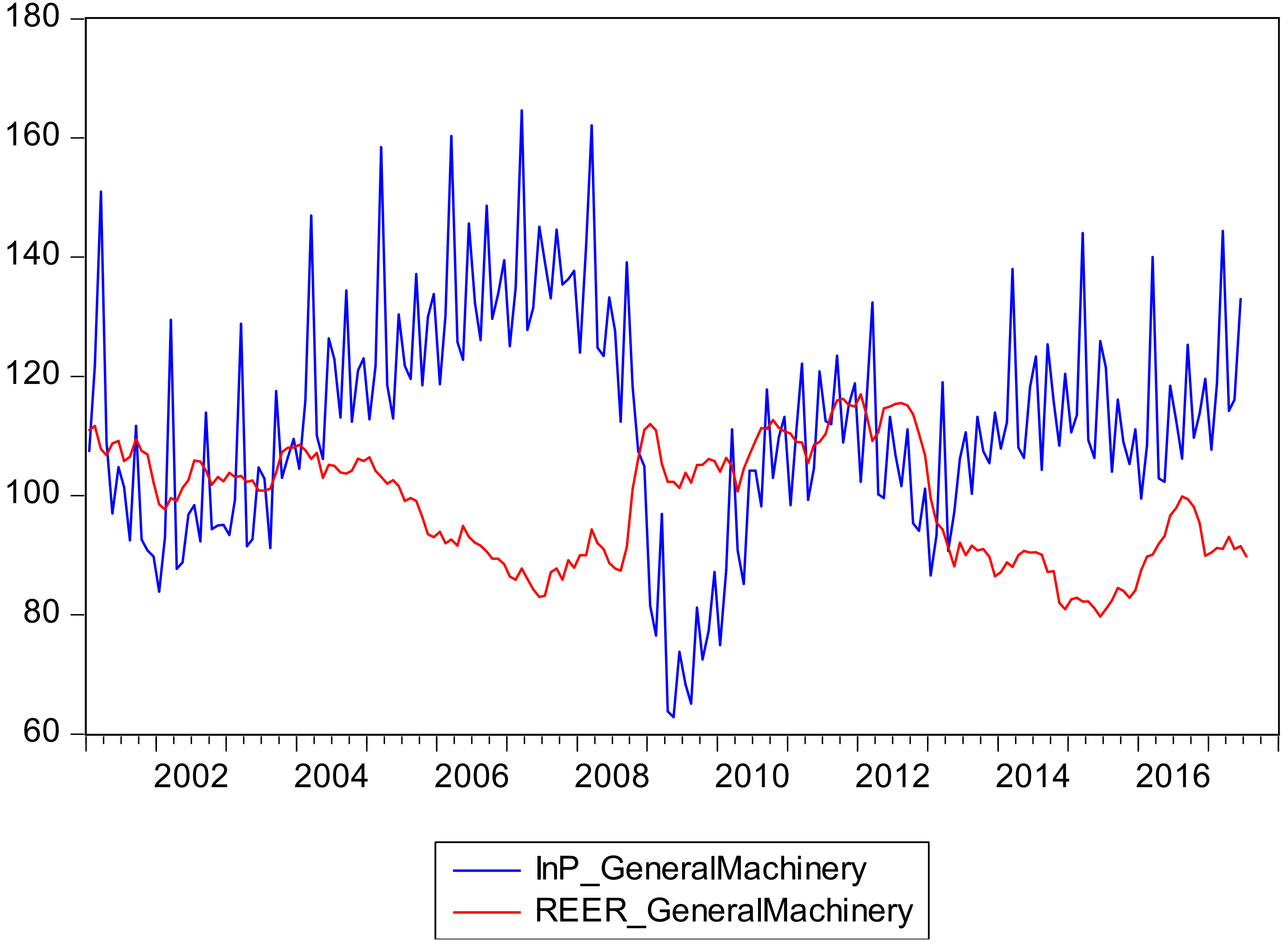
2016
lnP_Chemicals
REER_Chemicals


180
160
140
120
100
80
60
2002
2004
2006
2008
2010
2012
2014
2016
lnP_GeneralMachinery
REER_GeneralMachinery

Sector-specific autoregressive distributed lag-estimations for first differences

- Entries in the “selected model” column indicate the model selected according the Akaike information criterion.
- The first entry in brackets denote the lags of the endogenous lagged variable, the second entry corresponds with the lag number of the change of the **sector-specific exchange rate**, the third entry indicates the lag number of the change in **US industrial production** and the fourth one stands for the lag number of the change in **Japanese industrial input prices.**
- The column containing the yen exchange rate effect denotes the significant estimated coefficients for the exchange rate in the selected ARDL model.
- The **total** exchange rate effect (next column) is indicated by the **sum** of the period-specific significant entries.
- Values in brackets denote the respective significance level (probabilities).

Results of sector-specific ARDL models: Impact of the real effective yen exchange rate on Japanese industrial production (excl. EX)

Japanese industry sector	Selected ARDL model	Yen exchange rate effects	Yen exchange rate effect (total)
Manufacturing	ARDL(4, 3, 2, 0)	Lag 3: -0.61 (0.0032)	-0.61
Chemicals	ARDL(2, 3, 1, 0)	Lag 3: -0.41 (0.0036)	-0.41
Electrical equipment	ARDL(3, 3, 1, 2)	Lag 3: -1.04 (0.0101)	-1.04
Transport equipment	ARDL(3, 3, 2, 0)	Lag 3: -0.83 (0.0148)	-0.83
Rubber	ARDL(3, 3, 1, 0)	Lag 1: 0.44 (0.0981) Lag 3: -0.95 (0.0004)	-0.51
Optical instruments	ARDL(2, 3, 0, 0)	Lag 0: 0.90 (0.0294) Lag 3: 1.43 (0.0004)	-0.53
Paper	ARDL(4, 3, 1, 0)	Lag 3: -0.38 (0.0008)	-0.38
Food	ARDL(3, 0, 0, 0)	—	—
Textiles	ARDL(4, 3, 4, 0)	1: 0.27 (0.0785) 3: -0.25 (0.0830)	0.01

Dependent Variable: D(INP_MANUFACTURINGALL)
Method: ARDL
Sample (adjusted): 2001M06 2017M06
Included observations: 193 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): D(REER_MANUFACTURINGALL) D(INPUSA) D(INDINPUTPRICE)
Fixed regressors: C
Number of models evalulated: 500
Selected Model: ARDL(4, 3, 2, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
D(INP_MANUFACTURINGALL(-1))	-0.697699	0.072846	-9.577785	0.0000
D(INP_MANUFACTURINGALL(-2))	-0.867266	0.086039	-10.07993	0.0000
D(INP_MANUFACTURINGALL(-3))	-0.283453	0.087358	-3.244752	0.0014
D(INP_MANUFACTURINGALL(-4))	-0.165924	0.071672	-2.315035	0.0217
D(REER_MANUFACTURINGALL)	0.189543	0.219093	0.865127	0.3881
D(REER_MANUFACTURINGALL(-1))	0.213997	0.216040	0.990543	0.3232
D(REER_MANUFACTURINGALL(-2))	0.040311	0.213098	0.189164	0.8502
D(REER_MANUFACTURINGALL(-3))	**-0.614792**	**0.205586**	**-2.990434**	**0.0032**
D(INPUSA)	0.892882	0.661064	1.350675	0.1785
D(INPUSA(-1))	2.602084	0.653861	3.979568	0.0001
D(INPUSA(-2))	0.966521	0.681389	1.418456	0.1578
D(INDINPUTPRICE)	-0.013329	0.085517	-0.155863	0.8763
C	-0.227603	0.422910	-0.538183	0.5911
R-squared	0.549736	Mean dependent var		0.050777
Adjusted R-squared	0.519718	S.D. dependent var		8.436238
S.E. of regression	5.846512	Akaike info criterion		6.434549
Sum squared resid	6152.707	Schwarz criterion		6.654316
Log likelihood	-607.9340	Hannan-Quinn criter.		6.523548
F-statistic	18.31378	Durbin-Watson stat		2.104685
Prob(F-statistic)	0.000000			

- Correlations demonstrate that branch-specific **exports dominate** any impact on the respective sector's industrial **production.**

Example: Manufacturing all

	D(INP_MANUFACTURINGALL)	D(EX_MANUFACTURINGALL)	D(REER_MANUFACTURINGALL)	D(INDINPUTPRICE)	D(INPUSA)
D(INP_MANUFACTURINGALL)	1.000000	0.826584	-0.008935	-0.058282	-0.011778
D(EX_MANUFACTURINGALL)	0.826584	1.000000	-0.103245	0.023029	0.092910
D(REER_MANUFACTURINGALL)	-0.008935	-0.103245	1.000000	-0.308087	-0.120676
D(INDINPUTPRICE)	-0.058282	0.023029	-0.308087	1.000000	0.241691
D(INPUSA)	-0.011778	0.092910	-0.120676	0.241691	1.000000

Results of sector-specific ARDL models: Impact of the real effective yen exchange rate on Japanese industrial production (incl. EX)

Japanese industry sector	Selected ARDL model	Yen exchange rate effects	Yen exchange rate effect (total)
Manufacturing	ARDL(4, 3, 4, 1, 0)	Lag 0: 0.49 (0.0001) Lag 1: 0.30 (0.0198) Lag 2: 0.26 (0.0377) Lag 4: -0.27 (0.0183)	0.78
Chemicals	ARDL(2, 0, 3, 0, 1)	Lag 3: -0.40 (0.0020)	-0.40
Electrical equipment	ARDL(3, 4, 4, 2, 4)	Lag 3: -0.74 (0.0180) Lag 4: -0.57 (0.0604)	-1.31
Transport equipment	ARDL(3, 2, 0, 0, 1)	Lag 0: 0.67 (0.0004)	0.67
Rubber	ARDL(4, 1, 3, 0, 1)	Lag 1: 0.53 (0.0268) Lag 3: -0.84 (0.0004)	-0.31
Optical instruments	ARDL(4, 6, 3, 0, 2)	Lag 0: 1.30 (0.0008) Lag 1: 0.80 (0.0382) Lag 3: -0.83 (0.0276)	1.27
Paper	ARDL(4, 4, 3, 3, 2)	Lag 3: -0.26 (0.0101)	-0.26
Food	ARDL(3, 4, 3, 0, 0)	Lag 3: -0.67	-0.67
Textiles	ARDL(4, 4, 0, 3, 3)	—	—

Panel estimation

- Panel unit root tests were conducted:
  - Levin, Lin and Chu (2002), Breitung (2000), Im, Pesaran and Shin (2003), Fisher-type tests using ADF and PP tests (Maddala and Wu 1999; Choi 2001), and Hadri (2000)
  - All variables turned out to be I(1).
- We conduct **Pooled** Least Squares estimations of a **mixed time series-cross section** model with White cross-section standard errors and covariance (d.f. corrected) => Allow for general contemporaneous correlation between the branch-specific residuals.

Dependent Variable: D(INP?)				
Method: Pooled Least Squares				
Sample (adjusted): 2001M03 2017M05				
Included observations: 195 after adjustments				
Cross-sections included: 11				
Total pool (balanced) observations: 2145				
White cross-section standard errors & covariance (d.f. corrected)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-0.170941	0.316318	-0.540408	0.5890
D(INP?(-1))	-0.293775	0.027666	-10.61873	0.0000
D(EX?)	7.85E-09	3.31E-10	23.68930	0.0000
D(INPUSA)	**0.019544**	**0.545351**	**0.035837**	**0.9714**
D(INDINPUTPRICE)	**-0.030964**	**0.054417**	**-0.569018**	**0.5694**
_CHEMICALS--D(REER_CHEMICALS(-1))	0.158528	0.134324	1.180189	0.2381
_ELECTRICALEQUIPMENT--D(REER_ELECTRICALEQUIPMENT(-1))	0.377234	0.369837	1.020002	0.3078
_FOOD--D(REER_FOOD(-1))	0.153618	0.386024	0.397949	0.6907
_GENERALMACHINERY--D(REER_GENERALMACHINERY(-1))	0.169366	0.301498	0.561748	0.5743
_OPTICALINSTRUMENTS--D(REER_OPTICALINSTRUMENTS(-1))	0.183658	0.447416	0.410485	0.6815
_PAPER--D(REER_PAPER(-1))	-0.268302	0.114500	-2.343255	0.0192
_PETROLEUM--D(REER_PETROLEUM(-1))	0.073772	0.143998	0.512313	0.6085
_RUBBER--D(REER_RUBBER(-1))	0.170134	0.287215	0.592356	0.5537
_TEXTILES--D(REER_TEXTILES(-1))	0.040478	0.153250	0.264130	0.7917
_TRANSPORTEQUIPMENT--D(REER_TRANSPORTEQUIPMENT(-1))	0.258900	0.226158	1.144774	0.2524
_WOOD--D(REER_WOOD(-1))	0.319598	0.205977	1.551626	0.1209
Fixed Effects (Cross)				
_CHEMICALS—C	0.170479			
_ELECTRICALEQUIPMENT—C	0.204782			
_FOOD—C	0.241471			
_GENERALMACHINERY—C	0.051287			
_OPTICALINSTRUMENTS—C	0.026066			
_PAPER—C	0.055428			
_PETROLEUM—C	-0.035453			
_RUBBER--C	0.098011			
_TEXTILES--C	-0.582541			
_TRANSPORTEQUIPMENT--C	0.032515			
_WOOD--C	-0.262044			
	Effects Specification			
Cross-section fixed (dummy variables)				
R-squared	0.396352	Mean dependent var		-0.126667
Adjusted R-squared	0.389230	S.D. dependent var		10.77369
S.E. of regression	8.419831	Akaike info criterion		7.111104
Sum squared resid	150223.4	Schwarz criterion		7.179842
Log likelihood	-7600.659	Hannan-Quinn criter.		7.136254
F-statistic	55.65293	Durbin-Watson stat		2.301490

Dependent Variable: D(INP?)
Method: Pooled Least Squares
Sample (adjusted): 2001M05 2017M05
Included observations: 193 after adjustments
Cross-sections included: 11
Total pool (balanced) observations: 2123
White cross-section standard errors & covariance (d.f. corrected)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.281928	0.306146	-0.920894	0.3572
D(INP?(-1))	-0.303904	0.027273	-11.14315	0.0000
D(EX?)	7.62E-09	3.22E-10	23.66993	0.0000
_CHEMICALS--D(REER_CHEMICALS(-3))	-0.379311	0.114186	-3.321857	0.0009
_ELECTRICALEQUIPMENT--D(REER_ELECTRICALEQUIPMENT(-3))	-0.646238	0.393353	-1.642894	0.1006
_FOOD--D(REER_FOOD(-3))	-0.589979	0.421035	-1.401261	0.1613
_OPTICALINSTRUMENTS--D(REER_OPTICALINSTRUMENTS(-3))	-1.458646	0.327485	-4.454077	0.0000
_PAPER--D(REER_PAPER(-3))	-0.297608	0.137906	-2.158053	0.0310
_RUBBER--D(REER_RUBBER(-3))	-0.984842	0.253934	-3.878340	0.0001
_TRANSPORTEQUIPMENT--D(REER_TRANSPORTEQUIPMENT(-3))	**-0.129969**	**0.203684**	**-0.638092**	**0.5235**
_GENERALMACHINERY--D(REER_GENERALMACHINERY(-3))	**-0.389755**	**0.316481**	**-1.231528**	**0.2183**
_WOOD--D(REER_WOOD(-3))	-0.495384	0.180876	-2.738798	0.0062
_PETROLEUM--D(REER_PETROLEUM(-3))	**0.134202**	**0.139727**	**0.960463**	**0.3369**
_TEXTILES--D(REER_TEXTILES(-3))	-0.382260	0.137502	-2.780034	0.0055
Fixed Effects (Cross)				
_CHEMICALS--C	0.169254			
_ELECTRICALEQUIPMENT--C	0.072260			
_FOOD--C	0.103571			
_OPTICALINSTRUMENTS--C	-0.003121			
_PAPER--C	0.107106			
_RUBBER--C	0.020759			
_TRANSPORTEQUIPMENT--C	0.150397			
_GENERALMACHINERY--C	0.102156			
_WOOD--C	-0.213968			
_PETROLEUM--C	0.087544			
_TEXTILES--C	-0.595959			

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.407660	Mean dependent var	-0.132925
Adjusted R-squared	0.401169	S.D. dependent var	10.69130
S.E. of regression	8.273373	Akaike info criterion	7.075202
Sum squared resid	143673.8	Schwarz criterion	7.139194
Log likelihood	-7486.327	Hannan-Quinn criter.	7.098628
F-statistic	62.80755	Durbin-Watson stat	2.329529

Dependent Variable: D(INP?)				
Method: Pooled Least Squares				
Sample (adjusted): 2001M05 2017M05				
Included observations: 193 after adjustments				
Cross-sections included: 8				
Total pool (balanced) observations: 1544				
White cross-section standard errors & covariance (d.f. corrected)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-0.327666	0.345083	-0.949526	0.3425
D(INP?(-1))	-0.316519	0.029663	-10.67065	0.0000
D(EX?)	1.02E-08	6.96E-10	14.70618	0.0000
_CHEMICALS--D(REER_CHEMICALS(-3))	-0.373190	0.119660	-3.118762	0.0019
_ELECTRICALEQUIPMENT--D(REER_ELECTRICALEQUIPMENT(-3))	**-0.487159**	**0.390837**	**-1.246451**	**0.2128**
_FOOD--D(REER_FOOD(-3))	**-0.588434**	**0.418155**	**-1.407216**	**0.1596**
_OPTICALINSTRUMENTS--D(REER_OPTICALINSTRUMENTS(-3))	-1.428578	0.327642	-4.360175	0.0000
_PAPER--D(REER_PAPER(-3))	-0.293660	0.137400	-2.137258	0.0327
_RUBBER--D(REER_RUBBER(-3))	-0.959221	0.249355	-3.846805	0.0001
_WOOD--D(REER_WOOD(-3))	-0.497258	0.181351	-2.741969	0.0062
_TEXTILES--D(REER_TEXTILES(-3))	-0.375632	0.134174	-2.799598	0.0052
Fixed Effects (Cross)				
_CHEMICALS--C	0.188660			
_ELECTRICALEQUIPMENT--C	0.159948			
_FOOD--C	0.146594			
_OPTICALINSTRUMENTS--C	0.037604			
_PAPER--C	0.150949			
_RUBBER--C	0.047401			
_WOOD--C	-0.173349			
_TEXTILES--C	-0.557807			
	Effects Specification			
Cross-section fixed (dummy variables)				
R-squared	0.310158	Mean dependent var		-0.179210
Adjusted R-squared	0.302473	S.D. dependent var		9.786372
S.E. of regression	8.173388	Akaike info criterion		7.051234
Sum squared resid	101943.3	Schwarz criterion		7.113512
Log likelihood	-5425.552	Hannan-Quinn criter.		7.074401
F-statistic	40.35891	Durbin-Watson stat		2.204390
Prob(F-statistic)	0.000000			

Dependent Variable: D(INP?)				
Method: Pooled Least Squares				
Sample (adjusted): 2001M05 2017M05				
Included observations: 193 after adjustments				
Cross-sections included: 6				
Total pool (balanced) observations: 1158				
White cross-section standard errors & covariance (d.f. corrected)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-0.358571	0.337580	-1.062181	0.2884
D(INP?(-1))	-0.219148	0.047894	-4.575686	0.0000
D(EX?)	1.15E-08	1.30E-09	8.860615	0.0000
_CHEMICALS--D(REER_CHEMICALS(-3))	-0.360894	0.123608	-2.919660	0.0036
_OPTICALINSTRUMENTS--D(REER_OPTICALINSTRUMENTS(-3))	-1.337488	0.315744	-4.235989	0.0000
_PAPER--D(REER_PAPER(-3))	-0.297193	0.138053	-2.152741	0.0315
_RUBBER--D(REER_RUBBER(-3))	-0.883009	0.247108	-3.573367	0.0004
_WOOD--D(REER_WOOD(-3))	-0.480935	0.178896	-2.688341	0.0073
_TEXTILES--D(REER_TEXTILES(-3))	-0.356062	0.127916	-2.783562	0.0055
Fixed Effects (Cross)				
_CHEMICALS--C	0.205349			
_OPTICALINSTRUMENTS--C	0.081656			
_PAPER--C	0.197188			
_RUBBER--C	0.082447			
_WOOD--C	-0.105156			
_TEXTILES--C	-0.461484			
	Effects Specification			
Cross-section fixed (dummy variables)				
R-squared	0.214667	Mean dependent var		-0.221503
Adjusted R-squared	0.205743	S.D. dependent var		7.903358
S.E. of regression	7.043560	Akaike info criterion		6.754121
Sum squared resid	56755.83	Schwarz criterion		6.815228
Log likelihood	-3896.636	Hannan-Quinn criter.		6.777180
F-statistic	24.05440	Durbin-Watson stat		2.173264

Summary of findings for monthly data analysis

- **Both** sector-specific ARDL estimations and estimations of a mixed time series-cross section model suggest **small but highly significant** effects **of the REER on industrial production**.

Conclusions

- Results suggest that a strong yen had more than just transitory effects on Japanese manufacturing.
- Indication of hysteresis effects on manufacturing.
- While there are certainly also other factors that have contributed to a hollowing out of Japanese industry, a strong yen played a role, too.

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Merci de votre attention!

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