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The Balassa-Samuelson Effect and the Labor Market in Japan：1977-2008*

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Abstract

This study examines the BalassaSamuelson effect based on the real exchange rate by sectors in Japan and the United States. Although it is theoretically assumed that the effect holds under identical wages between tradable and non-tradable sectors, few empirical studies verify the validity of this assumption. We attempt to investigate the feasibility of the Balassa-Samuelson effect by focusing on Japanese labour market dynamics using a panel threshold model. The empirical results show that the effect may not have held since the end of the 1990s, given the wage discrepancy between tradable and non-tradable sectors, and that structural changes have been driven by the machinery sectors such as electricity and general machinery.

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1 Introduction

The role of exchange rate is gaining importance in the current global economy. It should be noted that in the long run, the real exchange rate—the exchange ratio of goods between two countries—is crucial.

Figure 1 illustrates changes in the real effective exchange rate in Japan. As described by Yamamoto (2013) and Ito (2015), the yen appreciated until 1995 and has depreciated since then. This exchange rate turnaround poses an interesting object for academic analysis.

Balassa (1964) and Samuelson (1964) formulated a theory for long-term real exchange rates, called the BalassaSamuelson effect,[1] which was originally intended to explain why the exchange rate deviates from purchasing power parity (PPP). The main mechanism is that there is a tendency for the real exchange rate to appreciate as productivity of traded goods sectors rises relative to that of non-traded goods sectors. As pointed out by Devereux (1999) and Ito et al. (1999), , this effect was in existence in Japan until 1995. In fact, productivity of the traded goods sectors was higher than that of non-traded goods and the yen appreciated. Since then, however, the real exchange rate trend has reversed; thus, if we consider it in the context of the BalassaSamuelson effect, it follows that tradable sector productivity declines while the non-tradable sector productivity increases. However, the data presented in Figure 2 provide no evidence for a relative increase of productivity in the non-tradable sectors since the 1990s. This suggests that the movements in the real exchange rate since the 1990s cannot be explained by the Balassa-Samuelson effect. It is necessary, therefore, to investigate the validity of assuming an identical wage between the tradable and non-tradable sectors. Only a few attempts have been made to examine this assumption.[2] Strauss (1997) investigated 14 OECD countries from 1970 to 1990

[1] As Tica and Družić points out, Harrod (1933) was the seminal work to formulate and goes back further to Ricardo (1821). Rogoff (1992) was the first to fully construct the Balassa-Samuelson effect within the general equilibrium framework. Although it seems that the name of "Harrod-Balassa-Samuelson effect" is popular, we call "Balassa-Samuelson effect" in this paper.

[2] Tica and Družić (2006) is a comprehensive survey concerning the empirical studies of Balassa-Samueslon effect.

and showed that the wage difference between tradable and non-tradable sectors affects the real exchange rate. Konopczak and Torój (2010) and Cardi and Restout (2015) applied the unit root test to examine the wage difference between two sectors in Poland from 1999 to 2008 and in 14 OECD countries, respectively.[3] In addition, Konopczak (2013) conducted the Granger test to check the wage causality in tradable and non-tradable sectors in Central and Eastern European countries[4]; however, these time-series tests were under-powered and lack persuasiveness. Yamamoto (2013) applied the cointegration test with regime switch, developed by Gregory and Hansen (1996), to the Japanese real exchange rate from 1970 to 2008. He pointed out that there has been a diminishing mechanism of the BalassaSamuelson effect since the 1990s. Although lacking empirical evidence, Yamamoto (2013) referred to the violence of the assumption that there is an identical wage between the tradable and non-tradable sectors.[5]

This study offers three analytical differences from earlier studies. First, we attempt to investigate the feasibility of the Balassa-Samuelson effect by focusing on the dynamics of the Japanese labour market using a panel threshold model. Hansen (1999) developed the panel threshold estimation method. This method does not require any specific functional form of parameter nonlinearity and assumes that the thresholds are endogenously determined. From this reasoning, we apply Hansen's panel threshold estimation method to test whether there is a threshold effect between the real exchange rate and relative wage between tradable and non-tradable sectors in Japan.

Second, we explicitly investigate the Japanese labour market structure by focusing on the part-time and non-regular workers ratio in the non-manufacturing sector. It is shown that this ratio has increased remarkably since the 1990s. Yamamoto

[3]Cardi and Restout (2015) search much further than that. They describe the importance of the degree of labor mobility across sectors.

[4]They include Poland, Czech republic, Hungary and Slovakia.

[5]Nagayasu and Liu (2008) investigate the relationship between wage dynamics and real exchange rate in China. He constructed the twenty nine areas (22 provinces, three municipalities directly under the control of central government and four autonomous areas) and focuses on the relative wage between home and foreign countries.

(2013) and Ito (2015) also recognised this point, although there is no quantitative analysis in their study.

Third, we divide industry into several sectors and examine each sector in detail. Previous studies mostly set the panel data with countries. However, as pointed out in Konopczak and Torój (2010), it is difficult to identify the characteristics of each country with these panel data..[6] Konopczak and Torój (2010) and Konopczak (2013) overcame this problem by dividing the non-manufacturing sector into several sectors. In Japan, however, manufacturing is a driving force of economic growth and it seems to be essential to divide manufacturing into several sectors. This point was emphasised by Marston (1986), who investigated the yen-dollar exchange rate movements since the 1960s.

This empirical study yielded three findings. First, the assumption of identical wages between sectors is relevant and the effect does not work in situations where the relative wage exceeds the threshold, which was determined endogenously to be around 1995. Second, the role of the non-regular workers ratio in the non-manufacturing sectors seems not to be important, although it is a matter of speculation, and further investigation is necessary. Third, the effect may not have held since the end of the 1990s under wage discrepancy between tradable and non-tradable sectors, and such a structural change has occurred in the machinery sectors (electricity and general machinery).

The remainder of this study is organised as follows. Section 2 describes the data and methodology and lays out estimation results. Section 3 discusses additional empirical evidence. Section 4 summarises the conclusions.

[6]Nagayasu's study was an interesting attempt to analyse the Balassa-Samuelson eect using spatial panel data by prefectures in Japan.

2 Data and Empirical Results

2.1 Data and Panel Unit Root Tests

This study uses annual balanced panel data for 23 manufacturing sub-sectors over the 1977-2008 period.[7] In the next subsection, we adopt the panel threshold regression method proposed by Hansen (1999). As a prerequisite for the methodology,[8] a panel unit root test is conducted for the real exchange rate (rer) and relative labour productivity (rlp) using the LLC (Levin et al. (2002)) and IPS (Im et al. (2003)) test. The results are shown in Table 3. All the tests reject the null hypothesis for levels except relative labour productivity using the IPS (Im et al. (2003)) test. Judging from these tests results, we decide that the data series is $I(0)$.

2.2 Empirical Results

As pointed out by Chinn and Johnston (1997),[9] we perform the analysis by focusing on the supply side (labour productivity). Specifically, we analyse the relative labour productivity of Japan's tradable/non-tradable sectors, considering the wage ratio in both sectors. Therefore, we use the panel threshold regression model proposed by Hansen (1999). The Balassa-Samuelson model assumes wage equalisation across tradable and non-tradable sectors, which means that the wage ratio in both sectors is one. We can easily imagine that the Balassa-Samuelson model does not hold as the wage ratio departs from one. This nonlinearity can be considered using Hansen's (1999) model and, thereby, we can endogenously determine the threshold value or the wage ratio.

[7] See the data appendix for detailed documentation. The reason why we choose 2008 as the sample end period is that it is the latest data which we can obtain at this time. Specifically, we only collect the data up to 2008 in OECD Stat in order to calculate the wage in service industries.

[8] The method propsed by Hansen (1999) is designed for balanced panel and stationary data.

[9] Chinn and Johnston (1997) classify previous studies into three categories.

Our estimation model is as follows[10][11]:

$$\ln rer_{it} = \alpha_i + \beta_1 \ln rlp_{it} I(rw_{it} \leq \gamma_1) + \beta_2 \ln rlp_{it} I(\gamma_1 > rw_{it}) + \epsilon_{it}. \qquad (1)$$

where $\ln rer$ denotes the log of the real exchange rate, $\ln rlp$ the relative labour productivity and α_i is an individual effect. Subscripts i and t denote sectors and time periods, respectively. Moreover, $\mathrm{I}(\cdot)$ denotes the indicator function, rw is the relative wage ratio which serves as the threshold variable and γ is the threshold parameter.

We use two kinds of relative wage.[12] One is the relative wage ratio of total manufacturing to non-tradable sector (Case 1). In this case, we assume the same relative wage ratio upon any manufacturing sector, which implies rw_t not rw_{it}. The other is the relative wage ratio of individual manufacturing sectors to non-tradable sector (Case 2). This means rw_{it} in mathematical presentation, which Hansen (1999) normally assumed.

Before estimation, we need to conduct a linearity test and determine the number of thresholds. The results are shown in Table 4. Whichever case (Case 1 or 2) is chosen, the tests reject the null hypothesis of linearity and support that the number of thresholds is one.

Following the above test results, we proceed to the estimation of Equation (1). The results are reported in Table 5. In any case, the results show that the relative labour productivity has a deteriorating effect on the real exchange rate when the threshold variables, or the relative wage ratio, exceed the threshold values. Specifically, the estimates are from -0.3132 to -0.1477, which implies a 52% decline in the absolute value in Case 1 and, in Case 2, from -0.2912 to -0.0220 (i.e. insignificant). These results show a decrease in the Balassa-Samuelson effect.

[10] We do not need to test the choice of fixed-effect or random-effect models because the fixed-effect model is assumed in Hansen (1999).

[11] Non-inclusion of control variables in Equation (1) may produce misspecification bias. On this point, we conduct the robustness check later.

[12] See the data appendix for detailed documentation.

2.3 Robustness Check

As a robustness check of previous results, we employ two methods. First, we re-estimate Equation (1) using the sub-sectors except other electrical equipment and precision equipment. The results are shown in Tables 7 and 8. These support the previous fact that the Balassa-Samuelson effect decreases when the relative wage ratio exceeds the threshold values.

Next, we add control variables for other factors which may influence the estimation results. Thus, we estimate the following equation:

$$\ln rer_{it} = \alpha_i + \beta_1 \ln rlp_{it} I(rw_{it} \leq \gamma_1) + \beta_2 \ln rlp_{it} I(\gamma_1 > rw_{it}) + \beta_3 \ln rlp^{US}_{it} + \beta_4 gc^{Jap}_{it} + \epsilon_{it} \quad (2)$$

where rlp^{US} denotes relative labour productivity in the United States (US) and gc is the Japanese government consumption to GDP ratio.[13] We add the latter variable because we follow Rogoff (1992), who considered the effects of the demand side as stated by Tica and Družić (2006) and others. The results are shown in Tables 9 and 10. Table 9 shows that the number of thresholds is one as in the previous subsection. Table 10 supports that while coefficients of relative labour productivity in the US and Japanese government consumption have the wrong sign,[14] the BalassaSamuelson effect decreases when the relative wage ratio exceeds the threshold values.

[13]Note that the subscript is not *i* but *it*. The reason is that when we construct the data, both numerator and denominator are divided by the deflator of each sector.

[14]While the coefficient of Japanese government consumption has the wrong sign, this is consistent with Rogoff's(1992) mention. He confirmed that the correlation between the ratio of Japanese government consumption to GNP and the real yen/dollar exchange rate has a positive sign, which supports our results. Moreover, other previous research has the wrong coefficient sign about government consumption as in Chinn (2000). We can think of two reasons why the coefficients of relative labour productivity in the US have the wrong sign. First, the data are constructed by connecting the older data set and the newer data set using the growth rate of the older dataset. Second, we use Y/L as a measure of labour productivity. In the case of the US, however, we use the number of employees in place of man-hour input as the denominator L. The use of the latter is supposed to more appropriate.

3 Discussion

We scrutinise the relation between the relative wage ratio and the threshold value. First, we consider Case 1, where the threshold value is 1.0958, as shown in Table 4. The above in Figure 4 shows the movement from the past of the relative wage ratio with the threshold value. We recognise that the relative wage ratio has exceeded the threshold value since 1997. Combined with the results shown in Table 5, the Balassa-Samuelson effect has decreased since then. This is consistent with the result of Yamamoto (2013), who empirically showed that the structural change occurred in the mid-1990s, with a view to the Balassa-Samuelson effect.

Next, Figure 4 and Table 12 are for Case 2. From these results, we classify 23 sub-sectors into three groups: five sub-sectors (pulp, paper, paperboard and coated and glazed paper, final chemical products, general industry machinery, motor vehicles and other transportation equipment) whose relative wage ratios remain above the threshold value throughout the estimation period; seven sub-sectors (special industrial machinery, miscellaneous and general machinery, heavy electrical equipment, electrical equipment and electric measuring, other electrical equipment, motor vehicles, parts and accessories and precision instruments) whose relative wage ratios cross the threshold value at a certain times; eleven sub-sectors (other than listed above) whose relative wage ratios remain below the threshold value throughout the estimation period.

Considering the results of Cases 1 and 2 together, we obtain the following interesting results. From the results of Case 1, the Balassa-Samuelson effect seems to have decreased since the late 1990s due to the increased ratio of relative wages. However, when we examine the relation between the relative wage and the threshold value by sub-sectors, such an interpretation is supported only by the above seven sub-sectors crossing the threshold value. We can suggest that the Balassa-Samuelson effect is not confirmed in the five sub-sectors and is confirmed in the other sub-sectors. This justifies the importance of examination by sector.

Following the above results, we examine another hypothesis that the rise in the ratio of relative wages is due to a difference in the ratio of part-time and non-regular employees between the tradable and non-tradable sectors. As shown in Figure 5, the difference seems to have widened in Japan since the 1990s. If we support the hypothesis, then this difference is a primary cause of the decrease in the BalassaSamuelson effect. To test this hypothesis, we examine the linearity of the following Equation (3) by replacing the threshold variable, or rw in Equation (1), with pt, which represents the part-time and non-regular employees ratio of non-tradable sector over tradable sector:

$$\ln rer_{it} = \alpha_i + \beta_1 \ln rlp_{it} I(pt_{it} \leq \gamma_1) + \beta_2 \ln rlp_{it} I(\gamma_1 > pt_{it}) + \epsilon_{it}. \tag{3}$$

If the hypothesis is supported, then we expect that the linearity test is rejected and the boundary of the threshold is approximately the 1990s, as shown in Equation (1). The results are shown in Table 6. We do not support the single threshold nor double threshold nor triple threshold.[15] While we carefully need to handle the results because of the non-rejection of the null hypothesis, the results here do not strongly support that the difference in the ratio of part-time and non-regular employees between the tradable and non-tradable sectors, and this seems not to be the root cause of the decrease in the Balassa-Samuelson effect. In fact, as Figure 6 shows, the behaviours of the part-time and non-regular employees ratio in the service sector over 19 sub-manufacturing sectors do not exhibit similar tendencies among the sub-sectors above, below or crossing the threshold.

4 Conclusion

This study empirically investigates the Balassa-Samuelson effect using the Japanese panel data by sectors from 1977 to 2008. Thise effect is well-known in international finance theory, and abundant research has been conducted on this topic.

Thise present study is differsent from earlier ones studies in three significant ways. First, we revisit the validity of the assumption that there is an identical wage between tradable and non-tradable sectors. Second, we focus on the recent changes in the

[15] We also conducted a robustness check on this result using the sub-sectors as in the previous analysis. As Table11 shows, the threshold effects are not detected.

non-tradable labour market, wherein the ratio of non-regular workers has increased remarkably. Thirds, we divide industries into several sectors and successfully examine their differences.

We succeed in obtaining a deeper understanding of the feasibility of the Balassa-Samuelson effect and present the following key findings. First, the assumption of an identical wage between sectors is relevant and the effect does not hold in situations wherein the relative wage exceeds the threshold value. Second, we recognised that the ratio of non-regular workers in the non-manufacturing sectors seems not to be important., even though it is a matter of speculation;, and more careful further investigation is necessary in this regard. Lastly, the effect may not have held since the end of the 1990s given the wage discrepancy between tradable and non-tradable sectors, and such a structural change has been driven by the machinery sectors—electricity and general machinery.

Finally, there are three directions for further research. The first is the inclusion of other factors into the estimation. The Balassa-Samuelson effect is basically a supply-side phenomenon; thus, demand-side variables that affect movements in the real exchange rate are not considered. The second direction is the extension of the threshold panel model to a dynamic version that explicitly considers the inertia of the real exchange rate. The last direction is the application of this study to other countries, particularly European countries. Since the 2010s, economic growth in European countries has been decelerated and the number of non-regular workers in the non-manufacturing sectors has increased. This trend may diminish the validity of the Balassa-Samuelson effect. Therefore, the empirical technique used in this study is useful for examining the medium- and long-term movements in the real exchange rate in these areas.

Data Appendix

We obtain the following data from JIP database 2015, Bureau of Economic Analysis (BEA) and OECD.Stat:

- Sectoral real exchange rate(rer)[16]

  The real exchange rate is calculated by multiplying nominal exchange rate (in yen per dollar) by the relative prices. When we calculate the relative prices, we use sectoral price levels. We calculate them by dividing sectoral nominal output by sectoral real output in Japan and chain-type price indexes for value added in the US. Due to the difference in the base year of price indexes in each country, we unify them as year 2000=100.

- Relative labor productivity between tradable and non-tradable sectors (rlp)

  Labour productivities are calculated by sectoral real outputs divided by sectoral man-hour labour inputs.[17] Using these, we calculate relative labour productivities as tradable productivities divided by non-tradable productivity. We treat 23 manufacturing sectors as tradable and construction as non-tradable.[18]

- Relative wage ratio between tradable and non-tradable sectors (rw)

  We use relative wage ratios as threshold variables. When we use Case 1 in the text, where we consider in terms of manufacturing as a whole and not by sector, the relative wage ratio is calculated as tradable (manufacturing) wage divided by non-tradable (service) wage. Specifically, we calculate the relative wage using 'labour costs (compensation of employees)' and 'number of persons engaged (total employment)' in OECD.Stat and then measure the ratio. When we use Case 2 in the text, where we consider in terms of manufacturing by sector, we calculate relative wage ratios using sectoral nominal labour cost divided by the number of sectoral persons engaged in the JIP database 2015.

- Part-time employees ratio (pt)

  We use ' part-time employees ratio ' in the JIP database 2015. Importantly, the data are only obtained every five years. Therefore, we convert them to annual data using linear interpolation. The relative part-time employees ratio is

[16]See Figure 1

[17]As stated in footnote 12, we do not sectoral manhour labor inputs but the number of employee in US data due to data availability,

[18]Because there does not exist aggregate service data, we use construction as a substitute.

calculated as the part-time employees ratio in the service sector divided by that in manufacturing. As explained above, although we consider manufacturing as a whole and not by sector in Case 1, we consider it sectorally.

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Table 1: Part-time Employees Ratio

	Max	Min	Mean	Median	Standard deviation
	Tradable good(manufacturing)				
1970	10.30	0.50	5.30	5.20	1.70
1975	16.20	0.90	8.60	8.50	2.50
1980	15.60	0.70	7.20	6.90	2.60
1985	17.40	0.70	7.70	7.50	2.80
1990	22.90	2.50	9.80	9.70	3.40
1995	26.80	5.10	11.10	10.90	3.90
2000	28.80	4.30	12.50	11.90	4.50
2005	30.20	6.30	13.40	12.90	4.50
2010	38.90	7.00	15.90	15.20	6.30
	Non-tradable good(Service, utilities and construction)				
1970	14.60	1.70	7.00	7.00	3.60
1975	18.70	2.30	9.40	9.40	4.60
1980	17.90	2.30	9.50	9.20	4.80
1985	21.00	2.20	10.00	9.40	5.50
1990	30.80	3.20	14.10	14.10	7.40
1995	33.30	2.20	16.70	16.90	7.70
2000	37.70	2.90	20.30	19.90	8.60
2005	45.20	3.20	22.80	22.90	10.40
2010	51.20	5.30	24.70	23.40	12.40

Source: RIETI JIP Database 2015, Share of part-time workers (part-time workers / total workers, %)

Table 2: Sectoral Correspondence(23 sectors)

	Japan	US
1	Livestock products	Food and beverage and tobacco products
2	Seafood products	Food and beverage and tobacco products
3	Beverages	Food and beverage and tobacco products
4	Sawing, planing mills and wood	Wood products
5	Furniture and fixtures	Furniture and related products
6	Pulp, paper, paperboard and coated and glazed paper	Paper products
7	Paper products	Paper products
8	Printing, plate making for printing, and bookbinding	Printing and related support activities
9	Rubber products	Plastics and rubber products
10	Final chemical products	Chemical products
11	Fabricated constructional and architectural metal products	Fabricated metal products
12	Miscellaneous fabricated metal products	Fabricated metal products
13	General industry machinery	Machinery
14	Special industrial machinery	Machinery
15	Miscellaneous general machinery	Machinery
16	Heavy electrical equipment	Electrical equipment, appliances, and components
17	Electrical equipment, electric measuring	Electrical equipment, appliances, and components
18	Other electrical equipment	Electrical equipment, appliances, and components
19	Motor vehicles	Motor vehicles, bodies and trailers, and parts
20	Motor vehicles, parts and accessories	Motor vehicles, bodies and trailers, and parts
21	Other transportation equipment	Other transportation equipment
22	Precision instruments	Electrical equipment, appliances, and components
23	Plastics	Plastics and rubber products

Table 3: Panel Unit Root Tests

	lnrer		lnrlp	
	level			
	Statistics	p-value	Statistics	p-value
LLC	-1.6150^{*}	(0.0532)	-4.6045^{***}	(0.0000)
IPS	-2.8288^{***}	(0.0023)	-1.0708	(0.1421)

1. $*, ***$ indicate 10% and 1% significance, respectively.
2. A constant is included for variables in levels and in first differences. In all these tests, the lag length is set to 2.

Table 4: Tests for Threshold Effects Using Wage Ratio as Threshold Value

	F value	
	case 1	case 2
Test for Single Threshold	51.51^{**}(0.0400)	30.62^{*}(0.0967)
	[41.46, 48.88, 65.02]	[30.40, 35.38, 42.31]
Test for Double Threshold	5.17(0.8367)	11.04(0.6400)
	[37.31, 43.04, 73.09]	[25.36, 29.03, 38.99]
Test for Triple Threshold	16.13(0.9933)	6.01(0.9633)
	[73.23, 78.20, 90.64]	[30.95, 33.42, 44.94]
Threshold estimates	1.0958	1.3898
95% confidence interval	[1.0766, 1.1070]	[1.3757, 1.3939]

1. $*, ***$ indicate 10% and 1% significance, respectively.
2. Values in parenthesis are bootstrap p-values.
3. Values in bracket are the 10%、5% and 1% critical values, respectively.

Table 5: Regression Estimates

	case 1	case 2
$\ln rlp_{it} I(rw_t \leq \gamma_1)$	-0.3132^{***}(0.0342)	-0.2912^{***}(0.0362)
$\ln rlp_{it} I(\gamma_1 < rw_t)$	-0.1477^{***}(0.0257)	-0.0220(0.0321)

1. $*, ***$ indicate 10% and 1% significance, respectively.
2. Values in parenthesis are standard error.

Table 6: Tests for Threshold Effects Using Ratio of Part-Time Workers as Threshold Value

	F value	
	case 1	case 2
Test for Single Threshold	62.15(0.2133)	16.38(0.5367)
	[79.10, 97.10, 118.51]	[31.10, 36.78, 41.45]
Test for Double Threshold	54.42(0.4667)	12.31(0.6300)
	[110.13, 139.50, 173.53]	[26.45, 29.48, 39.29]
Test for Triple Threshold	12.71(0.8367)	7.52(0.9267)
	[51.39, 70.03, 119.18]	[27.65, 33.63, 40.85]

1. $*$, $***$ indicate 10% and 1% significance, respectively.
2. Values in parenthesis are bootstrap p-values.
3. Values in bracket are the 10%、5% and 1% critical values, respectively.

Table 7: Robustness Check of Tests for Threshold Effects

	F value	
	case 1	case 2
Test for Single Threshold	59.15^{**}(0.0267)	39.49^{**}(0.0267)
	[47.54, 53.45, 77.64]	[30.66, 35.12, 43.36]
Test for Double Threshold	8.05(0.8133)	12.82(0.4300)
	[41.02, 52.46, 64.27]	[22.42, 24.95, 36.93]
Test for Triple Threshold	13.24(0.9767)	5.68(0.9667)
	[63.93, 69.70, 77.74]	[36.26, 43.96, 53.28]
Threshold estimates	1.0958	1.3757
95% confidence interal	[1.0766, 1.1070]	[1.3693, 1.3802]

1. $*$, $***$ indicate 10% and 1% significance, respectively.
2. Values in parenthesis are bootstrap p-values.
3. Values in bracket are the 10%、5% and 1% critical values, respectively.

Table 8: Robustness Check of Regression Estimates

	case 1	case 2
$\ln rlp_{it} I(rw_t \leq \gamma_1)$	$-0.3351^{***}(0.0377)$	$-0.3240^{***}(0.0411)$
$\ln rlp_{it} I(\gamma_1 < rw_t)$	$-0.1687^{***}(0.0287)$	$-0.0286(0.0349)$

1. $*$, $***$ indicate 10% and 1% significance, respectively.
2. Values in parenthesis are standard error.

Table 9: Robustness Check of Tests for Threshold Effects

	F value	
	case 1	case 2
Test for Single Threshold	$41.81^{***}(0.0100)$	$51.64^{***}(0.0000)$
	$[24.08, 29.80, 41.46]$	$[26.25, 28.98, 40.81]$
Test for Double Threshold	21.32(0.3333)	10.14(0.5667)
	$[36.56, 43.54, 59.19]$	$[21.25, 24.67, 30.10]$
Test for Triple Threshold	15.21(0.2367)	6.09(0.9033)
	$[19.06, 22.99, 29.63]$	$[23.92, 26.32, 33.69]$
Threshold estimates	1.1195	1.3898
95% confidence interal	$[1.0958, 1.1367]$	$[1.3777, 1.3928]$

1. Here, the ratio of tradable wage to nontradable wage is used as the threshold value.
2. $*$, $***$ indicate 10% and 1% significance, respectively.
3. Values in parenthesis are bootstrap p-values.
4. Values in bracket are the 10%、5% and 1% critical values, respectively.

Table 10: Robustness Check of Regression Estimates

	case 1	case 2
$\ln rlp_{it}\mathrm{I}(rw_t \leq \gamma_1)$	$-0.1993^{***}(0.0372)$	$-0.3220^{***}(0.0414)$
$\ln rlp_{it}\mathrm{I}(\gamma_1 < rw_t)$	$-0.0701^{*}(0.0422)$	$-0.0344(0.0419)$
$\ln rlp_{it}^{US}$	$-0.4279^{***}(0.0430)$	$-0.4160^{***}(0.0420)$
$rgcratio_{it}^{JAP}$	$0.0473^{***}(0.0060)$	$0.0608^{***}(0.0054)$

1. $*$, $***$ indicate 10% and 1% significance, respectively.
2. Values in parenthesis are standard error.

Table 11: Robustness Check of Tests for Threshold Effects

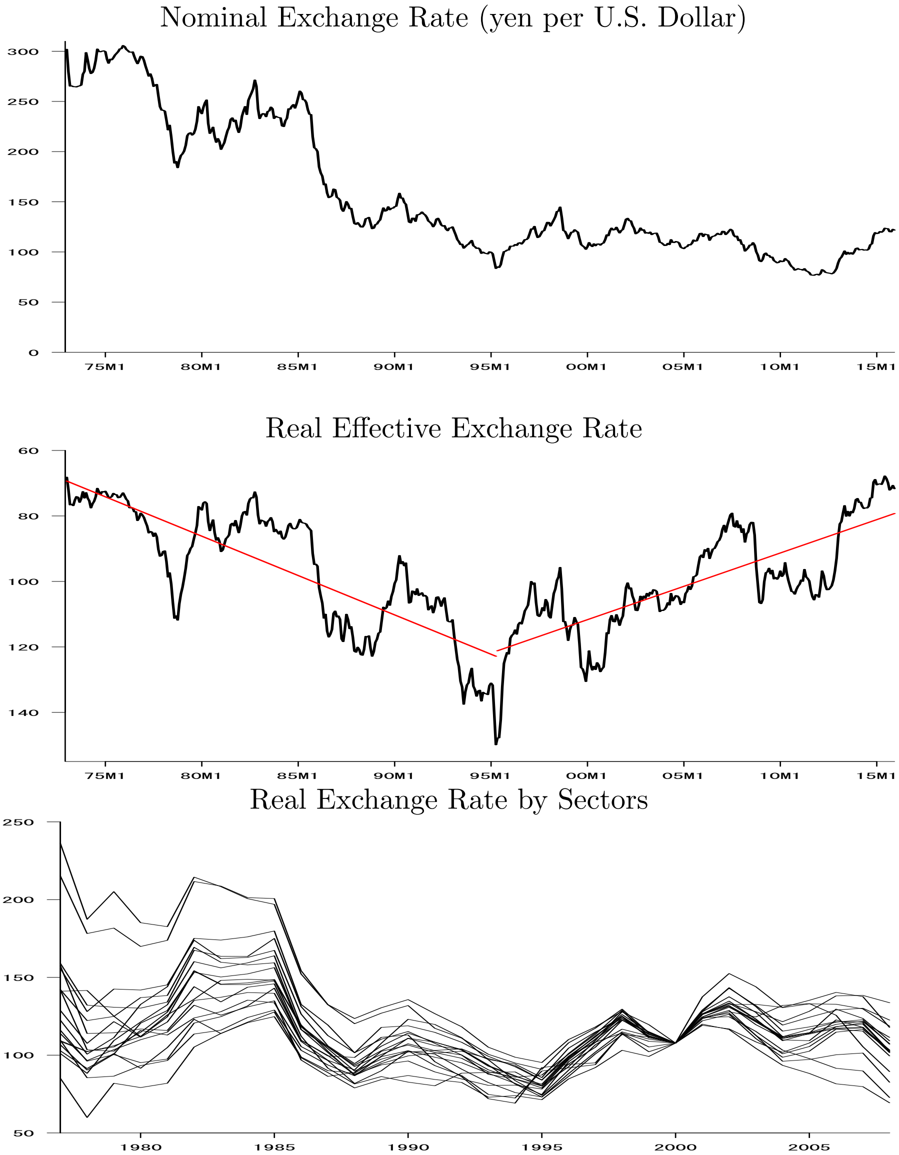
	F value	
	case 1	case 2
Test for Single Threshold	59.15(0.2500)	16.06(0.4833)
	[76.50, 100.74, 124.67]	[30.70, 33.58, 40.05]
Test for Double Threshold	47.52(0.4700)	11.19(0.6767)
	[115.81, 135.66, 167.37]	[25.33, 30.51, 36.33]
Test for Triple Threshold	11.95(0.9400)	7.43(0.8800)
	[73.40, 84.72, 116.46]	[33.38, 41.84, 62.40]

1. Here, the ratio of part-time workers is used as the threshold value.
2. $*$, $***$ indicate 10% and 1% significance, respectively.
3. Values in parenthesis are bootstrap p-values.
4. Values in bracket are the 10%、5% and 1% critical values, respectively.

Table 12: Threshold Value and Sectoral Relative Wage Ratio

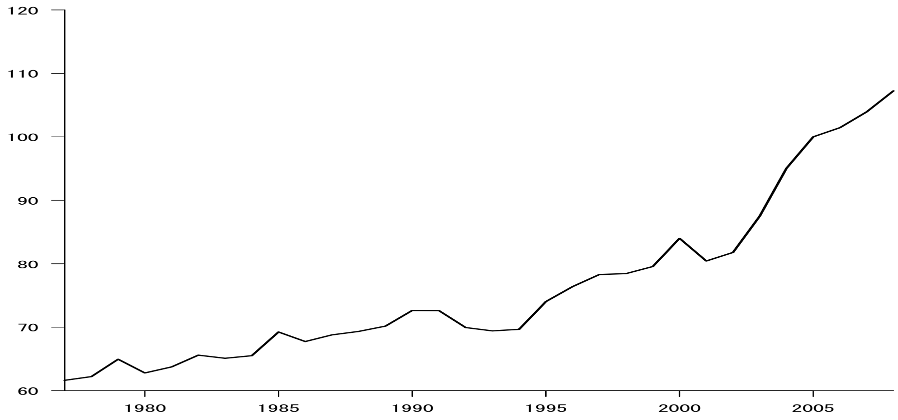
	Japan	US	relationship with threshold value
1	Livestock products	Food and beverage and tobacco products	below
2	Seafood products	Food and beverage and tobacco products	below
3	Beverages	Food and beverage and tobacco products	below
4	Sawing, planing mills and wood	Wood products	below
5	Furniture and fixtures	Furniture and related products	below
6	Pulp, paper, paperboard and coated and glazed paper	Paper products	above
7	Paper products	Paper products	below
8	Printing, plate making for printing, and bookbinding	Printing and related support activities	below
9	Rubber products	Plastics and rubber products	below
10	Final chemical products	Chemical products	above
11	Fabricated constructional and architectural metal products	Fabricated metal products	below
12	Miscellaneous fabricated metal products	Fabricated metal products	below
13	Miscellaneous general machinery	Machinery	above
14	Special industrial machinery	Machinery	across
15	Miscellaneous general machinery	Machinery	across
16	Heavy electrical equipment	Electrical equipment, appliances, and components	across
17	Electrical equipment, electric measuring	Electrical equipment, appliances, and components	across
18	Other electrical equipment	Electrical equipment, appliances, and components	across
19	Motor vehicles	Motor vehicles, bodies and trailers, and parts	above
20	Motor vehicles, parts and accessories	Motor vehicles, bodies and trailers, and parts	across
21	Other transportation equipment	Other transportation equipment	above
22	Precision instruments	Electrical equipment, appliances, and components	across
23	Plastics	Plastics and rubber products	below

Figure 1: Exchange Rate Movements



Source: Bank of Japan

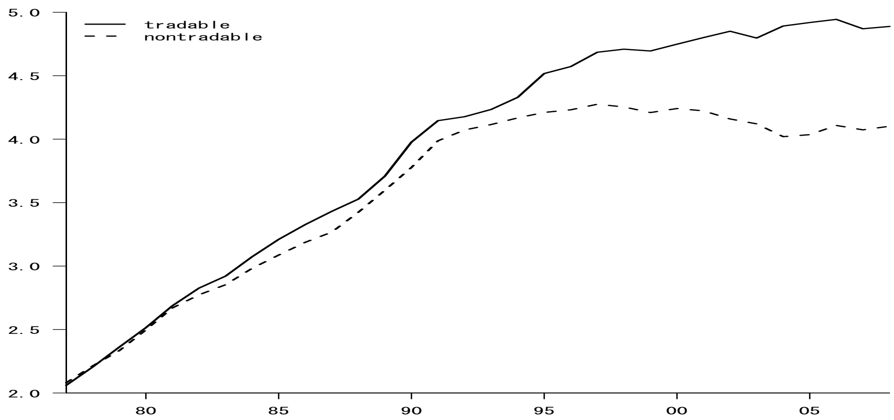
Figure 2: Movement of Relative Tradable/Non Tradable Labor Productivity in Japan



Source: OECD STAN Database for Structural Analysis。

Note: Labor productivity is calculated as Production (gross output), volumes/Number of persons engaged (total employment). We define the relative labor productivity as the ratio of tradable to nontradable labor productivity .

Figure 3: Movement of Nominal Wages

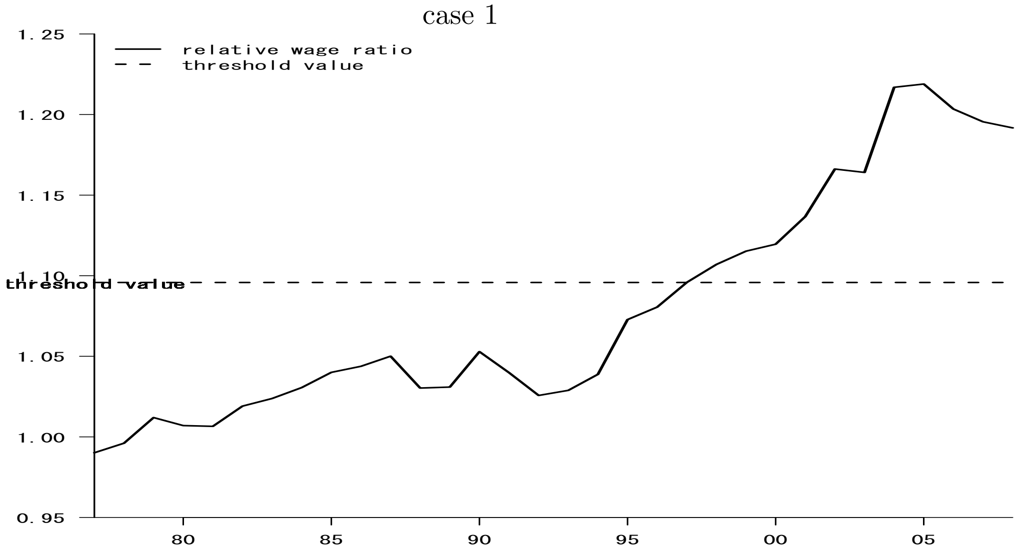


Source: OECD STAN Database for Structural Analysis。

注 : Wage is calculated as Labour costs (compensation of employees)/Number of persons engaged (total employment).

Figure 4: Relative Wage Ratio and Threshold Value

case 1



case 2

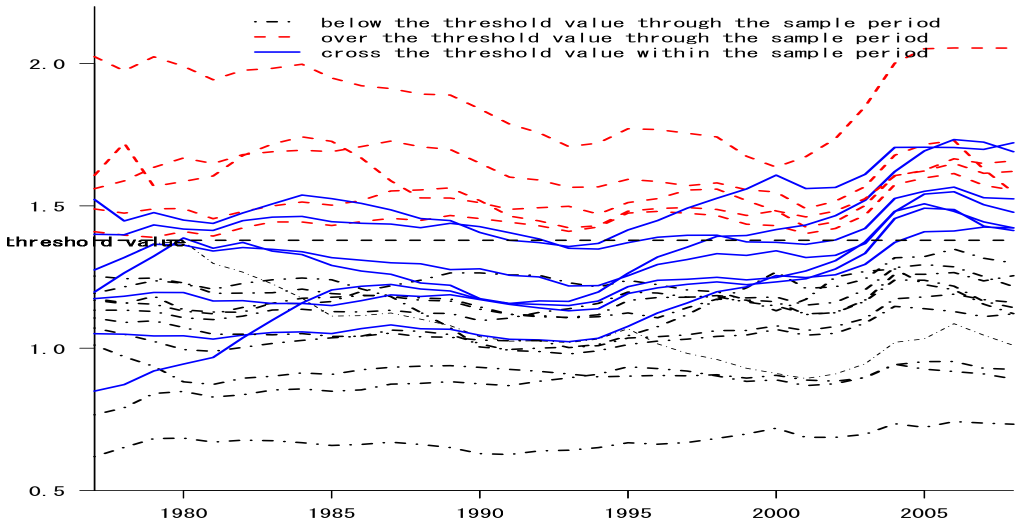
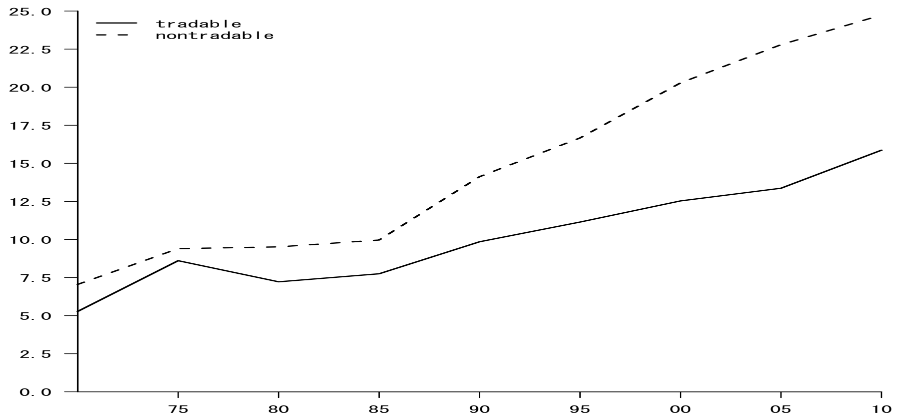
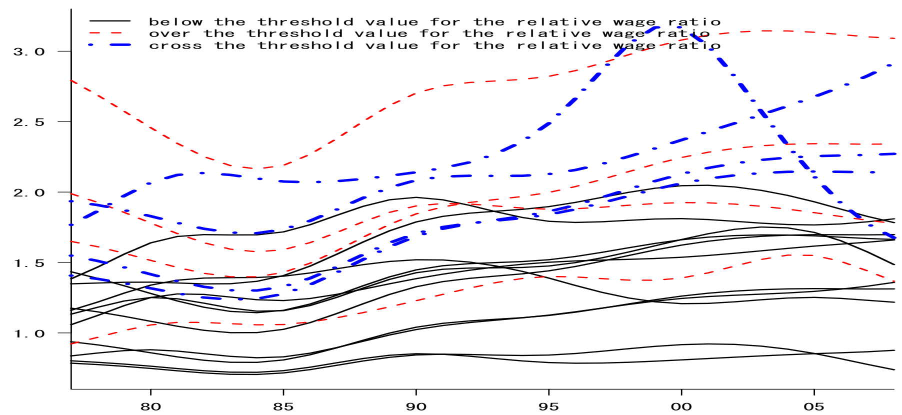


Figure 5: Movement of the Ratio of Part-time and Non-Regular Employees to Total Employees



Source: RIETI JIP Database 2015, Share of part-time workers (part-time workers / total workers, %)

Figure 6: Movement of the Ratio of Part-time and Non-Regular Employees to Total Employees(by sector)



Note: The figure plots the ratio of nontradable to tradable industry.