

On Regional Business Cycles in Japan:

An Analysis by Prefectural Composite Indexes

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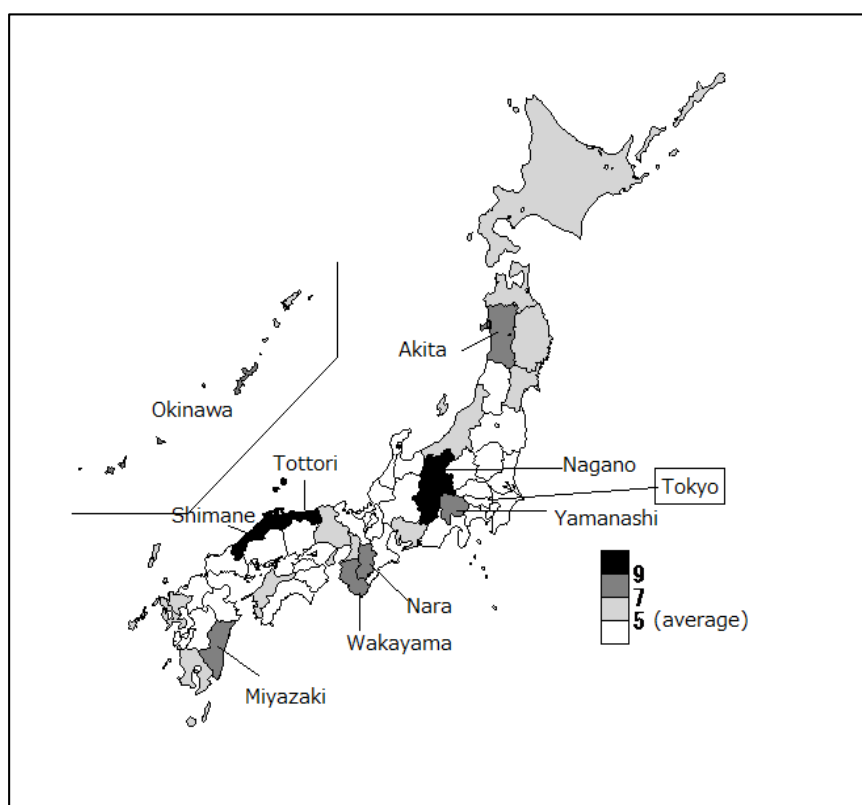
Objective of the paper

- To characterize regional-specific business cycles compared to the national business cycle.
 - To investigate influential factors to affect regional business cycles in the case of Japan.
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Analysis method

- Constructing monthly Composite Index (CI) for 47 prefectures over the period of 1985-2010, from four economic indicators. (Normalized to be 100 in 2005 for all prefectures and nationwide.)
 - Characterizing disparity of regional business cycles from national business cycle, by matching each prefectural CI sequence to the nationwide CI sequence. (Analysis-A)
 - Investigating factors that exert influences on regional economies to explain deviation of prefectural CIs from the national CI. (Analysis-B)
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Distribution of disparity measured by the standard deviation of $[PCI(t)-JCI(t)]$ (N=47)



PCI(t): Prefectural CI
JCI(t): Nationwide CI

Range: [1.9, 12.7]
Average: 5.2
Median of 4.8

Indicated prefectures are those with large disparity from the nationwide CI.

Figure 1. Geographical distribution of regional disparity

Analysis – A: Matching analysis

A-1. Matching method

Matching CI sequences of each prefecture: PCI(t) and Japan: JCI(t) . N=301 (1985-2010).

(1) Adjusting leads and lags in the timing of business cycle, by Dynamic Programming Matching (DPM).

(2) Linear transformation to adjust:

- CI levels and magnitude of variations
- Time trend
- Structural change between 1985-2001 and 2002-2010 (long expansion phase in 2002-2008)

$$\min \sum_{t=1}^T [\varepsilon(t)]^2$$

$$\text{s.t. } \begin{aligned} \text{CCI}(t) &= \beta_0 + \beta_1 \cdot \text{PCI}(t) + \beta_2 \cdot t + \varepsilon(t) && \text{for 1985-2001} \\ \text{CCI}(t) &= \beta_3 + \beta_4 \cdot \text{PCI}(t) + \beta_5 \cdot t + \varepsilon(t) && \text{for 2002-2010} \end{aligned}$$

where a sequence of CCI(t), {CCI(1), CCI(2), ...}, represents a rearranged national CI of JCI(t) after adjusting leads and lags of business cycle by DPM.

A-2. Result of matching

(1) Performance of introducing DPM and structural change

Table 1. Minimum and average R² for 47 prefectures

	Without structural change		With structural change	
	Minimum R ²	Average R ²	Minimum R ²	Average R ²
Without DPM	0.330	0.784	0.706	0.885
With DPM	0.524	0.902	0.827	0.961

Improved R²: Average: +0.076~0.118 (by DPM), +0.059~0.101 (by structural change)

Minimum: +0.121~0.194 (by DPM), +0.303~0.476 (by structural change)

(2) Time trend

Table 2. Summary of time trend estimate

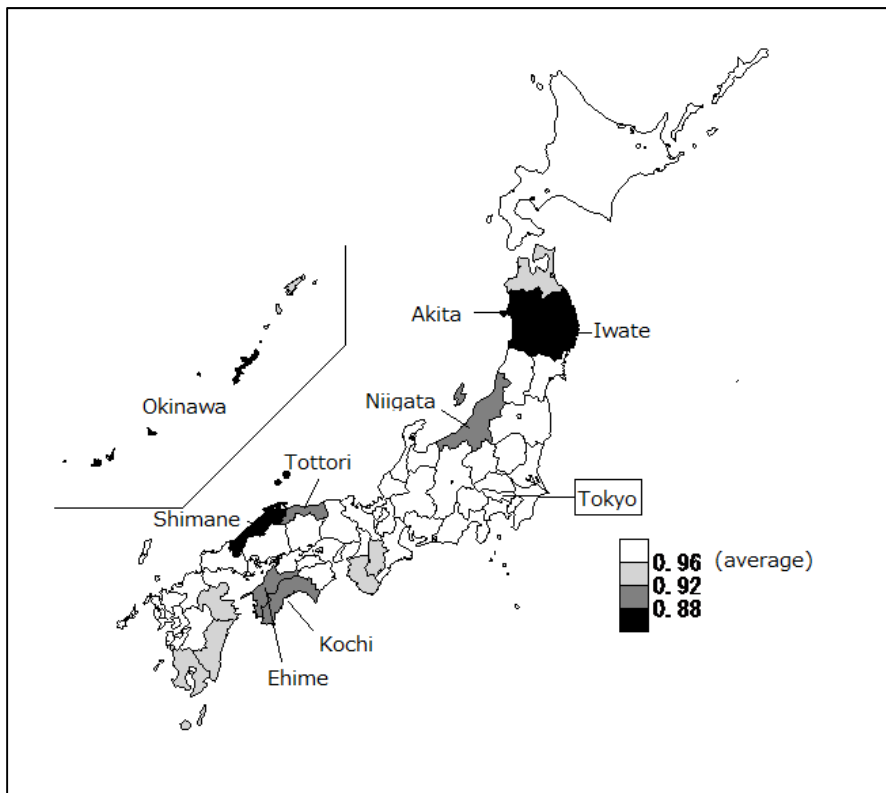
	Average	Median	Minimum	Maximum	No. of prefecture	
					Negative	Positive
up to Dec 2001	0.000	0.012	-0.160	0.080	19	28
Jan 2002 and after	0.050	0.037	-0.046	0.194	9	38

* Positive (Negative): Prefectural CI declines (rises) against national CI.

Before the structural change (-1990s): 19 prefectures show better performance than an average.

After the structural change (2000s): Only 9 prefectures show better performance than an average.

Figure 3. R^2 for matching with DPM and structural change



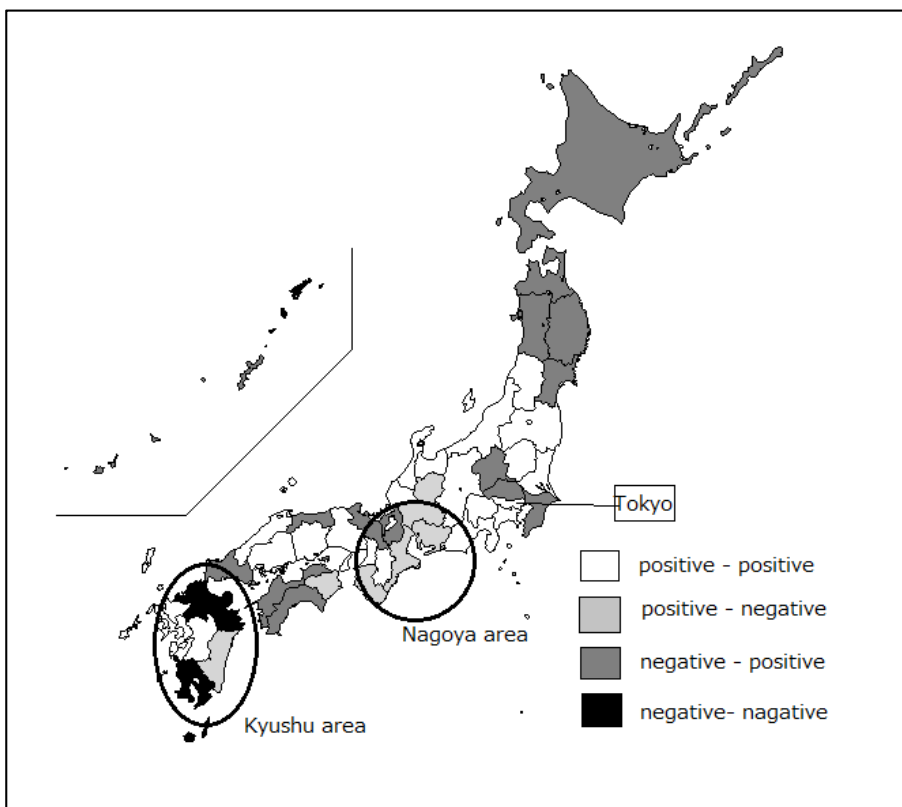
- R^2 with both DPM and the structural change applied

- 14 prefectures: below the average of 0.96

From the lowest:

1. Okinawa (0.827)
2. Iwate (0.840)
3. Shimane (0.865)
4. Akita (0.868)
5. Kochi (0.888)
6. Tottori (0.911)
6. Niigata (0.911)
8. Ehime (0.912)

Figure 5. Time Trend before and after Structural Change



Only 9 prefectures show better performance than national average after the structural change:

Nagoya are:

Gifu, Aichi, Mie
Wakayama
Tokushima

Kyushu area:

Fukuoka, Oita,
Miyazaki,
Kagoshima

Analysis – B: Factors to influence deviation of regional economies

B-1. Analysis Method

Panel data analysis (fixed-effects model, dynamic panel model with the Arellano-Bond estimators)

i for 47 prefectures, t for fiscal years of 1990-2008

$$PCI(i, t) - JCI(t) = \beta_0(i) + \beta_1 Pub(i, t) + \beta_2 Loan(i, t) + \beta_3 Export(i, t) + \varepsilon(i, t)$$

or $PCI(i, t) - CCI(i, t) = \beta_0(i) + \beta_1 Pub(i, t) + \beta_2 Loan(i, t) + \beta_3 Export(i, t) + \varepsilon(i, t)$

where $Pub(i, t)$: Ratio of public investment amount to gross prefecture product

$Loan(i, t)$: Growth rate of outstanding lending of financial institutions

$Export(i, t)$: Export demand to the machinery industry

Figure 6. Transition of three factors at the national level

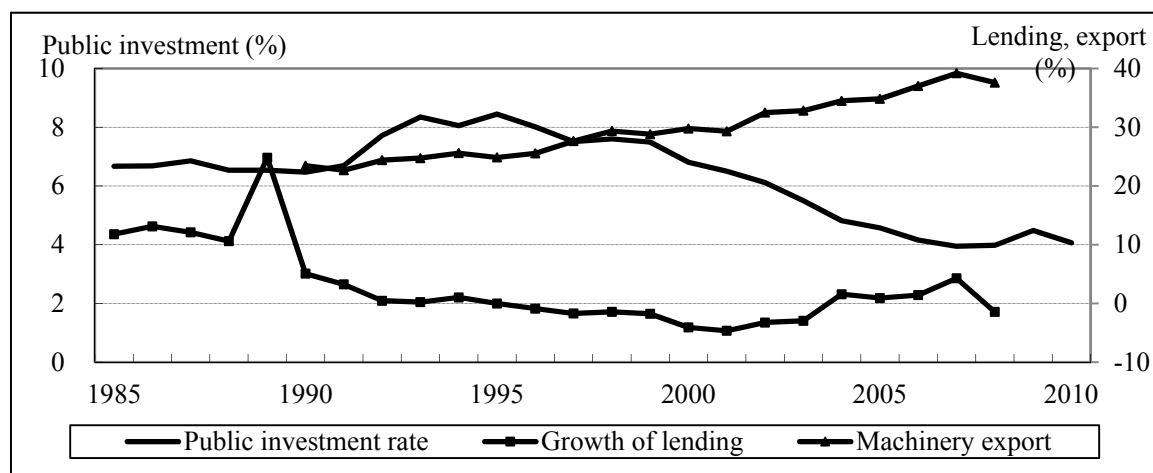
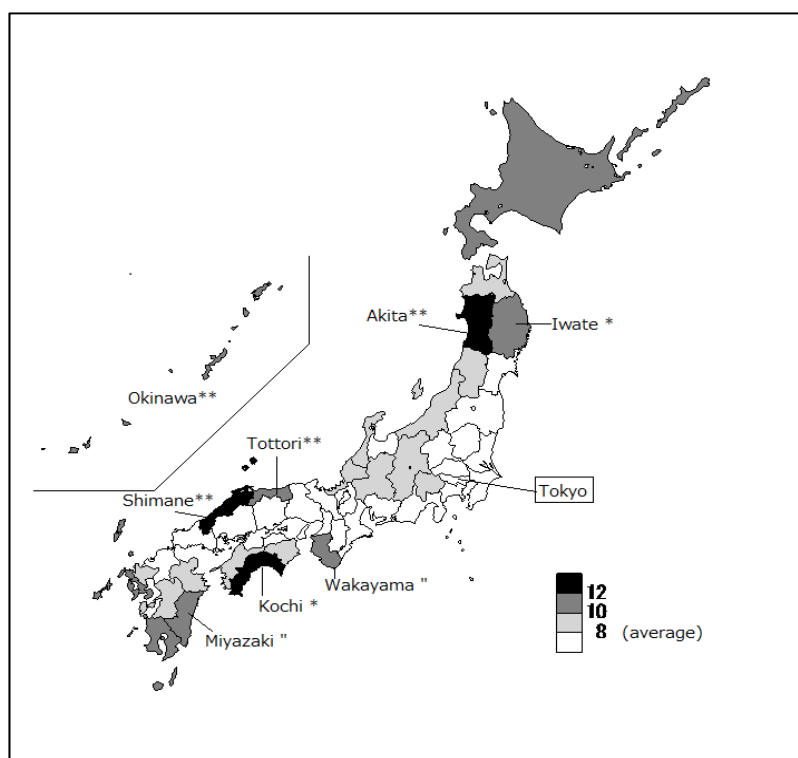


Figure 7. Prefectures with high public investment ratio



Average public investment ratio during the sample period

Range [3.0%, 14.9%]

Average: 8.2%

From the highest:

1. Shimane (14.9%)
2. Kochi (13.1%)
3. Akita (12.6%)
4. Okinawa (11.8%)
5. Kagoshima (11.8%)
6. Hokkaido (11.3%)
7. Iwate (10.8%)
8. Tottori (10.8%)

“: large CI disparity

*: low R2 of matching

** : both

Public investment rate:

- Reduced by half from 8% in the early 1990s to 4% in the late 2000s.
- Large disparity among prefectures from 3% in Tokyo to 15% in Shimane.

Growth of money lending

- Declined over the period of 1990s, negative in the late 1990s and in the early 2000s.
- Recovered in the long expansion phase in 2002-8.

Export demand to the machinery industry

- Approximately 25% in the early 1990s, and increased to nearly 40% in the late 2000s.
- Production rate of the machinery industry distributes from 0.1% to 20% (Shiga & Aichi).

B-2. Estimation result over the sample period

Table 4: Estimation Result of Panel Data Analysis: 1990-2008

Dependent variable	PCI(t)-JCI(t)					PCI(t)-CCI(t) (after timing adjustment)				
	Fixed-effects			Dynamic panel		Fixed-effects			Dynamic panel	
Lag of dependent				0.872	(0.024) ***				0.883	(0.019) ***
Public investment ratio	1.584	(0.095) ***		0.345	(0.079) ***	1.427	(0.084) ***		0.411	(0.055) ***
Growth rate of loans	0.051	(0.016) ***		0.175	(0.034) ***	0.074	(0.014) ***		0.121	(0.024) ***
Machinery export	0.779	(0.297) ***		0.827	(0.248) ***	0.766	(0.265) ***		0.967	(0.171) ***
Constant	-11.724	(1.412) ***		-5.008	(1.132) ***	-10.671	(1.258) ***		-6.052	(0.780) ***
R-squared	0.327					0.343				

Notes: Sample includes 47 prefectures by fiscal year of 1990-2008. Standard errors are in parentheses, and ***, **, and * indicate 1%, 5%, and 10% significant levels respectively.

- All of public investment ratio, growth rate of lending, and machinery export contribute to push up prefectural CI.

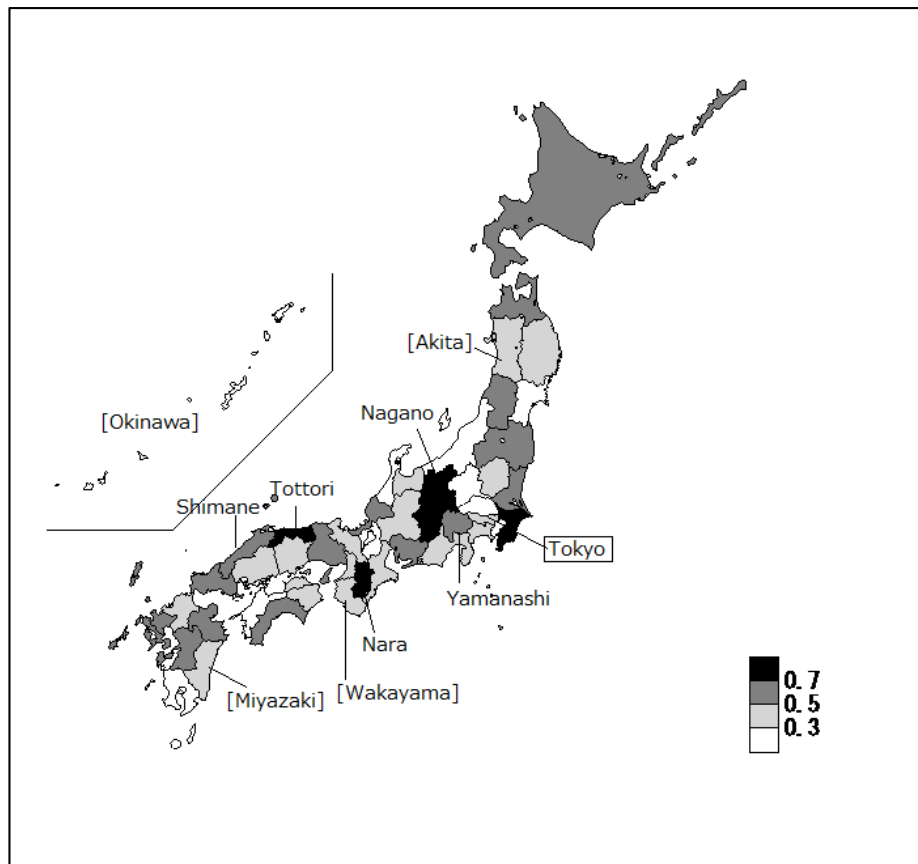
Table 5: Estimation Result of Panel Data Analysis: 1990-2001, and 2001-2008

Dependent: PCI(t)-CCI(t) (after timing-adjustment)												
	Fixed-effects			Fixed-effects			Dynamic panel			Dynamic panel		
Year	1990-2001			2002-2008			1990-2001			2002-2008		
Lag of dependent							0.832	(0.046)	***	0.584	(0.028)	***
Public investment ratio	0.310	(0.122)	**	1.118	(0.119)	***	0.218	(0.100)	**	0.546	(0.086)	***
Growth rate of loans	0.031	(0.011)	***	0.016	(0.055)		0.205	(0.036)	***	-0.041	(0.035)	
Machinery export	0.198	(0.479)		1.047	(0.272)	***	1.525	(0.465)	***	1.151	(0.172)	***
Constant	1.554	(1.785)		-10.016	(1.370)	***	-5.379	(1.571)	***	-7.371	(0.941)	***
R-squared	0.022			0.250								

Notes: Sample includes 47 prefectures by fiscal year. Standard errors are in parentheses, and ***, **, and * indicate 1%, 5%, and 10% significant levels respectively.

- Public investment: positive & significant, more influential in the 2000s than in the 1990s.
- Growth of lending: Positive & significant only in the 1990s.
- Machinery export: Positive & significant only in the 2000s.

Figure 9: R^2 of fixed-effects model with structural change by prefecture



Note: Prefectures with large disparity in Figure 1 are indicated. Those in brackets are explained less by panel data analysis.

Summary

1. Matching analysis

- Performance of the matching analysis looks fairly well: $R^2 > 0.82$, average $R^2 = 0.96$
- Deviations of regional business cycle are well explained by leads and lags of the timing, time trend, and the structural change.
- Only 9 prefectures show better performance in time trend than national average in the 2000s

2. Influential factors

- Public investment rate, growth rates of money lending, and export demand contribute to regional economies.
- Across the structural change, public investment becomes more influential, and export demand replaces to money conditions of influential.

3. “Deviated” prefectures

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|--|--|
| Explained well by both Analysis-A & B: | Nagano, Yamanashi and Nara |
| Explained well by Analysis-A, but not B: | Wakayama and Miyazaki |
| Explained well by Analysis-B, but not A: | Tottori and Shimane |
| Not explained well: | Akita and Okinawa; Iwate, Niigata, and Ehime |