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## Regional Business Cycles in Japan

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REAL 08-T-1      January 2008

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**Abstract:** In previous studies of regional business cycles in Japan, there were the critical differences of the amplitudes and the turning points among each business cycle by region. However, there is a problem in the previous studies; they relied on one series, typically an index of industrial production in manufacturing sectors, and neglected the performance of the other sectors in the region. Burns and Mitchell (1946) noted that business cycles consist of a pattern of recurrent, serially correlated and cross-correlated movements in many economic activities. Therefore it is necessary to include information on sectors other than manufacturing in order to provide a more complete measure the business conditions of a region. Specifically, we extract each regional business index from four business indicators using the principal components method, and applied the regime-switching model to identify the turning points in regional business cycles. Our result shows that the sector that relatively generates the greatest influence on the business cycles is different by region. Chubu, Hokuriku, Chugoku and Kyushu are more influenced by production activity and consumption change; Tohoku, Kanto and Shikoku are by production activity and employment situation. Kansai and Hokkaido are influenced by all factors of production activity, consumption change and employment situation. Furthermore, different regions have different features also from the viewpoint of the turning points of business cycles. The average duration of a business cycle in Kanto and Kansai is similar to that of the national cycle while those in Hokkaido, Chubu, Hokuriku, Chugoku and Shikoku are shorter. The share of the expansion phase in Tohoku and Kyushu are higher than that of the nation-wide business cycle.

## 1. Introduction

Recently, the concern with regional business conditions has been growing in Japan. This is because the regional disparities in business conditions seem to be slightly larger than in the past. For example, Cabinet Office (2004) demonstrated this finding by investigating some regional economic indicators such as an index of industrial production (IIP) and the unemployment rate. Figure 1 has been drawn in order to check the latest condition of disparity in each regional economy by IIP and effective job offer rate by regions. The vertical line of the both figures indicates the difference in effective job offer rate and the horizontal line indicates the growth rate in IIP during the expansion phase in the 13th and 14th cycles. We can see from the figures that the variance of the regional business conditions has continued to increase recently. Given these findings, the practical necessity of the measurement of the regional economic activities systematically has been raised in order to correctly grasp and interpret such diversity.

<<Insert Figure 1: Industrial Production and Effective Job Offered Rate>>

On the other hand, several studies in Japan have been also made in recent years from the viewpoint of business cycle analysis. It has been shown from the previous studies that differences have existed in the business cycles among regions. Okumura and Tanizaki (2004) estimated the business cycle turning points in each region by applying the quarterly regional IIP data from 1973 III to 2000 IV to the regime-switching model suggested by Hamilton (1989). The results revealed that, in the 1980s, the contraction was not observed in Hokkaido, Kanto, Shikoku and Chugoku areas, though two contractions have been observed in the national business cycles. In the 1990s, the contraction was not observed in Hokkaido, Chugoku and Shikoku areas, though the nation experienced two contractions, paralleling the experience of the 1980s. Wall (2006) has also estimated the regional business cycle turning points in Japan by applying quarterly regional IIP data from 1976 IV to 2005 II to the regime-switching model suggested by Hamilton (1989). However, he has considered the possibility of a structural break in the data generating process (DGP) in the business cycles in the early 1990s, assuming that the average growth rate of IIP before 1992 and after 1993 has changed. As for the result, the contraction in the nation-wide business cycle from 1991 to 1993 was never observed still in Hokkaido and Shikoku areas, though he has concluded that the business cycle turning points in almost all other areas have corresponded to the nation-wide business cycle turning points. On the other hand, Hayashida (2005) has extracted the nation-wide and Hokkaido area's business index from the monthly multiple economic variables using the principal components method. The business cycle turning points have been identified by applying each business index to the Bry and Boschan (1971) method. The results revealed that the timing of the turning points are different and the amplitudes of the business cycles in the Hokkaido area are generally smaller than the nation-wide business cycles. Moreover, the regularity that the change of regional business cycles follows that of the nation-wide business cycles under the conventional idea is not observed in this analysis of the Hokkaido area.

However, the analyses in Okumura and Tanizaki (2004) and Wall (2006) are not completely satisfactory for two reasons from the viewpoint of the business cycle analysis. The first is that their business indices rely on only a single economic measure, typically an index of industrial production in the manufacturing sectors, and neglect the performance of the other sectors in the region. Burns and Mitchell (1946) suggested that business cycles consist of the pattern of recurrent, serially correlated and cross-correlated movements in many economic activities. According to their definition, it remains possible that, if we estimate the aggregate change of business cycles using only a single indicator such as IIP, we could lead to an erroneous conclusion in the business cycle analysis, even though IIP is one of the most useful indicators for judging a business condition. The second is that the quarterly data was used in the previous studies. Monthly and rapidly released indicators are easier to handle for the purpose of the business cycle analysis.

Hence, the purpose of this study is to measure the monthly regional business indices using economic multivariate time series following Burns and Mitchell's definition, and to identify the turning points in the regional business cycles in Japan. Specifically, we developed the business

indices using a principal components method, and applied the regime-switching model to identify the turning points in the regional business cycles.

Another purpose of this paper is to interpret the disparity in regional business cycles economically. The analysis of Hitomi *et al.* (2000) could be helpful in this interpretation. They have studied the factors generating economic change in nine Japanese regions using a multi-regional input-output model with endogenous imports. They have decomposed contributions to the growth of the regional output into five factors: final demand excluding exports (DomFD), technical coefficients (A), inter-regional trade coefficients (T), foreign exports (E) and domestic purchasing coefficients (D). According to their analysis, the contribution of domestic purchasing coefficients, reflecting the effects of increased foreign imports penetration, has shown a drastic decrease in 1985-1990, while the contribution of final demand excluding exports has been the most influential factor and has shown a positive impact. However they point out that the differences of those two factors among regions are so small that those factors are not major contributors to generate the dispersion of regional outputs. On the other hand, they note that the contribution of technical coefficients yields a positive impact in Kanto and Kansai, but a negative impact in other regions in 1985-1990. Their analysis has implied that the positive contribution in Kanto and Kansai reflects the concentration of the service sector related to research and information processing and the negative contribution in the other regions reflects the decrease of output induced by technological change. For example, in Chugoku, the large number of industries supplying primary metal and input coefficients relating to primary metal fell dramatically in this period. Moreover, they have indicated that the contribution of inter-regional trade can be positive or negative in each region. Furthermore, the contribution of foreign export also can be positive or negative, though they did not mention it explicitly in their paper. This discussion reveals that three factors, technical coefficients, inter-regional trade and international exports, can play an important role in generating differences in each regional output.

We summarize their analysis in table 1 which shows whether the contribution of the three factors on regional output is positive or negative in 1985-1990. According to this table, the regions which experienced a negative contribution of technical coefficients to regional output are Hokkaido, Tohoku, Chubu, Chugoku, Kyushu and Shikoku. In this group, the direct effect of the demand generated within the region on output in the region is decreasing. That group is categorized more into four sub-groups. The first sub-group is Hokkaido, Tohoku and Chubu where the contribution of both international exports and inter-regional trade is positive. The second sub-group is Chugoku where the contribution of international exports is negative but the contribution of inter-regional trade is positive. The third sub-group is Kyushu where the contribution of international exports is positive but the contribution of inter-regional trade is negative. The last sub-group is Shikoku where the contribution of both international exports and inter-regional trade is negative. On the other hand, in Kanto and Kansai, the contribution of technical coefficients is positive. In Kanto, the contribution of international exports is positive but the contribution of inter-regional trade is negative; in Kansai, it is the other way around.

<<insert Table 1: Factor contribution to aggregate regional output growth (1985-1990)>>

The following two hypotheses can be generated from the above typology. The first is that the business cycles in Kanto and Kansai, where the direct effect of the intra-regional demand to the output is positive (that means the positive contribution of technical coefficients), could change independently, if the regional business cycles are predominantly influenced by the regional output. Moreover, the business cycles of both regions could dominate the nation-wide business cycles, because about 66% of growth of the output in Japan could be accounted for by the change in factors occurring in Kanto and Kansai. The second is that the business cycles in Hokkaido, Tohoku and Chubu, where the contribution of international exports and inter-regional trades is positive and the contribution of technical coefficients is negative, could be influenced by the change of the economies in foreign countries and the economies in the other regions. Further, the business cycles in Chugoku, where the contribution of inter-regional trade is positive, could depend on the change of the economies in the other regions. The business cycles in Kyushu, where the contribution of international exports is positive, could depend on the change of the economies in foreign countries. These hypotheses will be measured against the typology extracted from analysis of the turning points of the regional business cycles.

## 2. Data

Before developing the analysis, we should briefly explain the selection of business indicators and the data we used in this paper where the notion of a business indicator refers to data that are used in analyzing the business cycles and constructing the business index in this paper.

### 2.1. Criterion of Indicator Selection

It is important and difficult work to select business indicators from a large array of economic variables in order to construct the business index. Several studies have been made on the selection of business indicators.<sup>1</sup> It has been recognized from the results that business cycle indicators have to be selected from a wide cross-classification of all individual indicators by types of economic process and characteristics of timing in business cycle turning points. The National Bureau of Economic Research (NBER) provided a cross-classification which is divided into 7 and 3 classes that could be used to analyze the business indicators as shown below.

- Types of economic process
  1. Employment & unemployment
  2. Production & income
  3. Consumption, trade, orders & deliveries
  4. Fixed capital investment

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<sup>1</sup> More information can be found in Zarnowitz (1992).

5. Inventories & inventory investment
6. Price, costs & profits
7. Money & credit
- Characteristics of timing in recessions and recoveries
  1. Leading indicators
  2. Roughly coincident indicators
  3. Lagging indicators

In the case of Japan, the Economic and Social Research Institute (ESRI) of the Cabinet Office has selected the business indicators among many economic variables to construct the nation-wide business index according to same criteria as those proposed by the NBER. Table 2 shows the individual indicators of the coincident business index. ESRI has selected eleven series as the roughly coincident indicators to construct the coincident business index.<sup>2</sup> Two series have been selected from the economic process of “Employment & unemployment,” four series from “Production & income,” two series from “Consumption, trade, orders & deliveries,” one series from “Fixed capital investment” and two series from “Price, costs & profits” as the roughly coincident indicators. The number of the coincident business indices adopted in the business coincident index is more than that of the coincident business indices adopted in the U.S. business coincident index calculated by the Conference Board.<sup>3</sup>

<<insert Table 2: Eleven coincident economic indicators by the ESRI>>

## 2.2. Regional Division by Statistical Data Source

In this section, we describe the regional division of Japan that will be used in the analysis. The regions of Japan are not official units, but have been used as the regional divisions in many contexts. From the viewpoint of the statistical data, there are some definitions of the regional division by the sources of the statistics as shown in table 3.

<<Insert Table 3: Definitions of regional divisions in Japan by sources>>

The main differences may be summarized as follows. The division by electric power supply area (EPSA) and by Ministry of Internal Affairs and Communications (MIC) is divided into ten areas, whereas the division by Ministry of Economy, Trade and Industry (METI) and Bank of Japan (BOJ) is divided into nine areas. Most of these differences among the divisions center on how to divide Kanto, Chubu and Hokuriku areas and whether the Kyushu area includes Okinawa prefecture or not. Let us take the case of Kanto area; Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo and Kanagawa prefectures are common elements of Kanto area. However, the handling of Niigata and Yamanashi prefectures is different by the sources of the statistics. Niigata

<sup>2</sup> ESRI executes the review of business indicators regularly. For more information, see <http://www.esri.cao.go.jp/en/stat/di/041207components.html>.

<sup>3</sup> See <http://www.conference-board.org/>

prefecture is a part of Tohoku area in the division by EPSA, whereas it is a part of Kanto area in the division by METI and a part of Hokuriku area in the division by MIC and BOJ. On the other hand, Yamanashi prefecture is included in the Kanto area in the division by EPSA, METI and MIC, though it is placed in the Chubu area in the division by BOJ. For the Chubu and Hokuriku areas, Toyama, Ishikawa, Nagano and Shizuoka prefectures are located in different regions by the source of the statistics, though Gifu, Aichi and Mie prefectures are common elements of Chubu area. Toyama and Ishikawa prefectures are a part of Chubu area in the division by METI. Nagano belongs to Kanto area in the division by METI and MIC, though it belongs to Chubu area in the division by EPSA and BOJ. Shizuoka is contained in Chubu area in the division by EPSA, MIC and BOJ, though it is contained in Kanto area in the division by METI.

In this paper, we adopt the division by EPSA (see figure 2), because we make use of the data of the electric power consumption as one of the most important business indicators. The data has some favorable features since it is a business indicator not seen in other monthly economic variables. First, the coverage is quite wide encompassing home, commercial and industrial uses. Secondly, the data of the electric power consumption is released relatively earlier than other monthly economic variables. The data for the previous month is released around the 20th of every month. This timing of the release is earlier than other business indicators. In addition, it can be pointed out that the data is more accurate than other monthly business indicators in the sense that it is not a sample survey but a complete survey.

<<insert Figure 2: Japanese regions by power supply areas>>

When the analysis is carried out using the division by EPSA, we have to re-aggregate the data except for the data of electric power consumption into the division by EPSA. In the case of the qualitative data, we are able to create the region based on the division used by EPSA by aggregating from prefecture-basis data. On the other hand, in the case of the index data such as Index of industrial production or the ratio data such as Effective job offered rate, we have made the following simple calculations. The ratio data is calculated by dividing the numerator and the denominator summed up according to the division of EPSA. The aggregation method of index data in the case of Chubu area is shown as follows:

$$\begin{aligned}
 IPCB^* = & \frac{WPCB}{WPCB^*} \times IPCB - \frac{WIPT}{WPCB^*} \times IPT - \frac{WPI}{WPCB^*} \times IPI \\
 & + \frac{WPN}{WPCB^*} \times IPN + \frac{WPS}{WPCB^*} \times IPS,
 \end{aligned} \tag{1}$$

where  $IPCB^*$  is the index of industrial production in Chubu area (EPSA),  $IPCB$  is the index of industrial production in Chubu area (METI),  $IPT$  is the index of industrial production in Toyama prefecture,  $IPI$  is the index of industrial production in Ishikawa prefecture,  $IPN$  is the index of industrial production in Nagano prefecture,  $IPS$  is the index of industrial production in Shizuoka prefecture,  $WPCB$  is the value added in Chubu area (METI),  $WPCB^*$

is the value added in Chubu area (EPSA), *WIPT* is the value added in Toyama prefecture, *WIPI* is the value added in Ishikawa prefecture, *WIPN* is the value added in Nagano prefecture and *WIPS* is the value added in Shizuoka prefecture.

### *2.3. Selection of Regional Business Indicators*

In this section, discussion will center on the selection of the regional business indicators to construct each regional business index. In this paper, the same indicators as the nation-wide coincident business indicators of ESRI have been adopted in selecting the regional coincident business indicators. This is because the nation-wide business indicators of ESRI have been already well checked for their correspondence with the business cycles in Japan. Adopting this strategy will make it easier to compare the business indices between the areas and the nation. In addition, we have chosen to adopt the same indicators in all areas. It is reasonable to construct the regional business indices using the same business indicators when comparing them among areas, though we could change the regional business indicators adopted by areas based on the idiosyncrasy of each regional structure of economy and industry.

Table 4 shows the connection between the nation-wide coincident business indicators by ESRI and the regional data by EPSA. We can see from the table that there are a few regional business indicators consistent with the nation-wide business indicators.

<<insert Table 4: Selection of regional business indicators>>

The variables Effective Job Offer Rate (C5), Index of Industrial Production (C1) and Large-scale Industrial Power Consumption (C3) are available as a series consistent with the nation-wide coincident business indicators. On the other hand, the Index of producer's shipment (producer's goods for mining and manufacturing) (C2), Index of manufacturing capacity utilization ratio (C4), Wholesale sales value (C8), Index of producer's shipments (investment goods excluding transport equipment) (C6), Operating profits (C9) and Index of sales in small and medium sized enterprise (C10) are not available in the EPSA division. C2 has been replaced by an Index of producer's shipment (mining and manufacturing). Retail sales value (C7) is not available at the regional level. However, Large-scale Retail Sales are available but these are different in coverage from the Retail sales value. An index of Non-scheduled work hours (C5) is not suitable for monthly business cycle analysis; though it is available in the EPSA division the 6 month lag in its release makes it difficult to use. As a result, four indicators, Index of industrial production (NC1), Large industrial power consumption (NC2), Large-scale retail sales (NC3) and Effective job offer rate (NC4), have been used in order to develop the regional business indices used in this paper.

## **3. Econometric Methodology**

In this section, the methodology to construct each regional business index and to estimate the business cycle turning points is briefly explained.



### 3.1. Index construction methods

Ever since Burns and Mitchell (1947), there has been consensus about a definition of the business cycle, that is, the co-movement of many macroeconomic variables. According to this definition, Stock and Watson (1988) extracted an unobserved single common factor as the U.S. business index from four business indicators of industrial production, personal income less transfer payments, total manufacturing and trade sales using the dynamic factor model. It can be said that the construction method of the business index suggested by Stock and Watson (1988) has evolved from an older type business index, such as the composite index, where the main objective was to try to measure the business cycle using econometric techniques.

The simplest case of the Stock and Watson (1988) model is given by:

$$y_{it} = \lambda_i c_t + e_{it}, \quad (2)$$

$$c_t = \phi c_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim i.i.d.N(0,1), \quad (3)$$

$$e_{it} = \gamma_i e_{i,t-1} + u_{it}, \quad u_{it} \sim i.i.d.N(0,\Sigma), \quad (4)$$

where  $y_{it}$  ( $i=1, \dots, n$ ) is the  $i$ -th observable business indicator at period  $t$  and is transformed to mean deviation in order to reduce the parameter,  $\lambda_i$  are the factor loadings with respect to the  $i$ -th indicators and the factor  $c_t$  which is unobservable. This specification shows that the change of  $y_{it}$  is composed of an unobserved common component  $c_t$  and an idiosyncratic term  $e_{it}$ . Hence,  $c_t$  is regarded as a business index and has an influence on individual business indicators  $y_{it}$  with the weight of  $\lambda_i$ . Equations (3) and (4) represent the stochastic process of  $c_t$  and  $e_{it}$ . In addition, the variance of  $\varepsilon_t$  is set to 1 in order to normalize the common component. The parameter set  $\theta = \{\phi, \lambda_i, \gamma_i, \sigma_i\}$  is estimated by applying maximum likelihood estimation combined with Kalman filter and smoothing, as is the usual practice. Alternatively, Stock and Watson (1998) showed that the model could be estimated by the following two-step procedures.<sup>4</sup> The first step is to estimate the factors and factor loadings using the principal components method in (2). The second step is to estimate the time series model of the factors in (3).

The Chicago Federal Reserve Bank National Activity Index (CNFAI) is the business index practically constructed by applying the principal components method. The CNFAI is extracted as the index of U.S. economic activity from a nation-wide data set containing 85 monthly business indicators.<sup>5</sup> Park *et al.* (2002) have developed a regional economic activity index for

<sup>4</sup> Maximum likelihood estimators combined with Kalman filter algorithm are more efficient than the estimators by principal components method when the model is correctly specified and when the number of the economic indicator  $N$  is small. However the latter method is more convenient in computation when  $N$  is large. It also allows very flexible structure, including cross-sectional and serial correlation in the error term. A recent large  $N$  asymptotic theory developed by Stock and Watson (1998) and Bai (2002) shows that, under mild conditions on moments and memory, the principal components estimator is a consistent of the population mean up to a scaling constant.

<sup>5</sup> You can show more detail at ([http://www.chicagofed.org/economic\\_research\\_and\\_data/cfnai.cfm](http://www.chicagofed.org/economic_research_and_data/cfnai.cfm)).

Chicago metropolitan area. They trace the regional economic movements as a set influenced by the national components, local components and idiosyncratic shocks. The principal components method is applied to extract the local components in their paper. In section 4.1, we will explain the estimation results by applying the principal components method to four regional business indicators in Japan.

### 3.2. Turning points judgment methods

Hamilton's model is well known as the statistical model for determining the business cycle turning points. In this section, we explain the outline of the model because we used it in order to estimate the business cycle turning points by regions using each regional business index estimated by method described in the previous section. Hamilton (1989) applied a state-dependent Markov-switching model to identify business cycle turning points under the assumption that the turning points are treated as a structural event that is inherent in the data-generating process. An important feature of such models is that they can capture a particular form of nonlinear dynamics or asymmetry in the business cycles. Hamilton (1989) allows the mean of the growth in U.S. real GNP to be evolving according to a two-state Markov-switching process, thus allowing the dynamics of contractions to be qualitatively distinct from those of expansions.

We specified the first differences in each regional business index as following an autoregressive process after  $S_t$  was defined as a discrete variable which indicates that  $S_t = 1$  when the period  $t$  is in the expansion phase and  $S_t = 0$  when the period  $t$  is in the contraction phase.

$$S_t = \begin{cases} 1 : \text{Expansion phase} , \\ 0 : \text{Contraction phase} , \end{cases} \quad (5)$$

$$(\Delta c_t - \mu_{S_t}) = \phi_1(\Delta c_{t-1} - \mu_{S_{t-1}}) + \dots + \phi_r(\Delta c_{t-r} - \mu_{S_{t-r}}) + e_t , \quad (6)$$

$$e_t \sim i.i.d.N(0, \sigma^2) , \quad (7)$$

$$\mu_{S_t} = \mu_0(1 - S_t) + \mu_1 S_t , \quad (8)$$

$$\Pr[S_t = 1 | S_{t-1} = 1] = p , \quad \Pr[S_t = 0 | S_{t-1} = 1] = 1 - p , \quad (9)$$

$$\Pr[S_t = 0 | S_{t-1} = 0] = q , \quad \Pr[S_t = 1 | S_{t-1} = 0] = 1 - q ,$$

where  $\Delta c_t$  is the first difference of each regional business index and  $\mu_{S_t}$  which varies depending on  $S_t$  indicates the mean of  $\Delta c_t$ . The evolution of  $S_t$  which is unknown a priori is assumed to follow the first-order Markov-switching process based on the transition probability in (9). The parameters of this model can be estimated by applying maximum likelihood estimation combined with the Hamilton (1989) filter. After that, we can calculate the smoothing probability  $Pr(S_t | y_1, \dots, y_T)$  by applying the smoother suggested by Kim (1994). The turning points of the business cycles are determined according to the smoothing probability. In

Hamilton (1989), the period is regarded as the contraction phase when the probability  $Pr(S_t = 0 | y_1, \dots, y_T)$  exceeds 0.5. In section 4.2, we will explain the estimation results of each regional business cycle turning points in detail.

## 4. Estimation Results

### 4.1. Regional Business Index

In this section, we explain the estimation results of the nation-wide business index as well as the regional business indices by nine power supply areas excluding Okinawa in Japan, using the principal components method. We used four business indicators from Jan. 1986 to Mar. 2006 to construct the business indices and transformed them into seasonally adjusted series using the US Census-X12 ARIMA method. The four business indicators were the index of industrial production (NC1), large industrial power consumption (NC2), large-scale retail sales (NC3) and effective job offer rate (NC4) as explained above.

Figure 3 shows the changes of the nine regional business indices and the nation-wide business index estimated in this paper. In the principal components method, we can obtain four principal components, when using the four indicators. Hence we have selected one principal component among all the principal components by areas based on the following two types of policy. One is the sign condition of factor loadings. For example, we can expect that the factor loading relating the industrial production to the business index might be positive. Another is the form of the variation in the principal components. We should select the principal component showing the cyclical change among them. In this paper, the second principal component is adopted in Tohoku and Kanto area, and the first principal component is adopted in the other areas. We can see from figure 3 that each regional business index has represented the cyclical changes by areas. Moreover, we also found that the amplitude of the cyclical changes in Chugoku is relatively lower and that of the cyclical changes in Tohoku, Kanto while those in Kansai are relatively higher than the other areas. As observed above, the amplitude of business cycles seems to be different by region.

*<<insert Figure 3: Regional business indices by Principal components method>>*

Table 5 shows the factor loadings and the explanatory variances. The value of the factor loadings indicates the influence of a business indicator on the nation-wide and each regional business indices. We can find from the values which indicators have an important role for each business cycle. The percent of explanatory variance shows the ratio of variation of the business index in the total variation of individual business indicators; this can be interpreted as the share of cyclical variation in economic total variations, because we have extracted the cyclical variation as a business index in this paper. The ratio of explanatory variances of the regional business indices are distributed from 42.8 to 67.2 percent in contrast with 65.8 percent in the case of the nation-wide business index. It was found from these results that the cyclical variation plays an important role not only in nation-wide economy but also in each regional

economy.

<<insert Table 5: Estimation results by Principal components method>>

Let us examine the factor loadings in more detail. First, we should examine the nation-wide business index. The factor loadings that are related to NC1, NC2 and NC3 are more than 0.9. On the other hand, the factor loading which is related to NC4 is less than 0.1. We can see from these values that industrial production and consumption have a great influence on the nation-wide business cycles while the employment situation has little influence on them. Next, we will provide a comparison among each regional business index and the nation-wide business index. The values of the factor loadings of either NC1 or NC2 are more than 0.74 in all areas, implying that industrial production generates a considerable influence on not only nation-wide business cycles but also regional business cycles since we consider NC1 and NC2 to be indicators showing the change of industrial production. However, the level of the influence is larger in Chubu, Chugoku and Kyushu and is smaller in Tohoku and Kanto. On the other hand, the factor loading related to NC2 which is the indicator showing the change of consumption are relatively small from 0.13 to 0.35 in Shikoku, Kanto and Tohoku, although they are larger, varying from 0.76 to 0.92, in Chubu, Hokkaido, Chugoku, Hokuriku, Kansai and Kyushu. The influence of the change of consumption on regional business cycles is quite different by region although the change of consumption has a great influence on nation-wide business cycles. In addition, the factor loadings related to NC4, which is the indicator showing employment situation in regional business indices, are larger than in the nation-wide business index with the exception of the value of 0.02 for the Hokuriku. They are distributed from 0.13 of Chugoku area to 0.75 of Tohoku area. Hence, the role of the employment situation is relatively important in regional business cycles compared with the nation-wide business cycles.

To sum up, the characteristics of regional business cycles in Japan from the estimation results can be classified into the following three groups:

### **1) The regions influenced relatively by production and consumption**

In Chubu, Chugoku, Kyushu and Hokuriku, the industrial production and the consumption change have more influence on each regional business index than the employment situation.

### **2) The regions influenced relatively by production and employment**

In Tohoku, Kanto and Shikoku areas, the employment situation as well as industrial production has more influence on each regional business index than the consumption change.

### **3) The regions influenced by all factors in balanced manner**

In Kansai and Hokkaido areas, the industrial production, the consumption change and the

employment situation in a balanced manner have an influence on each regional business index.

#### 4.2. Turning Point Chronologies by Region

In this section, we explain the characteristics of each regional business cycle from the estimation results of the regime-switching model that has already been explained in section 3.2, using the estimated regional business indices derived previously.

##### 4.2.1. Characteristics of regional business cycles

Table 6 shows the estimation results of regime-switching models by region. The first differences of nine regional business indices and a nation-wide business index from July 1989 to March 2006 are used to estimate the parameters of the models.

<<Insert Table 6: Estimation results of regime-switching models>>

The order of the autoregressive (AR) process is selected by the statistical significance of the parameters and the Schwartz Bayes information criterion (SBIC). Accordingly, AR (1) is selected in the nation-wide business index, AR (4) is selected in the Shikoku area business index and AR (2) is selected in other areas business indices. The autoregressive coefficients are shown in the rows of  $\phi_1 \sim \phi_4$  in the table. The entries for  $p$  and  $q$  are the transition probabilities between the expansion phase ( $S_t = 1$ ) and the contraction phase ( $S_t = 0$ ), that is  $p = Pr[S_t = 1 | S_{t-1} = 1]$  and  $q = Pr[S_t = 0 | S_{t-1} = 0]$ . These transition probabilities contain important information on the expected duration of an expansion and a contraction phase. The expected duration of the expansion phase and the contraction phase<sup>6</sup> can be calculated by  $(1-p)^{-1}$  and  $(1-q)^{-1}$ . On the other hand,  $\pi_0$  and  $\pi_1$  indicate the steady state probability of the contraction phase and expansion phase.<sup>7</sup> These values indicate the probability of a contraction and an expansion phase occurring in the long run. The values of  $\mu_0$  and  $\mu_1$

<sup>6</sup> Conditional on being in expansion phase ( $S_t = 1$ ), the expected duration of a contraction is given by

$$\sum_{k=1}^{\infty} kq^{k-1}(1-q) = (1-q)^{-1}. \text{ Similarly, the expected duration of expansion phase is } (1-p)^{-1}.$$

<sup>7</sup> Consider the forecast of the expansion and contraction. The relation between the probability of contraction and expansion at period  $t$  and that of contraction and expansion at period  $t+h$  is given by

$$\begin{bmatrix} Pr(S_{t+h} = 0 | \Psi_t) \\ Pr(S_{t+h} = 1 | \Psi_t) \end{bmatrix} = \begin{bmatrix} q & 1-q \\ 1-p & p \end{bmatrix}^h \begin{bmatrix} Pr(S_t = 0 | \Psi_t) \\ Pr(S_t = 1 | \Psi_t) \end{bmatrix}, \text{ where } \Psi_t \text{ shows the information available up to}$$

period  $t$ .  $Pr(S_{t+h} | \Psi_t)$  converges to  $\pi_j$  as  $h \rightarrow \infty$ . The  $\pi_j$  is the steady state probability. Substituting

$Pr(S_{t+h} = j | \Psi_t) = Pr(S_t = j | \Psi_t) = \pi_j$  with  $h=1$ , the steady state probability of expansion and

contraction is given by solving the following equation,  $\begin{bmatrix} \pi_0 \\ \pi_1 \end{bmatrix} = \begin{bmatrix} q & 1-q \\ 1-p & p \end{bmatrix} \begin{bmatrix} \pi_0 \\ \pi_1 \end{bmatrix}$ . Therefore each steady state

probability is  $\pi_0 = (1-p)/(2-p-q)$  and  $\pi_1 = (1-q)/(2-p-q)$ .

indicate the average growth of contraction and expansion phases. The  $\mu^*$  indicates the average growth in the long run.<sup>8</sup> We now show the characteristics of regional business cycles based on the estimation results of the regime-switching model.

### 1. Hokkaido

The transition probabilities of  $p$  ( $Pr[S_t = 1 | S_{t-1} = 1]$ ) and  $q$  ( $Pr[S_t = 0 | S_{t-1} = 0]$ ) are 0.939 (0.967) and 0.844 (0.921); these probabilities are both lower than their national values (listed in parentheses). The expected duration of the expansion phase  $(1-p)^{-1}$  is 16.3 (30.4) months while the expected duration of the contraction phase  $(1-q)^{-1}$  is 6.4 (12.7) months; both of these durations for Hokkaido are about half of those of the nation-wide business cycles. In addition, the steady state probability of expansion  $\pi_1$  is 0.719 (0.705) while the steady state probability of contraction  $\pi_0$  is 0.281 (0.295); the steady state probability of expansion is higher and that of contraction is lower than the national values. The results suggest that, in Hokkaido, the average duration of a business cycle is shorter than that of a national cycle and the expansion phase has the tendency to be extend for a longer time than that of national cycles. Let us check these facts from the panel for Hokkaido in figure 4 that shows the smoothing contraction probability  $Pr(S_t = 0 | y_1, \dots, y_T)$ . In the period from 1991 to 1993, that is the contraction phase of the 12th cycle in the nation-wide business cycles, two expansion phases are observed in Hokkaido. In the period since 2001, that is the expansion phase of the 14th cycle in the nation-wide business cycles, one contraction phase is observed in Hokkaido. Moreover, the average growth rates of the contraction phases and the expansion phases  $\mu_0$  and  $\mu_1$  are -0.060 (-0.046) and 0.027 (0.030). The average growth in the long run  $\mu^*$  is 0.003 (0.007) that is lower than the national value.

<<insert Figure 4: Contraction probability by region ( $Pr[S_t | y_1, \dots, y_T]$ )>>

### 2. Tohoku

The transition probability  $p$  ( $Pr[S_t = 1 | S_{t-1} = 1]$ ) and  $q$  ( $Pr[S_t = 0 | S_{t-1} = 0]$ ) are 0.971 (0.967) and 0.872 (0.921);  $p$  is higher and  $q$  is lower than the nation values. The expected duration of the expansion phase  $(1-p)^{-1}$  is 35.1 (30.4) months while the expected duration of the contraction phase  $(1-q)^{-1}$  is 7.8 (12.7) months. However, the expected duration of a business cycles 42.9 (43.0) months is similar to that of the nation-wide business cycles. In addition, the steady state probability of expansion  $\pi_1$  is 0.818 (0.705) while the steady state probability of contraction  $\pi_0$  is 0.182 (0.295); these steady state probability of expansion is higher and that of contraction is lower than the national values. The results suggest that, in Tohoku, the average

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<sup>8</sup> The expected growth at period t is given by  $\sum_{j=0}^1 \mu_j Pr(S_t = j | \Psi_T)$ , where  $\Psi_T$  is the information available up to period T (All samples). In this paper, the average growth in the long run is defined by  $\sum_{j=0}^1 \pi_j \mu_j$ , substituting  $Pr(S_t | \Psi_T)$  by the steady state probability  $\pi_j$ .

duration of a business cycle is similar to that of a national cycle and the expansion phase has the tendency to be extend beyond that of national cycles. We can also check the facts from the panel for Tohoku in figure 4. Moreover, the average growth rates of the contraction and the expansion phases  $\mu_0$  and  $\mu_1$  are -0.192 (-0.046) and 0.048 (0.030); both of these are higher than the nation values. In particular, the average growth in the contraction phase is four times as high as the nation-wide business cycles. As the result, the average growth in the long run  $\mu^*$  is 0.004 (0.007), which is lower than the national value in spite of the higher steady state probability of the expansion phase.

### 3. Kanto

The transition probabilities  $p$  ( $Pr[S_t = 1|S_{t-1} = 1]$ ) and  $q$  ( $Pr[S_t = 0|S_{t-1} = 0]$ ) are 0.969 (0.967) and 0.924 (0.921) are very similar to the national values. The expected durations of the expansion phase and the contraction phase  $(1-p)^{-1}$  and  $(1-q)^{-1}$  are 32.3 (30.4) and 13.2 (12.7) months, which are also similar to the nation-wide business cycles. In addition, the steady state probabilities  $\pi_1$  and  $\pi_0$  are 0.709 (0.705) and 0.291 (0.295), which are also similar to the national values. The results suggest that, in Kanto, business cycles have similar features to the nation-wide business cycles from the viewpoint of both the expected duration of a business cycle and the ratio of expansion phases. Moreover, the average growth rates of the contraction and the expansion phases,  $\mu_0$  and  $\mu_1$  are -0.112 (-0.046) and 0.050 (0.030) which are higher than the national values and the average growth in the long run  $\mu^*$  is 0.003 (0.007) which is lower than the national value.

### 4. Chubu

The transition probabilities of  $p$  ( $Pr[S_t = 1|S_{t-1} = 1]$ ) and  $q$  ( $Pr[S_t = 0|S_{t-1} = 0]$ ) are 0.941 (0.967) and 0.895 (0.921); these probabilities are both lower than their national values. The expected duration of the expansion phase  $(1-p)^{-1}$  is 17.0 (30.4) months while the expected duration of the contraction phase  $(1-q)^{-1}$  is 9.5 (12.7) months. The expected duration of a business cycles 26.5 (43.0) months is significantly shorter than that of the nation-wide business cycles. In addition, the steady state probability of expansion  $\pi_1$  is 0.642 (0.705) while the steady state probability of contraction  $\pi_0$  is 0.358 (0.295); these steady state probability of expansion is lower and that of contraction is higher than the national values. The results suggest that, in Chubu, the average duration of a business cycle is shorter than that of a national cycle and the expansion phase has the tendency to be shorter than that of national cycles. Let us check the results from the panel for Chubu in figure 4. In both the period from 1994 to 1995 (the expansion phase of the 12th national cycle) and the period since 2002 (the expansion phase of the 14th national cycle), one contraction phase is observed in Chubu. Moreover, the average growth rates of the contraction and the expansion phase are -0.048 (-0.046) and 0.044 (0.030). The average growth of the expansion phase in Chubu area is higher than in the nation-wide business cycles. As the result, the average growth in the long run  $\mu^*$  is 0.011 (0.007), which is higher than the national value.

## 5. Hokuriku

The transition probabilities of  $p$  ( $Pr[S_t = 1|S_{t-1} = 1]$ ) and  $q$  ( $Pr[S_t = 0|S_{t-1} = 0]$ ) are 0.957 (0.967) and 0.816 (0.921); these probabilities are both lower than their national values. The expected duration of the expansion phase  $(1-p)^{-1}$  is 23.2 (30.4) months while the expected duration of the contraction phase  $(1-q)^{-1}$  is 5.4 (12.7) months. The expected duration of a business cycles 28.6 (43.0) months is significantly shorter than that of the nation-wide business cycles. In addition, the steady state probability of expansion  $\pi_1$  is 0.810 (0.705) while the steady state probability of contraction  $\pi_0$  is 0.190 (0.295); these steady state probability of expansion is higher and that of contraction is lower than the national values. The results suggest that, in Hokuriku, the average duration of a business cycle is quite shorter than that of a national cycle and the expansion phase has the tendency to extend longer than that of national cycles. From figure 4, it can be seen that in the period from 1991 to 1993 (the contraction phase in the 11th national cycle), three contraction phases are observed in Hokuriku. Moreover, the average growth rates of the contraction and the expansion phases  $\mu_0$  and  $\mu_1$  are -0.105 (-0.046) and 0.040 (0.030). The average growth in the long run is 0.013 (0.007), which is higher than the national value.

## 6. Kansai

The transition probabilities of  $p$  ( $Pr[S_t = 1|S_{t-1} = 1]$ ) and  $q$  ( $Pr[S_t = 0|S_{t-1} = 0]$ ) are 0.963 (0.967) and 0.926 (0.921);  $p$  is marginally lower than  $q$  is marginally higher than the nation values. The expected duration of the expansion phase  $(1-p)^{-1}$  is 26.8 (30.4) months while the expected duration of the contraction phase  $(1-q)^{-1}$  is 13.6 (12.7) months. However, the expected duration of a business cycles 40.3 (43.0) months is similar to that of the nation-wide business cycles. In addition, the steady state probability of expansion  $\pi_1$  is 0.663 (0.705) while the steady state probability of contraction  $\pi_0$  is 0.337 (0.295); these steady state probability of expansion is lower and that of contraction is higher than the national values. The results suggest that, in Kansai, the average duration of a business cycle is similar to that of a national cycle, but the expansion phase has the tendency to be shorter than that of national cycles. The reason why the ratio of the contraction phase is slightly higher than the national business cycles is that one short contraction phase is observed in 1995 when the Hanshin-Awaji (Kobe) Earthquake occurred as shown by the panel for Kansai in figure 4. Moreover, the average growth rates of the contraction and the expansion phases  $\mu_0$  and  $\mu_1$  are -0.073 (-0.046) and 0.035 (0.030). The average growth in the long run  $\mu^*$  is -0.001 (0.007), which is slightly negative in the Kansai.

## 7. Chugoku

The transition probabilities of  $p$  ( $Pr[S_t = 1|S_{t-1} = 1]$ ) and  $q$  ( $Pr[S_t = 0|S_{t-1} = 0]$ ) are 0.816 (0.967) and 0.904 (0.921); these probabilities are both lower than their national values. The expected duration of the expansion phase  $(1-p)^{-1}$  is 5.4 (30.4) months while the expected duration of the



contraction phase  $(1-q)^{-1}$  is 10.5 (12.7) months. The expected duration of a business cycles 15.9 (43.0) months is quite shorter than that of the nation-wide business cycles. In addition, the steady state probability of expansion  $\pi_1$  is 0.342 (0.705) while the steady state probability of contraction  $\pi_0$  is 0.658 (0.295); the steady state probability of expansion is considerably lower and that of contraction is quite higher than the national values. Notably, the steady state probability of contraction is higher than that of expansion. This feature is seen only in Chugoku. The results suggest that, in Chugoku, the average duration of a business cycle is quite shorter than that of a national cycle and the expansion phase has the tendency to be shorter than that of national cycles. Let us check the facts from the panel for Chugoku in figure 4. In the period from 1994 to 96 which is the expansion phase in the 12th cycle in the nation-wide business cycles, two contraction phases are observed in Chugoku. In the period since 2002 which is the expansion phase in the 14th cycle in the nation-wide business cycles, two contraction phases are also observed in Chugoku area. Moreover, the average growth rates of the contraction and the expansion phases  $\mu_0$  and  $\mu_1$  are -0.023 (-0.046) and 0.063 (0.030). The average growth in the long run  $\mu^*$  is 0.007, which is similar to the nation-wide business index.

## 8. Shikoku

The transition probabilities of  $p$  ( $Pr[S_t = 1|S_{t-1} = 1]$ ) and  $q$  ( $Pr[S_t = 0|S_{t-1} = 0]$ ) are 0.955 (0.967) and 0.870 (0.921); these probabilities are both lower than their national values. The expected duration of the expansion phase  $(1-p)^{-1}$  is 22.0 (30.4) months while the expected duration of the contraction phase  $(1-q)^{-1}$  is 7.7 (12.7) months. The expected duration of a business cycles 29.7 (43.0) months is significantly shorter than that of the nation-wide business cycles. In addition, the steady state probability of expansion  $\pi_1$  is 0.741 (0.705) while the steady state probability of contraction  $\pi_0$  is 0.259 (0.295); these steady state probability of expansion is higher and that of contraction is lower than the national values. The results suggest that, in Shikoku, the frequency of the business cycles is higher than that of the national cycles, but the expansion phase has the tendency to be kept longer than that of national cycles. From figure 4, it can be seen that in the period from 1991 to 93 that is the contraction phase in the 11th cycle of the nation-wide business cycles, one contraction phase is observed in Shikoku. Moreover, the average growth rates of the contraction and the expansion phases  $\mu_0$  and  $\mu_1$  are -0.094 (-0.046) and 0.033 (0.030). The average growth in the long run  $\mu^*$  is 0.000 (0.007), which is lower than the nation-wide business index.

## 9. Kyushu

The transition probability  $p$  ( $Pr[S_t = 1|S_{t-1} = 1]$ ) and  $q$  ( $Pr[S_t = 0|S_{t-1} = 0]$ ) are 0.969 (0.967) and 0.875 (0.921);  $p$  is higher and  $q$  is lower than the nation values. The expected duration of the expansion phase  $(1-p)^{-1}$  is 32.3 (30.4) months while the expected duration of the contraction phase  $(1-q)^{-1}$  is 8.0 (12.7) months. However, the expected duration of a business cycles 40.3 (43.0) months is similar to that of the nation-wide business cycles. In addition, the steady state probability of expansion  $\pi_1$  is 0.801 (0.705) while the steady state probability of

contraction  $\pi_0$  is 0.199 (0.295); the steady state probability of expansion is higher and that of contraction is lower than the national values. The results suggest that, in Tohoku, the average duration of a business cycle is similar to that of a national cycle and the expansion phase has the tendency to extend longer than that of national cycles. We can also check the facts from the panel for Kyushu in figure 4. In the period from 1991 to 1993 (the contraction phase in the 11th cycles), the contraction period of the Kyushu business cycles is for 9 months in contrast to the national value of 28 months. In the period from 1997 to 99 (the contraction phase in the 12th cycles), the contraction period of Kyushu business cycles is for 12 months in contrast that the period of the nation-wide business cycles is for 19 months. Moreover, the average growth rates of the contraction and the expansion phases  $\mu_0$  and  $\mu_1$  are -0.051 (-0.046) and 0.023 (0.030). The average growth in the long run  $\mu^*$  is 0.008 (0.007), which is similar to the nation-wide business index.

#### 4.2.2. Regional business cycle turning point chronology in Japan

Table 7 provides a summary of the regional business turning points in Japan. Considering the results in the above section, the characteristics of the regional business cycles are classified into the following five groups.

<<insert Table 7: Regional business cycle turning point chronology>>

##### **1) Expected duration of a business cycle is similar to that of a national cycle**

In Tohoku, Kanto, Kansai and Kyushu, the expected duration of a business cycle is distributed from 40.3 (Kansai) to 45.6 (Kanto) months, which is similar to that of a national cycle (43.0 months).

##### **2) Expected duration of a business cycle is shorter than that of a national cycle**

In Hokkaido, Chubu, Hokuriku, Shikoku and Kyushu, the expected duration of a business cycle is distributed from 15.9 (Chugoku) to 29.7 (Shikoku) months, which is quite shorter than that of a national cycle (43.0 months).

##### **3) Share of the expansion phases is higher than the national cycles**

In Tohoku, Hokuriku, Shikoku and Kyushu, the steady state probability of expansion is distributed from 0.74 (Shikoku) to 0.82 (Tohoku), which is higher than the national value (0.71). Note that the average duration of a expansion phase is 35.1 and 32.3 months respectively in Tohoku and Kyushu where the expected duration of a business cycle is similar to that of a national cycle and that the average duration of an expansion phase is 23.2 and 22.0 months respectively in Hokuriku and Shikoku where the expected duration of a business cycle is shorter than that of a national cycle.

#### **4) Share of the expansion phases is similar to the national cycles**

In Hokkaido and Kanto, the steady state probability of expansion is 0.72 and 0.71 respectively, which is similar to the national value (0.71). In terms of the average number of months in an expansion phase, the average duration of an expansion phase is 32.3 months in Kanto where the expected duration of a business cycle is similar to that of a national cycle and the average duration of an expansion phase is 16.3 months in Hokkaido where the expected duration of a business cycle is shorter to that of a national cycle.

#### **5) Share of the expansion phases is lower than the national cycles**

In Chubu, Kansai and Chugoku, the steady state probability of expansion is distributed from 0.34 (Chugoku) to 0.66 (Kansai), which is lower than the national value (0.71). The average duration of an expansion phase is 5.4 and 17.0 months respectively in Chugoku and Chubu where the expected duration of a business cycle is shorter than that of a national cycle, while the average duration of an expansion phase is 26.8 months in Kansai where the expected duration of a business cycle is similar to that of a national cycle. Especially, the steady state probability of contraction is higher than that of expansion only in Chugoku. In addition, the exogenous shock such as the Hanshin-Awaji (Kobe) Earthquake and the rapid appreciation of the yen against the dollar occurred in 1995. Around that year, the contraction phase is observed in Chubu and Kansai.

### **5. Conclusions**

In this paper, we take the following two steps in order to capture the wider economic process by region than the previous research. First, the regional business indices have been extracted from multiple business indicators. We have tried to cover the regional economic activities as widely as possible by making this step. Secondly, the analysis of the regional business cycles has been made by applying the regime-switching model suggested by Hamilton (1989) to the estimated business indices by region. Not only the business cycle turning points but also the features of the business cycles by regions are clarified in this step. It was found that from those empirical analyses that there are some differences in the features of the business cycles by regions in common with the previous researches.

First, from the results from the principal components application to the generation of business cycle indices, the regions can be categorized into the following three groups from the view point of the main factor affecting the regional business cycles:

- 1. Regions predominantly influenced by production and consumption:**  
Chubu, Chugoku, Kyushu and Hokuriku.
- 2. Regions predominantly influenced by production and employment:**

Tohoku, Kanto and Shikoku.

**3. Regions influenced by production, consumption and employment:**

Kansai and Hokkaido.

As shown above, different regions have different main factors affecting regional business cycles. One of the most influential reasons why the above difference could arise is the difference of the industrial structure in each area. In the regions predominantly influenced by production, the share of manufacturing sectors tends to be relatively high. On the other hand, in the regions predominantly influenced by employment and consumption, the share of service sectors tends to be relatively high.

Secondly, we can find from the estimation results from the application of the regime-switching model that the areas are classified into the following five groups:

**1. Expected duration of a business cycle is similar to the national cycle:**

Tohoku, Kanto, Kansai and Kyushu.

**2. Expected duration of a business cycle is shorter than the national cycle:**

Hokkaido, Chubu, Hokuriku, Chugoku and Shikoku.

**3. Share of the expansion phases is higher than the national cycles:**

Tohoku, Hokuriku, Shikoku and Kyushu.

**4. Share of the expansion phases is similar to the national cycles:**

Hokkaido and Kanto.

**5. Share of the expansion phases is lower than the national cycles:**

Chubu, Kansai and Chugoku.

As shown above, different regions have different features also from the viewpoint of the turning points of business cycles. Especially, in this paper, the contraction phase in the early 1990s is observed in Hokkaido, Chugoku and Shikoku, though it was not observed in the previous research. This result is more comprehensive than the previous research, because we use multiple business indicators to estimate the regional business cycles based on Burns and Mitchell's definition, while a single indicator such as an index of industrial production was used in the previous research.

We have discussed the main factors generating the dispersion in regional outputs based on Hitomi *et al.* (2000) and have presented two hypotheses earlier. We could presume the economic backgrounds generating the differences in the turning points in regional business cycles by comparing and verifying between two typologies. First, Kanto and Kansai among the regions where the average duration of a business cycle is similar to that of a national cycle, are characterized as the regions where the direct effect of the intra-regional demand to the output is positive and the regions where the contribution of the change in all factors occurring in these regions to the total output in Japan is high. We could presume from the point of view that the business cycles in Kanto and Kansai have a tendency to be affected by the other regions and to

dominate the change in the business cycles in Japan. Secondly, Tohoku and Kyushu, where the share of the expansion phase is higher than the national cycle among the regions (the expected duration of a business cycle is similar to the national cycle) are characterized as the regions where the contribution of the international exports is positive. In the three expansion phases during 1990's in Japan, the positive contribution of international exports played a major role in boosting GDP growth with continuing sluggishness in domestic demands such as household consumption and so on. From this point in view, it is easy to understand that the share of the expansion phase in Tohoku and Kyushu is higher than in the other regions. On the other hand, the four regions where the average duration of a business cycle is shorter than the nation-wide business cycle (Hokkaido, Chubu, Chugoku and Shikoku), are characterized as the regions where the direct effect of the intra-regional demand on output is negative. It implies the possibility that those regions experienced the reduction of output induced by technological change. It has the possibility to weaken the autonomous change of the regional business cycles. Such technological changes could generate the result that the business cycles in these regions more rapidly move into a contraction phase even in the case but they also have a tendency to shorten the average duration of a business cycle. In addition, although above the four regions can be characterized whether the contribution of international exports and interregional trades is positive or not, we could not clearly identify much in common between both typologies. In this regard, however, Hokkaido, Chubu, and Chugoku among the above four regions are characterized as the regions where the contribution of interregional trade to outputs is positive. This fact may provide the reason why the average duration of a business cycle is shorter than that of a nation-wide business cycle at this point.

We need to note a few important caveats in this discussion. The first is that the regional division adopted in this paper is the power supply areas while the regional division adopted in Hitomi *et al.* (2000) is the division by Ministry of Economy, Trade and Industry (METI). As shown in 2.2, the prefectures included are not strictly comparable in Tohoku, Kanto, Kansai and Chubu. The second is that the typology in the turning points of the business cycles estimated in this paper are based on the information since 1990, while the typology under Hitomi *et al.* (2000) are based on the information during the latter half of 1980's. It is a matter of course that the structure of the multi-regional input-output table continues to change even during 1990's. For example, the co-movement among regional business cycles in the latter half of 1990's is more noticeable than in the early 1990's in figure 4. It could imply that the connection through interregional trade among the regions might have become stronger in this decade.

In closing, we take up some issues that we should extend the analysis of this paper. First, we construct the regional business indices using the multiple regional business indicators in order to capture the wider economic variation than in the previous studies. However, the business indicators that we have adopted are only four in number. This number is considerably less than that of the indicators to construct the nation-wide business coincident index by ESRI. Zarnowitz (1992) has pointed out three reasons why we need to use as many indicators as possible to construct the business index. The first is that the co-movement of the indicators is

itself an essential characteristic of the business cycles. The second is that no single adequate measure of aggregate economic activity is available in a consistent form for a long historical period. The third is that economic statistics generally are subject to error, so that the evidence from a number of independently compiled indicators tends to be more reliable than the evidence from any individual series. From this perspective, we should use more business indicators to construct more reliable and precise business indices in each region. However, the monthly cyclical indicators that are available by power supply areas and which are consistent among regions are currently limited to the four indicators. It would be desirable in the future to enhance the monthly regional economic statistics to reflect the diversity of information now available at the national level. Secondly, in the previous studies that measured the turning points of Japanese regional business cycles, the nation-wide contraction phase during the first half of 1990's, which occurred after *the bubble economy*, was not observed in Hokkaido, Chugoku and Shikoku. In this paper, the nation-wide contraction phase after *the bubble economy* could have been observed even in the above three regions. This results are nearer to the actual experiences in the regions, considering that the contraction phase at that period are recorded also in the prefectural business cycle peak and trough which are published by the prefectural governments correspond to those regions. However, the contraction probabilities during the contraction phase in the three regions are changing near 0.5; the switch of the phases is not clear compared with in the latter half of 1990's. It points to a possibility that there is a structural change in the data generating process of the regional business cycles. This phenomenon could justify the analysis of Wall (2006); however, in his analysis, the period of the structural break is determined in an ad hoc manner. If the time-series characteristic of the business cycles is different each region, we need to consider the timing of the structural break by region. The methodology proposed by Qu and Perron (2005) for endogenously identifying structural breaks might be applied. Finally, since the seminal work by Anselin (1988), attention to spatial dependency should become a concern in modeling economic activities over space. It is implied from the comparing the typology based on the multi-regional input-output model that interregional trade influences the regional business cycles of Hokkaido, Chubu, Chugoku and Shikoku. In business cycle analysis, we have to consider the spatial dependency such as geographical and economical proximity in the case of analyzing the pervasive process of the regional business cycles.

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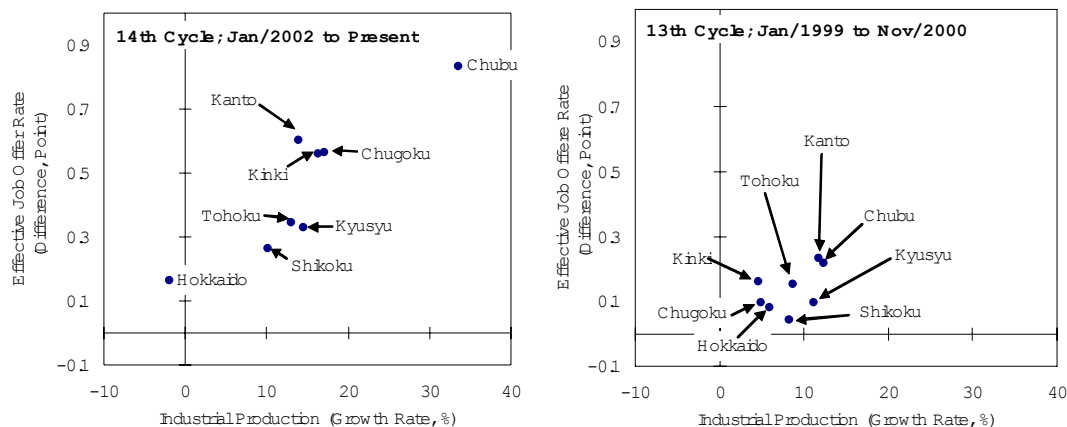


Figure 1: Industrial production and Effective job offer rate

Table 1: Factor contribution to aggregate regional output growth 1985-1990

Typology	Feature #1	Feature #2	Sign of factor contribution		
			Technical coefficients (A)	International expts (E)	Interregional trade coefficients (T)
Hokkaido, Tohoku, Chubu	(A) is negative	(E) & (T) is positive		{	{
Chugoku		(T) is positive			{
Kyusyu		(E) is positive		{	
Shikoku		All negative			
Kanto	(A) is positive	(E) is positive	{	{	
Kansai		(T) is positive	{		{

Note: This typology is made by authors based on Hitomi et al. (2000).

Table 2: Eleven coincident indicators by the ESRI

#,	Coincident Indicators	Classification
C1	Index of Industrial Production (Mining and Manufacturing)	(ii)
C2	Index of Producer's Shipments (Producer Goods for Mining and Manufacturing)	(ii)
C3	Large Industrial Power Consumption	(ii)
C4	Index of Capacity Utilization Ratio (Manufacturing)	(ii)
C5	Index of Non-Scheduled Worked Hours (Manufacturing)	(i)
C6	Index of Producer's Shipment (Investment Goods Excluding Transport Equipments)	(iv)
C7	Retail Sales Value (Change From Previous Year)	(iii)
C8	Wholesale Sales Value (Change From Previous Year)	(ii)
C9	Operating Profits (All Industries)	(vi)
C10	Index of Sales in Small and Medium Sized Enterprises (Manufacturing)	(vi)
C11	Effective Job Offer Rate (Excluding New School Graduates)	(i)

Source: Economic and Social Research Institute, Cabinet Office in Japan. Classification: (i) Employment & unemployment, (ii) Production & income, (iii) Consumption, trade, orders & deliveries, (iv) Fixed capital investment, (v) Inventories & inventory investment, (vi) Prices, costs & profits, (vii) Money & credit.



Table 3: Reference of regional divisions in Japan by sources

#,	Prefecture	EPSA	METI	MIC	BOJ
1	Hokkai do	Hokkai do	Hokkai do	Hokkai do	Hokkai do
2	Aomori	Tohoku	Tohoku	Tohoku	Tohoku
3	Iwate				
4	Myagi				
5	Akita				
6	Yamagata				
7	Fukushima				
15	Niigata				
8	Ibaraki	Kanto	Kanto	Kanto	Kanto
9	Tochigi				
10	Gunma				
11	Saitama				
12	Chiba				
13	Tokyo				
14	Kanagawa				
19	Yamanashi				Chubu
16	Toyama	Hokuriku	Chubu	Hokuriku	Hokuriku
17	Ishikawa				
18	Fukui		Kinki		
20	Nagano	Chubu	Kanto	Kanto	Chubu
22	Shizuoka				
21	Gifu		Chubu	Tokai	
23	Aichi				
24	Mei				
25	Shiga	Kansai	Kinki	Kinki	Kinki
26	Kyoto				
27	Osaka				
28	Hyogo				
29	Nara				
30	Wakayama				
31	Tottori	Chugoku	Chugoku	Chugoku	Chugoku
32	Shimane				
33	Okayama				
34	Hiroshima				
35	Yamaguchi				
36	Tokushima	Shikoku	Shikoku	Shikoku	Shikoku
37	Kagawa				
38	Ehime				
39	Kochi				
40	Fukuoka	Kyushu	Kyushu	Kyushu	Kyushu
41	Saga				
42	Nagasaki				
43	Kumamoto				
44	Oita				
45	Myazaki				
46	Kagoshima				
47	Okinawa				

Notes: 1. EPSA means electric power supply area. There are ten electric power supply companies in Japan. Each company releases the data of electric power consumption in their power supply area. Especially, "Large industrial power consumption" is regarded as one of the most important among many business indicators. 2. METI means Ministry of Economic, Trade and Industry in Japan's government. METI releases the statistical data such as "Indices of Industrial Production, Producer's Shipments and Producer's Inventory", "Current Survey of Commerce" and so on. 3. MIC means Ministry of Internal Affairs and Communications in Japan's government. MIC has a portal office of the information of statistical data in Japan. They release the statistical data such as "Family Income and Expenditure Survey", "Labor Force Survey" and so on. 4. BOJ means Bank of Japan. BOJ releases financial market data, Price of Producer Goods and so on.



Figure 2: Japanese regions by power supply area

Table 4: Selection of regional business indicators

‡ ,	Nation- wide Coincident Indicators by ESRI	Availa- bility	‡ ,	Regional Coincident Indicators by Power Supply Area
C5	Index of Non- Scheduled Worked Hours	*1	--	--
C11	Effective Job Offer Rate	>	NC4	Effective Job Offered Rate
C1	Index of Industrial Production	>	NC1	Index of Industrial Production
C2	Index of Producer's Shipments (Producer's goods)	N/A	--	--
C3	Large Industrial Power Consumption	>	NC2	Large Industrial Power Consumption
C4	Index of Capacity Utilization Ratio	N/A	--	--
C7	Retail Sales Value	*2	NC3	Large-scale Retail Sales
C8	Wholesale Sales Value	N/A	--	--
C6	Index of Producer's Shipments (Investment goods excluding transport equipment)	N/A	--	--
C9	Operating Profits	N/A	--	--
C10	Index of Sales in Small and Medium Sized Enterprises *5	N/A	--	--

Source: Economic and Social Research Institute, Cabinet Office in Japan.

Notes: \*1 The classification is defined by the National Bureau of Economic Research in the U.S. The classification is as following. (i) Employment & unemployment, (ii) Production & income, (iii) Consumption, trade, orders & deliveries, (iv) Fixed capital investment, (v) Inventories & inventory investment, (vi) Price, cost & profit, (vii) Money & credit. \*2 The regional data has the interval of 6 months until released. \*3 This data is replaced by Large-scale retail sales, though Retail sales value does not exist in regional data. \*4 This is a quarterly data.

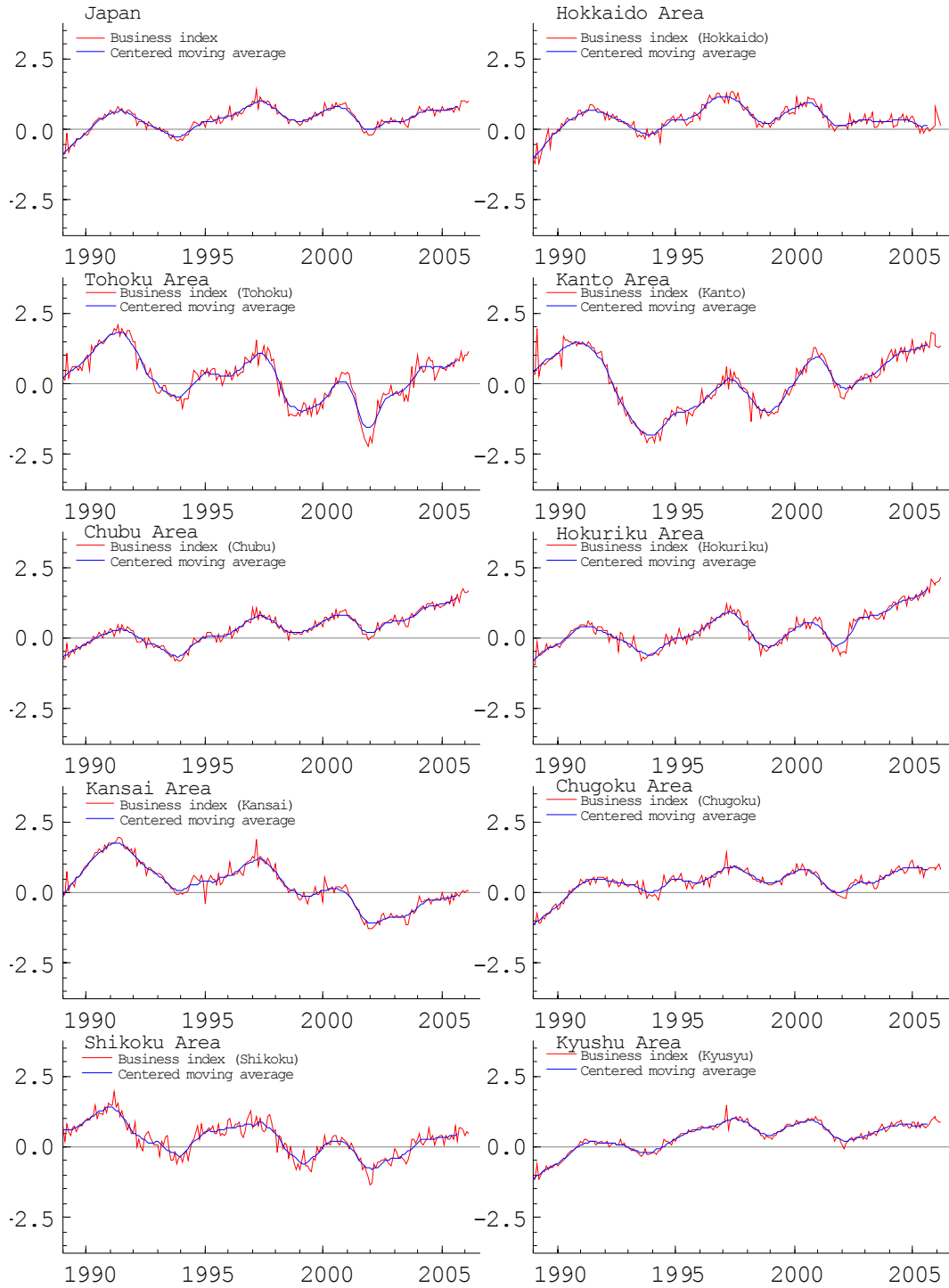


Figure 3: Regional business indices by Principal components method

Table 5: Estimation results by Principal components method

	Factor loadings				Expl.	
	NC1	NC2	NC3	NC4	variance	(%)
<b>Japan</b>	<b>0.908</b>	<b>0.971</b>	<b>0.928</b>	<b>0.050</b>	<b>2.631</b>	<b>65.8</b>
<b>Hokkaido</b>	<b>0.842</b>	<b>0.742</b>	<b>0.908</b>	<b>0.460</b>	<b>2.296</b>	<b>57.4</b>
<b>Tohoku</b>	<b>0.799</b>	<b>0.308</b>	<b>0.348</b>	<b>0.753</b>	<b>1.421</b>	<b>49.5</b>
<b>Kanto</b>	<b>0.742</b>	<b>0.274</b>	<b>0.274</b>	<b>0.592</b>	<b>1.051</b>	<b>50.6</b>
<b>Chubu</b>	<b>0.915</b>	<b>0.973</b>	<b>0.920</b>	<b>0.242</b>	<b>2.689</b>	<b>67.2</b>
<b>Hokuriku</b>	<b>0.841</b>	<b>0.972</b>	<b>0.823</b>	<b>0.023</b>	<b>2.332</b>	<b>58.3</b>
<b>Kansai</b>	<b>0.658</b>	<b>0.911</b>	<b>0.808</b>	<b>0.462</b>	<b>2.130</b>	<b>53.3</b>
<b>Chugoku</b>	<b>0.935</b>	<b>0.933</b>	<b>0.826</b>	<b>0.139</b>	<b>2.445</b>	<b>61.1</b>
<b>Shikoku</b>	<b>0.795</b>	<b>0.801</b>	<b>0.126</b>	<b>0.651</b>	<b>1.713</b>	<b>42.8</b>
<b>Kyushu</b>	<b>0.951</b>	<b>0.954</b>	<b>0.761</b>	<b>0.206</b>	<b>2.438</b>	<b>60.9</b>

Note: Regional business indices are calculated as follows,

$$BI_t = \beta_1 \cdot NC1_t + \beta_2 \cdot NC2_t + \beta_3 \cdot NC3_t + \beta_4 \cdot NC4_t,$$

$$\beta_i = f_i \cdot \lambda^{-1}, \quad f_i = c_i \sqrt{\lambda}, \quad i = 1, \dots, 4,$$

where  $BI_t$  is the principal component showing the value of business index at period  $t$ ,  $NC1_t$ ,  $NC2_t$ ,  $NC3_t$  and  $NC4_t$  are the value of each business indicator at period  $t$ , which are Index of industrial production, Large industrial power consumption, Large-scale retail sales and Effective job offer rate in each area,  $f_i$  is factor loading,  $c_i$  is  $i$ -th element of characteristic vector, and  $\lambda$  is the element of characteristic roots corresponding to the principal component used as the business index. The  $\lambda$  is appeared as Explanatory variance in this table. The right side column indicates  $\left( \lambda_i / \sum_{i=1}^4 \lambda_i \right)$ .

Table 6: Estimation results of regime switching models

	00 Japan AR(1)	01 Hokkaido AR(2)	02 Tohoku AR(2)	03 Kanto AR(2)	04 Chubu AR(2)
$p$	0.967 (0.0201)	0.939 (0.0718)	0.971 (0.0245)	0.969 (0.0150)	0.941 (0.0239)
$q$	0.921 (0.0288)	0.844 (0.1167)	0.872 (0.0479)	0.924 (0.0255)	0.895 (0.0259)
$f \hat{\rho}_P$	-0.505 (0.0041)	-0.561 (0.0098)	-0.497 (0.0064)	-0.598 (0.0063)	-0.792 (0.0064)
$f \hat{\rho}_Q$	--	-0.143 (0.009)	-0.186 (0.006)	-0.204 (0.006)	-0.387 (0.006)
$f \hat{\rho}$	0.122 (0.0001)	0.172 (0.0005)	0.248 (0.0003)	0.215 (0.0002)	0.123 (0.0002)
$f \hat{\rho}_O$	-0.046 (0.0005)	-0.060 (0.0062)	-0.192 (0.0015)	-0.112 (0.0008)	-0.048 (0.0003)
$f \hat{\rho}_P$	0.030 (0.0003)	0.027 (0.0031)	0.048 (0.0006)	0.050 (0.0005)	0.044 (0.0005)
$\ln L$	122.05	57.03	-20.94	8.82	110.76
SBIC	-212.46	-77.16	78.79	19.27	-184.62
$f \hat{\rho}^-$	0.007	0.003	0.004	0.003	0.011
$f \hat{\rho}_O$	0.295	0.281	0.182	0.291	0.358
$f \hat{\rho}_P$	0.705	0.719	0.818	0.709	0.642
$(1-p)^{-1}$	30.4	16.3	35.1	32.3	17.0
$(1-q)^{-1}$	12.7	6.4	7.8	13.2	9.5

	05 Hokuriku AR(2)	06 Kansai AR(2)	07 Chugoku AR(2)	08 Shikoku AR(4)	09 Kyushu AR(2)
$p$	0.957 (0.0482)	0.963 (0.0236)	0.816 (0.1159)	0.955 (0.0411)	0.969 (0.0311)
$q$	0.816 (0.0859)	0.926 (0.0262)	0.904 (0.0445)	0.870 (0.0668)	0.875 (0.0502)
$f \hat{\rho}_P$	-0.560 (0.0078)	-0.563 (0.0062)	-0.503 (0.0081)	-0.492 (0.0086)	-0.582 (0.0066)
$f \hat{\rho}_Q$	-0.298 (0.007)	-0.256 (0.006)	-0.249 (0.007)	-0.215 (0.011)	-0.202 (0.006)
$f \hat{\rho}_R$	--	--	--	-0.169 (0.010)	--
$f \hat{\rho}_S$	--	--	--	-0.203 (0.007)	--
$f \hat{\rho}$	0.168 (0.0005)	0.177 (0.0002)	0.138 (0.0004)	0.241 (0.0006)	0.113 (0.0001)
$f \hat{\rho}_O$	-0.105 (0.0036)	-0.073 (0.0005)	-0.023 (0.0022)	-0.094 (0.0034)	-0.051 (0.0009)
$f \hat{\rho}_P$	0.040 (0.0009)	0.035 (0.0007)	0.063 (0.0052)	0.033 (0.0012)	0.023 (0.0005)
$\ln L$	54.85	46.49	94.12	-10.97	137.37
SBIC	-72.79	-56.08	-151.33	69.39	-237.84
$f \hat{\rho}^-$	0.013	-0.001	0.007	0.000	0.008
$f \hat{\rho}_O$	0.190	0.337	0.658	0.259	0.199
$f \hat{\rho}_P$	0.810	0.663	0.342	0.741	0.801
$(1-p)^{-1}$	23.2	26.8	5.4	22.0	32.3
$(1-q)^{-1}$	5.4	13.6	10.5	7.7	8.0

Note: The numbers in parentheses give the asymptotic standard errors.

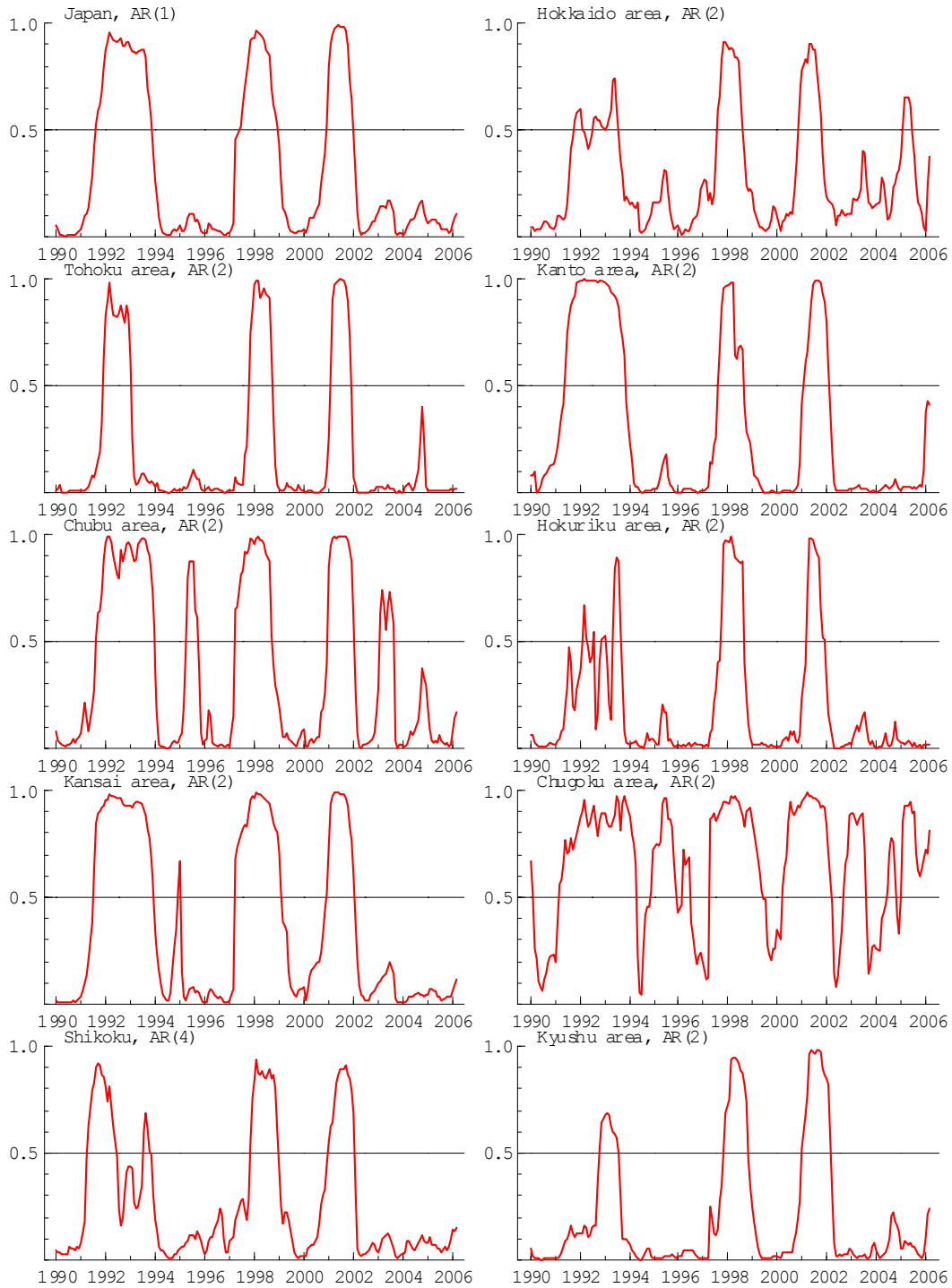


Figure 4: Contraction probability by area ( $\Pr[S_t = 0 | y_1, \dots, y_T]$ )

Note: The period is regarded as the contraction phase when the smoothing probability  $\Pr[S_t = 0 | y_1, \dots, y_T]$  is more than 0.5.

Table 7: Regional business cycle turning point chronology

(a) Dating the business cycle turning points by month and year

	00 Japan		Duration of a business cycle is similar to that of a national cycle							
			Lower ratio of expansion phase		Similar ratio of expansion phase		Higher ratio of expansion phase			
			06 Kansai		03 Kanto		02 Tohoku		09 Kyusyu	
	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough
11th	Jul-91	Nov-93	Jun-91	Dec-93	May-91	Nov-93	Nov-91	Jan-93	Oct-92	Jul-93
			Nov-94	Jan-95						
12th	May-97	Dec-98	Mar-97	Feb-99	Aug-97	Aug-98	Oct-97	Sep-98	Oct-97	Oct-98
13th	Nov-00	Dec-01	Nov-00	Jan-02	Jan-01	Feb-02	Jan-01	Nov-01	Dec-00	Feb-02

(b) Average duration in months

	Expansion	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Contraction
11th	--	28	--	30	--	30	--	14	--	9
			11	2						
12th	42	19	26	23	45	12	57	11	51	12
13th	23	13	21	14	29	13	28	10	26	14
*1	30.4	12.7	26.8	13.6	32.3	13.2	35.1	7.8	32.3	8.0
*2		43.0		40.3		45.6		42.9		40.3
*3	0.030	-0.046	0.035	-0.073	0.044	-0.048	0.048	-0.192	0.023	-0.051
*4	0.705	0.295	0.663	0.337	0.709	0.291	0.818	0.182	0.801	0.199
*5		0.007		-0.001		0.003		0.004		0.008

(a) Dating the business cycle turning points by month and year

	Duration of a business cycle is shorter than that of a national cycle									
	Lower ratio of expansion phase				Similar ratio of expansion phase		Higher ratio of expansion phase			
	04 Chubu		07 Chugoku		01 Hokkaido		05 Hokuriku		08 Shikoku	
	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough
11th	Jul-91	Dec-93	Feb-91	Apr-94	Oct-91	Jan-92	Feb-92	Apr-92	Apr-91	May-92
			Nov-94	Dec-95	Jul-92	Jan-93	Jul-92	Aug-92	Jun-93	Oct-93
			Feb-96	Jun-96	Jan-93	Jul-93	Nov-92	Jan-93		
	Apr-95	Sep-95	Mar-97	May-99			Apr-93	Sep-93		
12th	Mar-97	Sep-98	Feb-00	Feb-02	Jul-97	Jul-98	Sep-97	Sep-98	Oct-97	Dec-98
13th	Dec-00	Jan-02	Aug-02	Jul-03	Nov-00	Oct-01	Feb-01	Dec-01	Dec-00	Jan-02
	Jan-03	Aug-03	May-04	Oct-04	Jan-05	May-05				
			Dec-04							

(b) Average duration in months

	Expansion	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Contraction
11th	--	29	--	38	--	3	--	2	--	13
			7	13	6	6	3	1	13	4
			2	4	0	6	3	2		
			9	26			3	5		
	16	5	9	24						
12th	18	18	6	11	48	12	48	12	48	14
13th	27	13	10	5	28	11	29	10	24	13
	12	7	2		39	4				
*1	17.0	9.5	5.4	10.5	16.3	6.4	23.2	5.4	22.0	7.7
*2		26.5		15.9		22.7		28.6		29.7
*3	0.044	-0.048	0.063	-0.023	0.027	-0.060	0.040	-0.105	0.033	-0.094

Note: \*1: indicates expected durations. \*2: indicates total durations from trough to trough based on expected duration. \*3: indicates the average growth in the phase. \*4: indicates the steady state probability which keeps one phase. \*5: indicates the long-term average growth in the business index.