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Identifying Trough of Recent Recession in Japan: An Application of Stochastic Business Indicator

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Abstract

In Japan, the Indexes of Business Conditions (CI) calculated by the Cabinet Office of the Government of Japan is employed for assessing business cycle. The CI consists of three components, such as leading, coincident, and lagging indexes. The CI is calculated by composing month-to-month percentage changes in multiple economic indicators. On contrary, in the U.S., for observing business condition, a stochastic business indicator is mainly employed. This study applies the latter U.S. approach to estimate a latent stochastic business indicator for Japanese economy according to Stock and Watson (1989, 1990) using a state space model solved by Kalman filter. The estimated stochastic business indicator seems to fit quite well to existing Japanese official Indexes of Business Conditions. The estimated results appear to indicate that the trough month of the latest recession in Japan is March 2009.

Key words: Business cycle, Recession, Stochastic business indicator, State space model, Kalman filter, Japan

JEL Classification: C13, C22, C43, C82, E32, and O53

1. Introduction

From April 2008 on, the Government of Japan has officially adopted a composite index, named Indexes of Business Conditions prepared by the Cabinet Office for assessing business cycles. This Indexes of Business Conditions (hereafter, CI) consists of three indexes, such as leading, coincident, and lagging indexes. Each Index includes following components:

Table 1: Components of Indexes of Business Conditions

Leading Index	
	L1: Index of Producer's Inventory Ratio of Finished Goods (Final Demand Goods)
	L2: Index of Producer's Inventory Ratio of Finished Goods (Producer Goods For Mining and Manufacturing)

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	L3: New Job offers (Excluding New School Graduates)
	L4: New Orders for Machinery at Constant Prices (Except for Volatile Orders)
	L5: Total Floor Area of New Housing Construction Started
	L6: Index of Producer's Shipment of Durable Consumer Goods (Change From Previous Year)
	L7: Consumer Confidence Index
	L8: Nikkei Commodity Price Index (42items) (Change From Previous Year)
	L9: Interest Rate Spread
	L10: Stock Prices (TOPIX) (Change From Previous Year)
	L11: Index of Investment Climate (Manufacturing)
	L12: Sales Forecast D.I. of Small Business
Coincident Index	
	C1: Index of Industrial Production (Mining and Manufacturing)
	C2: Index of Producer's Shipments (Producer Goods for Mining and Manufacturing)
	C3: Large Industrial Power Consumption
	C4: Index of Capacity Utilization Ratio (Manufacturing)
	C5: Index of Non-Scheduled Worked Hours (Manufacturing)
	C6: Index of Producer's Shipment (Investment Goods Excluding Transport Equipments)
	C7: Retail Sales Value (Change From Previous Year)
	C8: Wholesale Sales Value (Change From Previous Year)
	C9: Operating Profits (All Industries)
	C10: Index of Sales in Small and Medium Sized Enterprises (Manufacturing)
	C11: Effective Job Offer Rate (Excluding New School Graduates)
Lagging Index	
	Lg1: Index of Tertiary Industry Activity (Business Service)
	Lg2: Index of Regular Workers Employment (Manufacturing) (Change From Previous Year)
	Lg3: Business Expenditures for New Plant and Equipment at Constant Prices (All Industries)
	Lg4: Living Expenditure (Workers' Households) (Change From Previous Year)
	Lg5: Corporation Tax Revenue
	Lg6: Unemployment Rate
	Lg7: Interest Rates on New Loans and Discounts (Domestically licensed banks)

Source: CAO (2004)

According to CI,[1] the Cabinet Office of the Government of Japan identifies the reference date of business cycle in Japan as follows:

1 Although the CI is one of main criteria, more generalized and broader approach is taken for the identification of the reference dates of business cycle in Japan.

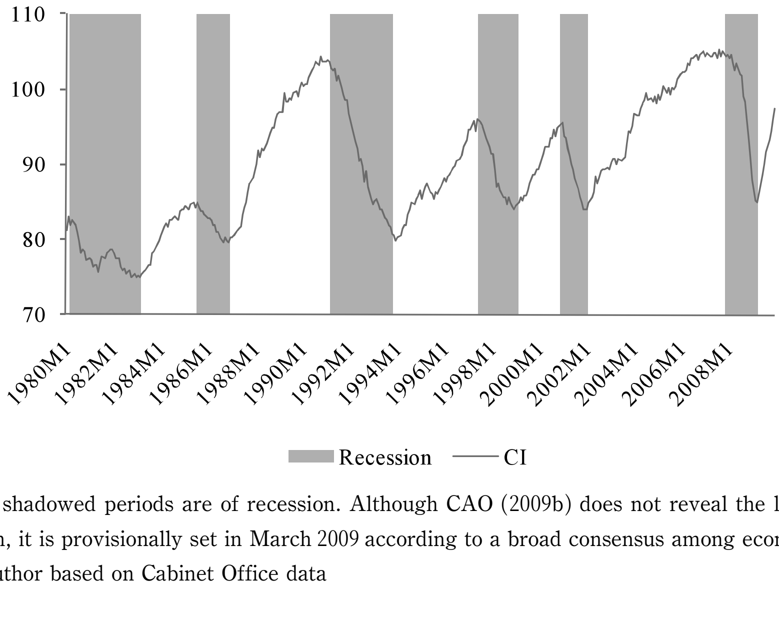
Table 2: The Reference Dates of Business Cycles in Japan

Peak (By Month)	Trough (By Month)	Peak (By Quarter)	Trough (By Quarter)
Jun. 1951	Oct. 1951	2Q 1951	4Q 1951
Jan. 1954	Nov. 1954	1Q 1954	4Q 1954
Jun. 1957	Jun. 1958	2Q 1957	2Q 1958
Dec. 1961	Oct. 1962	4Q 1961	4Q 1962
Oct. 1964	Oct. 1965	4Q 1964	4Q 1965
Jul. 1970	Dec. 1971	3Q 1970	4Q 1971
Nov. 1973	Mar. 1975	4Q 1973	1Q 1975
Jan. 1977	Oct. 1977	1Q 1977	4Q 1977
Feb. 1980	Feb. 1983	1Q 1980	1Q 1983
Jun. 1985	Nov. 1986	2Q 1985	4Q 1986
Feb. 1991	Oct. 1993	1Q 1991	4Q 1993
May. 1997	Jan. 1999	2Q 1997	1Q 1999
Nov. 2000	Jan. 2002	4Q 2000	1Q 2002
Oct. 2007 (provisional)	n.a.	4Q 2007 (provisional)	n.a.

Source: CAO (2009b)

Although the Cabinet Office has not officially identified the trough of the recent recession after the peak of October 2007, many economists regard that the recession ended in the first quarter in 2009. This is mainly because of the movement of CI, which is indicated as follows:

Figure 1: Development of CI (2005=100)



Note: The shadowed periods are of recession. Although CAO (2009b) does not reveal the latest trough month, it is provisionally set in March 2009 according to a broad consensus among economists.

Source: Author based on Cabinet Office data

While the Japanese CI is calculated by composing month-to-month percentage changes in multiple economic indicators, The U.S. takes another approach, which employs a stochastic business indicator. The latter methodology uses a state space model to be solved by Kalman filter, in order to estimate a latent indicator. This study applies the latter U.S. approach to estimate a stochastic business indicator for Japan. Including this introductive section, this paper consists of four sections; the second section focuses on methodology of Japanese CI and stochastic business indicator; the third present data and estimation results; and, the final section briefly concludes the paper. This study is based on available data and information until March 1, 2010 and EViews V6 is employed for estimation.

2. Methodology and Model

2.1 Methodology of Indexes of Business Conditions

Summarizing[2] CAO (2009a), the Indexes of Business Conditions (CI) is calculated according to following four steps:

Step 1: A formula is used for calculating the symmetric percent change of individual series as in the following:

$$r_i(t)=200\times\frac{y_i(t)-y_i(t-1)}{y_i(t)+y_i(t-1)}$$

where r Symmetric percent change
y Individual series
i Number assigned to each indicator
t Time point

If the given time series is zero or a negative value, or is already in percentage form, simple arithmetic differences are calculated:

$$r_i(t)=y_i(t)-y_i(t-1)$$

Then, outliers are trimmed using the following formula:

$$\varphi_2(r_i(t))=\begin{cases}-k\times(Q3_i-Q1_i) & \text{for} \quad r_i(t)<-k\times(Q3_i-Q1_i)\\ r_i(t) & \text{for} \quad -k\times(Q3_i-Q1_i)\leq r_i(t)\leq k\times(Q3_i-Q1_i)\\ k\times(Q1_i-Q3_i) & \text{for} \quad r_i(t)>-k\times(Q3_i-Q1_i)\end{cases}$$

where $Q1$ The first quartile in the interquartile range
$Q3$ The third quartile in the interquartile range

2 For more detailed and precise information, see " Note for Calculation " of CAO (2009a).

Step 2: The trend of individual series (mean percent change) is calculated by the trimmed 60-month backward moving average as follows:

$$\mu_i(t)=\frac{\sum_{\tau=t-59}^{60}\varphi\,(r_i(\tau))}{60}$$

where $\mu_i(t)$ Mean percent change

Next, percent change normalized by interquartile range is calculated by applying the following formula:

$$Z_i(t)=\frac{\varphi\,(r_i(t))-\mu_i(t)}{Q3_i-Q1_i}$$

where $Z_i(t)$ Mean percent change

Step 3: Composite percentage change is calculated by adding up trend (composite mean percent change), and the mean of percent change normalized by interquartile range (composite percent change normalized by interquartile range). In this process, composite percent change normalized by interquartile range is multiplied by the mean of interquartile ranges (composite interquartile range) so that the levels of the trend component and the cyclical component coincide as follows:

$$\overline{\mu(t)}=\frac{\sum_{i}^{n}\mu_i(t)}{n}$$

$$\overline{Z(t)}=\frac{\sum_{i}^{n}Z_i(t)}{n}$$

$$\overline{Q3_i-Q1_i}=\frac{\sum_{i}^{n}(Q3_i-Q1_i)}{n}$$

$$V(t)=\overline{\mu(t)}+\overline{(Q3_i-Q1_i)}\times\overline{Z(t)}$$

where $V(t)$ Composite percent change

n Number of individual indicators (y)

Step 4: As in the previous calculation method of composite indexes, composite percent change is cumulated as follows:

$$I(t)=I(t-1)\times\frac{200+V(t)}{200-V(t)}$$

Finally, the index is rebased so that the value for the reference year is equal to 100. The current reference year is 2005.

2.2 Model of Stochastic Business Indicator

On contrary of above methodology of CI in Japan, that of stochastic business indicator assumes a unique and latent index, which affects and reveals existing and observable indicator, such as production, labor, income, and consumption, etc. Assuming that this unique and latent index and the error terms follow autoregressive (AR) process, the model of stochastic business indicator is mathematically represented in the following model:

$$y_i(t)=\alpha_i+\beta_i c(t)+u_i(t)$$
$$c(t)=\gamma+\tau_1 c(t-1)+\tau_2 c(t-2)+\ldots+\tau_n c(t-n)+e(t)$$
$$u_i(t)=\lambda_i u_i(t-1)+\lambda_i u_i(t-2)+\ldots+\lambda_i u_i(t-m)+\varepsilon_i(t)$$

where	y	Observable business indicators (i=1, 2, 3, ...)
	c	Unique and latent business indicator
	u, e, ε	Error term (i=1, 2, 3, ...)
	i	Number of observable indicators
	n	Number of lags of AR process for c
	m	Number of lags of AR process for u
	$\alpha, \beta, \gamma, \tau, \lambda$	Parameters

Using lag operator L, above model can be expressed as follows:

$$y_i(t)=\alpha i+\beta_i c(t)+u_i(t)$$
$$\phi(L)c(t)=\omega+e(t)$$
$$\theta(L)u(t)=\varepsilon(t)$$

Here, ϕ represents a lag polynomial of $\phi=1-\phi_1 L-\phi_2 L^2-\ldots-\phi_n L^n$ and θ does that of $\theta=1-\theta_1 L-\theta_2 L^2-\ldots-\theta_m L^m$. On the other hand, error term e is a scalar stochastic variable that follows $e\sim N(O,\sigma^2)$, and ε is too a scalar stochastic variable that follows $\varepsilon\sim N(O,\sigma^2 H)$. Of course, O is a null matrix.

Since this model for stochastic business indicator includes latent variables, the equation system is represented as a state space model. According to Okusa (1992), the generalized state space representation of the stochastic business indicator is as follows:

1) **State variable** δ

$$\delta=\begin{bmatrix} c(t) \\ c(t-1) \\ \vdots \\ c(t-n+1) \\ u(t) \\ u(t-1) \\ \vdots \\ u(t-m+1) \end{bmatrix}$$

2) **Observation equation** y

$$y(t)=Z\delta(t)$$

3) **Transit equation** δ

$\delta(t) = X\delta(t-1) + \xi(t)$

4) **Disturbance term** ξ

$\xi(t) \sim N(O_{i+1}, \sigma^2 \Sigma)$

where $Z = [\beta \quad O_{i,n} \quad I_i \quad O_{i,m}]$

$$X = \begin{bmatrix} \begin{matrix} \phi_1 & \phi_2 & \cdots & \phi_{n-1} & \phi_n \\ 1 & 0 & \cdots & 0 & 0 \\ 0 & 1 & \cdots & \vdots & \vdots \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & 1 & 0 \end{matrix} & O_{n,im} \\ O_{im,n} & \begin{matrix} \Theta_1 & \Theta_2 & \cdots & \Theta_{m-1} & \Theta_m \\ I_i & O_i & \cdots & O_i & O_i \\ O_i & I_i & \cdots & O_i & O_i \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ O_i & O_i & \cdots & O_i & O_i \end{matrix} \end{bmatrix}$$

Of course, the state variable δ is an $n+m$ vector. According to usual definition, I_k means a unit matrix with k rows and columns, and $O_{k,l}$ represents a null matrix with k rows and l columns. Σ means a diagonal matrix with its elements of $\Sigma = diag(1 \ O'_{n-1} \ h_1 \ h_2 \ \cdots \ h_{n-1} \ h_n \ O'_{(n-1)m})$, while h is a diagonal element of H. is a parameter of n-degree lag polynomial for the latent index. Θ is a diagonal matrix with elements of θ, which is a parameter of m-degree lag polynomial for the error term u.

Since above-mentioned general form of the state space model quoted from Okusa (1992) is quite complicated, this study assumes following three points, which seem adequately plausible, to simplify the model according to existing literatures, including Stock and Watson (1989, 1990) and Okusa (1992):

1) The observable indicators are taken from production, labor, income, and consumption, i.e., i=4.
2) The unique and latent business indicator c is subject to AR(2) process, i.e., n=2.
3) The error term u is subject to AR(1) process, i.e., m=1.

Above model for stochastic business indicator will be transformed into following simplified state space model system:

1) **Observation Equations**

$$\begin{bmatrix} y_1(t) \\ y_2(t) \\ y_3(t) \\ y_4(t) \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix} + \begin{bmatrix} \beta_1 & 1 & 0 & 0 & 0 \\ \beta_2 & 0 & 1 & 0 & 0 \\ \beta_3 & 0 & 0 & 1 & 0 \\ \beta_4 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} c(t) \\ u_1(t) \\ u_2(t) \\ u_3(t) \\ u_4(t) \end{bmatrix}$$

2) **Transit Equations**

$$\begin{bmatrix} c(t) \\ u_1(t) \\ u_2(t) \\ u_3(t) \\ u_4(t) \end{bmatrix} = \begin{bmatrix} \phi_1 & \phi_2 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \lambda_1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \lambda_2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \lambda_3 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \lambda_4 \end{bmatrix} \begin{bmatrix} c(t\text{-}1) \\ c(t\text{-}2) \\ e(t) \\ u_1(t\text{-}1) \\ u_2(t\text{-}2) \\ u_3(t\text{-}3) \\ u_4(t\text{-}4) \end{bmatrix}$$

This simplified state space model will be solved with Kalman filter presented at Kalman (1960). In this study, further explanation for state space models and Kalman filter will be out of target. For comprehensive information on application of a state space model to econometric field, Harvey (1981) is one of the most useful literatures if necessary. Apart from Kalman's original paper, Meinhold and Singpurwalla (1983), Snyder and Forbes (1999), and Grewal and Andrews (2002) will provide further information on Kalman filter and its algorithm. Some relevant internet sites, including " *Kalman Filter* "[3] of the Department of Computer Science at the University of North Carolina, where the reprint of Kalman (1960) is uploaded, are also helpful.

3. Data and Estimation Results

According to the assumption and the model presented in the previous section, following actual and observable data are employed:[4]

1) **Production**: Index of Industrial Production (Mining and Manufacturing) published by the Ministry of Economics, Trade and Industry, seasonally adjusted series.
2) **Employment**: Index of Non-Scheduled Worked Hours (establishments with 30 employees or more) published by the Ministry of Health, Labor and Welfare, seasonally adjusted series.
3) **Income**: Real Wage Index of Total Cash Earnings (establishments with 30 employees or more) published by the Ministry of Health, Labor and Welfare, seasonally adjusted series.
4) **Consumption**: Retail Commercial Sales Value of Monthly Report on the Current Survey of Commerce published by the Ministry of Economics, Trade and Industry, adjusted to real term by Consumer Price Index published by the Statistics Bureau, and seasonally adjusted by X-12 with a default option by author.

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3 *http://www.cs.unc.edu/~welch/kalman/*

4 All data are monthly and available from January to December 2009.

First of all, Augmented Dickey-Fuller (ADF) unit root tests based on Dickey and Fuller (1979, 1981) are completed in order to check the data generating process of relevant above four data. Table 4 reports the test results.

Table 3: Results of ADF Tests

	log level			log difference		
	t-Statistic	p-value	lag	t-Statistic	p-value	lag
Production	-2.739634	0.2213	3	-7.967689	0	4
Employment	-2.172442	0.503	2	-8.759122	0	1
Income	0.378053	0.9989	5	-15.5381	0	4
Consumption	-0.910036	0.9526	3	-15.82819	0	2

Note: (1) Lag length are decided according to Akaike Information Criteria based on Akaike (1969, 1973) under the condition of maximum 12 months.
(2) P-value is measured at a one-sided basis on MacKinnon (1996).
Source: Author

According to the results of ADF tests, log first-order differential series reject the existence of unit root for all relevant data such as production, employment, income, and consumption, while log level series do not. Hence, log differential series will be employed for estimation. Table 4 reports their descriptive statistics. All data are available from February 1980 to December 2009.[5]

Table 4: Descriptive Statistics
(1) **Data Description**

	Production	Employment	Income	Consumption
Mean	0.000821	-0.000398	0.000188	0.000418
Median	0.001496	0.000811	0.000000	0.000479
Maximum	0.057788	0.033218	0.066939	0.081954
Minimum	-0.106273	-0.078212	-0.076715	-0.172911
Std. Dev.	0.017409	0.012874	0.015184	0.016596
Skewness	-1.552789	-1.081703	-0.77251	-3.053021
Kurtosis	11.6704	8.446555	7.958566	39.2128
Jarque-Bera	1268.773	513.7482	403.4929	20173.57
Probability	0.00000	0.00000	0.00000	0.00000
Sum	0.294768	-0.142883	0.067416	0.150114
Sum Sq. Dev.	0.108506	0.059331	0.082539	0.0986
Observations	359	359	359	359

5 Taking first-order differential series, an observation will be missed.

(2) Correlation Matrix

	Production	Employment	Income	Consumption
Production	1			
Employment	0.45377246	1		
Income	0.000904632	0.041830297	1	
Consumption	0.182361247	0.043893782	0.0801602	1

Source: Author's calculation

Based on above model and data, the unique and latent business indicator is estimated. Table 5 reports the estimation results. The parameters for production and employment are rela-

Table 5: Estimation Results

		parameter	std. error	t-statistics	R^2 adjusted
Production	constant	-0.00067	0.00079	-0.847603	0.279262
	SWI	1.416777	0.119862	11.82002	
Employment	constant	-0.002407	0.000177	-13.58769	0.933765
	SWI	1.909019	0.026869	71.04912	
Income	constant	-0.000317	0.000796	-0.398558	0.039718
	SWI	0.479761	0.120669	3.975835	
Consumption	constant	-0.000216	0.000863	-0.250275	0.053369
	SWI	0.602689	0.130947	4.602528	

Source: Author's estimation

Figure 2: Stochastic Business Indicator and Index of Business Conditions (2005=100)

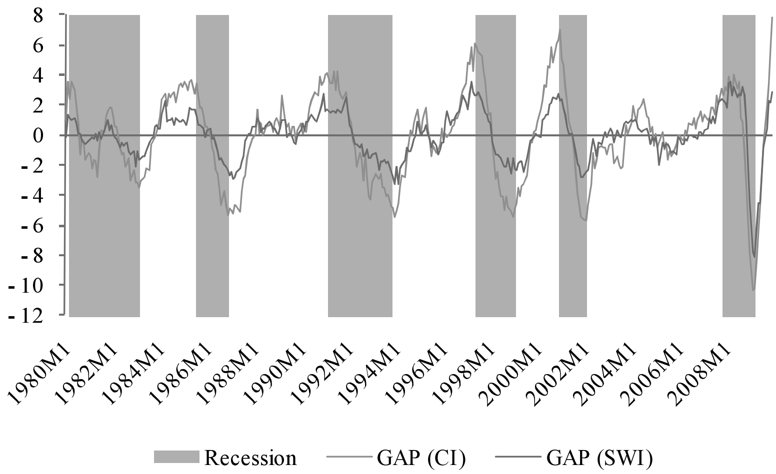
Note: Same as Figure 1.

Source: Cabinet Office data and author's estimation tively large, while those for income and consumption are small. This fact indicates the sensitivity to business cycle, of course.

Figure 2 depicts the estimated stochastic business indicator (SWI) compared with the coincident index of Indexes of Business Conditions (CI) calculated by the Cabinet Office, the Government of Japan.

Although the estimated stochastic business indicator (SWI) does not show clear cyclical movements in the first half of 1980s, after the bubble economy that began in late 1980s, the SWI indicates distinct cycles. To check properties, CI and SWI are decomposed to cycle and trend series using Hodrick-Prescott filter based on Hodrick and Prescott (1981, 1997). The smoothness parameter λ is set at 14400 according to wide and common consensus among economists. Defining the " *GAP* " as percentage ratio of cycle series to trend, i.e., $GAP=\frac{Cycle}{Trend}\times 100$, estimated SWI movement during the estimation period fits quite well to CI as Figure 3 depicts.

Figure 3: *GAP* of Stochastic Business Indicator and Index of Business Conditions



Note: (1) The unit of vertical axis is percent of cycle series to trend.
(2) Same as Figure 1.
Source: Author's estimation

Here, Table 6 compares four kinds of peak and trough months of Japan's business cycle, identified by the official reference dates of the Government of Japan (CAO), turning points of the Indexes of Business Conditions (CI), the reference chronology of the turning points of the OECD Composite Leading Indicator[6] (OECD), and the turning points of the estimated stochastic business indicator in this study (SWI). They are not necessarily coincident, but siz-

6 See http://www.oecd.org/document/21/0,3343,en_2649_34349_1890581_1_1_1_1,00.html (accessed on March 1, 2010).

ably close to each other, including the trough of the latest recession. While the OECD Composite Leading Indicator points to April 2009, both CI and SWI identify March 2009 as the trough, which appear quite plausible and acceptable among Japanese economists.

Table 6: Peak and Trough Months of Business Cycles in Japan after 1990

	Peak Month	Trough Month	Peak Month	Trough Month
CAO	Feb. 1991	Oct. 1993	May. 1997	Jan. 1999
CI	Oct. 1990	Dec. 1993	May. 1997	Dec. 1998
OECD	Feb. 1991	Dec. 1993	Jun. 1997	Oct. 1998
SWI	Dec. 1990	Feb. 1994	Jul. 1997	Feb. 1999
	Peak Month	Trough Month	Peak Month	Trough Month
CAO	Nov. 2000	Jan. 2002	Oct. 2007	n.a.
CI	Dec. 2000	Jan. 2002	Aug. 2007	Mar. 2009
OECD	Oct. 2000	Dec. 2001	Apr. 2008	Apr. 2009
SWI	Nov. 2000	Nov. 2001	Oct. 2007	Mar. 2009

Note: (1) CAO's peak month of October 2007 for the latest recession is provisional.
(2) The OECD Composite Leading Indicator identifies a recession with its peak as June 2004 and its trough as August 2005, but it is not included in the table.

Source: (1) CAO: CAO (2009b)
(2) CI: CAO CI data
(3) OECD: OECD Composite Leading Indicator data
(4) SWI: Author's estimation

4. Conclusion

This study has successfully estimated the stochastic business indicator based on Stock-Watson methodology and has identified the trough month of the latest recession in Japan as March 2009, which many economists will support. The results are too consistent to coincident Index of Business Conditions calculated by the Government of Japan.

Concerning to identification of business cycle turning point, this study focuses on Indexes of Business Conditions of the Government of Japan, which is based on observable indicators, and stochastic approach, suggested by Stock and Watson (1989, 1990). The latter approach is also employed for many economists: Melo V. et al. (2003) adopts for Colombian economy; Picchetti and Toledo (2002) estimate Brasirian industrial index; and, Lemoine (2005) applies to the UK, French, German and the Euro-zone business cycles. Additionally, many other methodologies are also explored: Hamilton (1989, 1990) introduces a Markov regime switching model; Kim and Nelson (1999) propose a Bayesian approach based on a Markov-switching model; Yoshioka (2009a) utilizes GDP gap estimated with a state space model for business cycle dating; and, Yoshioka (2009b) employs Markov Regime Switching model. Fukuda and

Onodera (2001) also propose a new index of coincident economic indicators in Japan to improve the forecast performance. Relating only to business cycle dating, there are plenty of literatures, including Harding and Pagan (2002, 2006), Artis et al (2004), and Chauvet and Hamilton (2005), which propose " quarterly real-time GDP based recession probability index. "

Finally, it is noteworthy to stress that identification of business cycle is essentially important for the macroeconomic stabilization policy.

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