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Structural Changes and Economic Growth: Evidence from Japan

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Abstract

In this paper, we introduce an index of structural changes of the economy, and investigate the relationship between economic growth and structural changes in the Japanese economy We find that (i) there is no clear relationship between structural changes and business cycles in the short run; however, (ii) the long run movements of structural changes are positively correlated with economic growth. In the short run, our result is consistent with the neoclassical view; it is also consistent with the Schumpeterian view of economic growth in the long run.

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1 Introduction

What is the relationship between the structural change and economic growth? Does the economy grow independently from economic structure? There are two representative views about this relationship: the neoclassical and the Schumpeterian. The Schumpeterian view claims that creative destructions are the engines of economic growth, as in Schumpeter (1939). On the contrary, we often consider balanced growth across industries in neoclassical literature. In other words, the structural change of the economy does not matter in terms of economic growth in the neoclassical view while it matters in the Schumpeterian view. Which of these two views is empirically supported?

In order to investigate these problems, in this paper, we use the Japanese monthly index of industrial production, and measure an index of the structural changes of the economy. We find that (i) there is no clear relationship between structural changes and business cycles in the short run; however, (ii) the long-run movement of structural changes are positively correlated with economic growth. Our result for the short run is consistent with the neoclassical theories of balanced growth, and that for the long run is consistent with the Schumpeterian theories where the entry of a new industry leads to long-run economic growth, as stated in Aghion and Howitt (1992) and Aoki and Yoshikawa (2002).

Yoshikawa and Matsumoto (2001) is closely related to the present paper. Our measure of structural changes is identical to theirs. They use the System of National Accounts data for Japan, the U.S., and Germany, and find that, in the long run, there are positive contemporary correlations between structural changes and economic growth in Japan and Germany but not in the U.S..[1] A unique feature of this paper is that we use the Japanese index of industrial productions and investigate the "dynamic" relationship between the structural changes and economic growth using a time-series analysis. We use a filtering method in the time-series analysis to divide data into a long-run trend and a short-run cyclical component, and we find that the role of structural changes in the long run is different from that in the short run.

The remainder of this paper is organized as follows. Section 2 introduces our measure of the structural changes of the economy, and reveals certain empirical results from our data. In Section 3, we investigate the relationship between structural changes and economic growth. Finally, Section 4 draws the conclusion.

[1] They compare the economic growth and structural changes for these countries to the case 5 years ago.

2 Measurement of Structural Changes

2.1 Measure

First, we introduce a measure of structural changes of the economy. Following Yoshikawa and Matsumoto (2001), in this paper, we employ the following σ as a measure of structural changes in the economy:

$$\sigma \equiv \frac{1}{t_2 - t_1} \sum_n \left[w_{t_2}^n - w_{t_1}^n \right]^2, \tag{1}$$

where w_t^n denotes the share of sector n in the output at period t. This is a squared mean of growth rates of the sectors' weights. It is then affected by the decline of a sector. Therefore, this is not a measure of innovation. However, we believe that σ can capture a perspective of the dynamics of the economic structure. For example, if a leading sector is formed and grows, σ moves. If each sector grows in a balanced manner, σ should be zero. Our measure, σ, depends on the industrial nomenclature. According to Yoshikawa and Matsumoto (2001), the scale of σ is theoretically independent of the industrial nomenclature; however, using the U.S. data, σ tends to be large if the number of sectors is large. We also measure economic growth by

$$\text{(economic growth)} \equiv \frac{1}{t_2 - t_1} \cdot \frac{\sum_n y_{t_2}^n - \sum_n y_{t_1}^n}{\sum_n y_{t_1}^n}, \tag{2}$$

where y_t^n denotes the output of sector n at period t.

2.2 Data

We use the industrial production index (hereafter IIP) of the Japanese economy as output. The data is monthly; moreover, it is from October 1978 to October 2006. We set $t_2 - t_1 = 12$; we consider growth or changes from the same month of the previous year. We use X12-ARIMA for seasonal adjustment. To calculate σ, we employ the "medium-scale" nomenclature. It might be perferable to use the small-scale nomenclature; however, we employ the medium-scale nomenclature since there are many revisions in the definition of the small-scale nomenclature and it is difficult to use long-period data. Since our goal is mainly on the long run, we adopt this nomenclature. One might point out that IIP only covers the mining and manufacturing sectors, and not the entire economy. This might result in a bias if we take IIP as the output. However, it is often used as a measure of output for an economy in vector autoregression (hereafter VAR) literature. In keeping with the VAR literature, we employ IIP in this paper.

2.3 Empirical Results

We measure structural change σ and economic growth using the data described in the previous subsection. The upper column of Table 1 shows the basic statistics of the measured σ and economic growth. The average and the median of economic

Table 1: Basic Statistics

	σ	output growth
mean	.0014	-.0155
standard deviation	.0006	.05022
median	.0013	-.0227

growth rates are negative in this data period. This is because the data period includes the periods of long stagnation that occured during the 1990s; i.e., *Japan's Lost Decade*. In this period, the Japanese economy fell into a long slump. The relative standard deviation of economic growth is larger than that of σ.

3 Economic Growth and Structural Changes

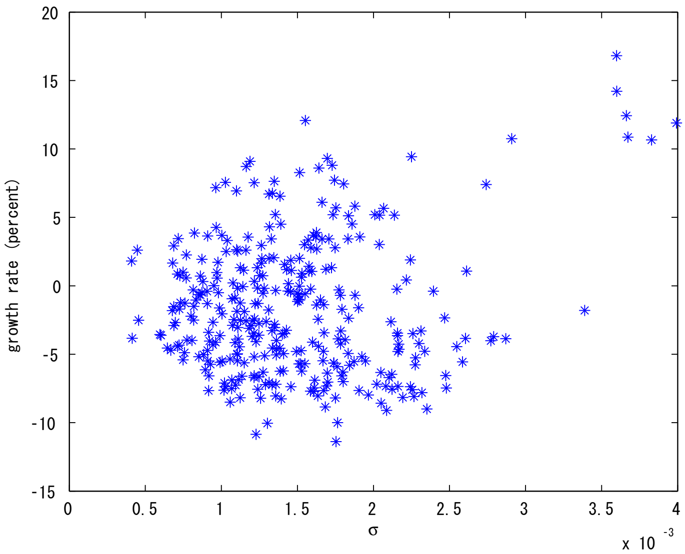
3.1 Raw Series

In Figure 1, we plot σ in relation to economic growth rate. From the figure, it appears that there is no clear correlation between σ and economic growth. The contemporary correlation is .1725, and its p-value is significant at .0016. However, one might point out that this is possibly due to certain outliers in the upper-right corner of the figure. If we exclude these outliers, this appear to be no significant relationship between σ and economic growth.

3.2 Long-run and Short-run Relationships

In the previous subsection, we analyzed raw data. However, there is a lot of data concerning frequency domains, and the relationships between structural changes and economic growth might be different in the case of each domain. In order to capture such effects, we have to divide the raw data into high frequency and low frequency components. We employ the Hodrick-Prescott filter in this paper. It is often used in the business cycle literature to divide original series into long-run trends and cyclical components. The Hodrick-Prescott filter is calculated using the

Figure 1: σ vs. Growth: Raw Series



following problem:

$$\min_{\tau_t} \sum_{t=1}^{T} \left[Y_t - \tau_t\right]^2 + \lambda \left\{ \sum_{t=2}^{T-1} \left[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})\right]^2 \right\}, \tag{3}$$

where Y_t, τ_t, and λ denote the raw data, the low frequency trend, and the smoothing parameter, respectively. Since our data is monthly, we set $\lambda = 14,400$.

3.2.1 Contemporary Relationships

To investigate the relationship between economic growth and structural changes, we plot graphs of σ versus economic growth. Figures 2 and 3 depict these graphs. Figure 2 is quite similar to Figure 1, and there is no clear positive relationship between σ and economic growth in the short run in Figure 2. The contemporary correlation is .1687, and its p-value is .0020; thus, it is significant. However, as in Figure 1, if we exclude certain outliers located in the upper-right corner, these appear to be no clear correlations. On the contrary, there is a clear positive relationship between σ and economic growth, as in Figure 3. The contemporary correlation is .2073, and its p-value is 1.3588e-004, which is positively correlated. We summarize the results as follows. In the short run, there is no clear relationship between structural changes and economic growth; however, structural changes are positively correlated with economic growth in the long run, as in Figure 3.

Figure 2: σ vs. Growth: HP Cycle

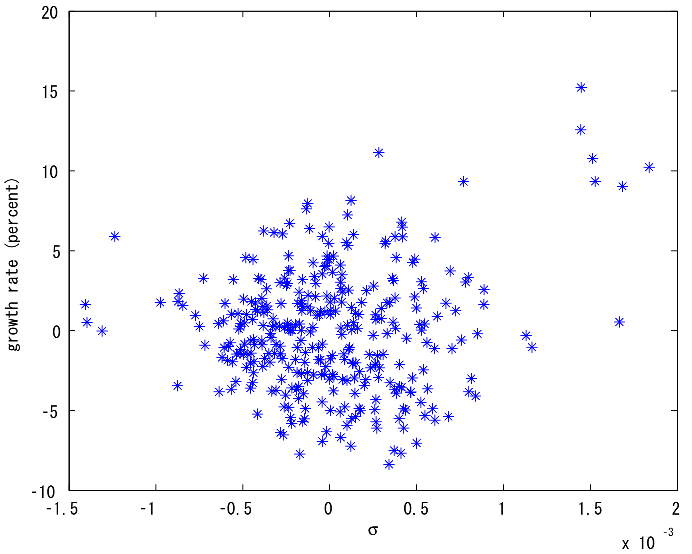
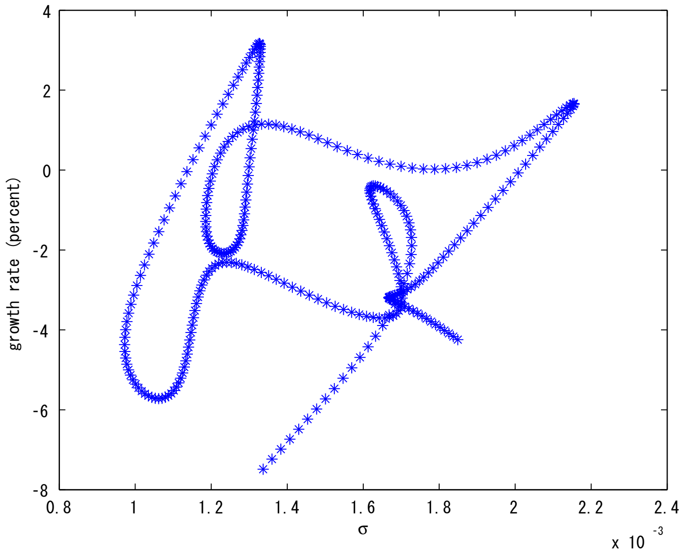


Figure 3: σ vs. Growth: HP Trend



3.2.2 Dynamic Relationships

Thus far, we have only focused on the contemporary relationship between structural changes and economic growth. With respect to dynamic relationship, a number of macroeconomists have displayed interest in the dynamic relationship of variables both in theoretical and empirical terms. The dynamic relationship might diffe from the contemporary one. Recently, there was a discussion about the effects of technology shocks on factor-inputs in the short run; new Keynesian economists claim that technology shock is contractionary, while neoclassical economists claim that it is expansionary. However, both share a common view in the long run; technology shock is expansionary in the long run. This example shows that the effects of technology shock in the short run might differ in the long run. Thus, the relationship between structural changes and economic growth might be different.

To capture these dynamic relationships, we employ the vector autocorrelation functions as in Fuhrer and Moore (1995).[2] The vector autocorrelation functions are calculated using the VAR process; thus, they are eliminated effects of other economic variables; *unconditional* correlations. In the time-series literature, the major approach is to analysis using the impulse response function. However, we do not employ it here since we have to apply certain assumptions for the identification of structural shocks in order to calculate the impulse response functions; for example, the order of the determination of variables, long run relationship of structural shocks and variables, and so on. It is difficult to assume a relationship between σ and economic growth. An advantage of the vector autocorrelation function is that we do not need explanation of any assumptions for the identification of structural shocks.

Addition to σ and economic growth, we include certain monetary variables in the VAR process: the call rate, the monetary base, and the consumer price index. This is because an estimated VAR process with a small number of variables might not be a good approximation of the actual system.[3] These monetary variables are taken from the Bank of Japan website. Before the VAR estimation, we test the unitroot of variables using the augmented Dickey-Fuller test. We cannot reject the null hypothesis that the variables do not have unit roots for the monetary base, the consumer price index, and σ. Then, we take the first-order differences for these variables. We set the number of lags in the VAR estimation as 10.[4] We use monthly data, therefore, this number of lags is standard. Figures 9 and 5 show the vector autocorrelation functions of σ and economic growth in the short run and the long run. The horizontal axes show years. There is no clear dynamic

[2] A theoretical explanation of the vector autocorrelation functions is grounded in the Appendix.

[3] For example, see Chari, Kehoe and McGrattan (2005).

[4] We set 10 as the number of lags since the maximum number of lags is 10 in the test under the Ng-Perron-Hayashi's rule for the determination of the number of lags is 10.

Figure 4: Vector Auto-Correlation Functions: HP Cycle

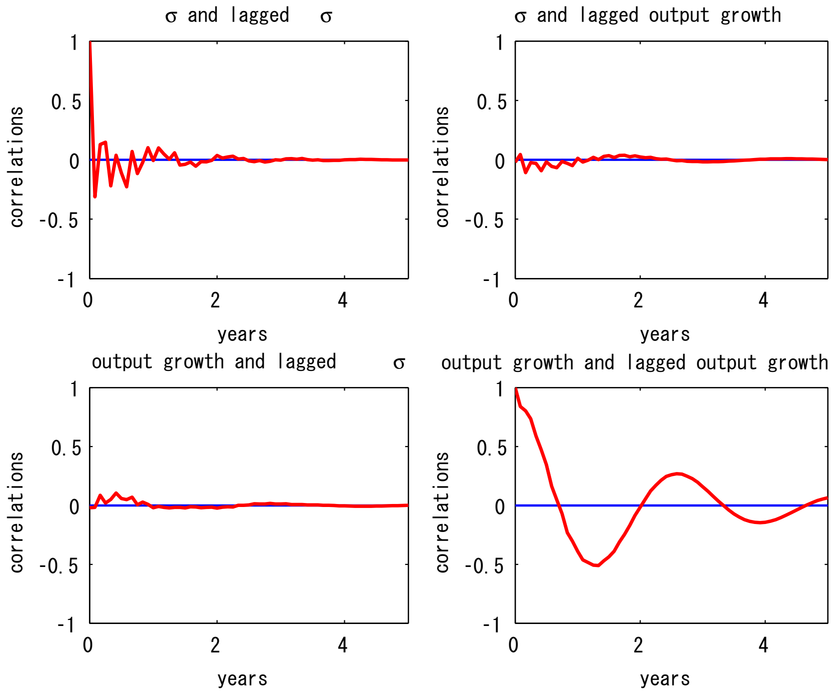
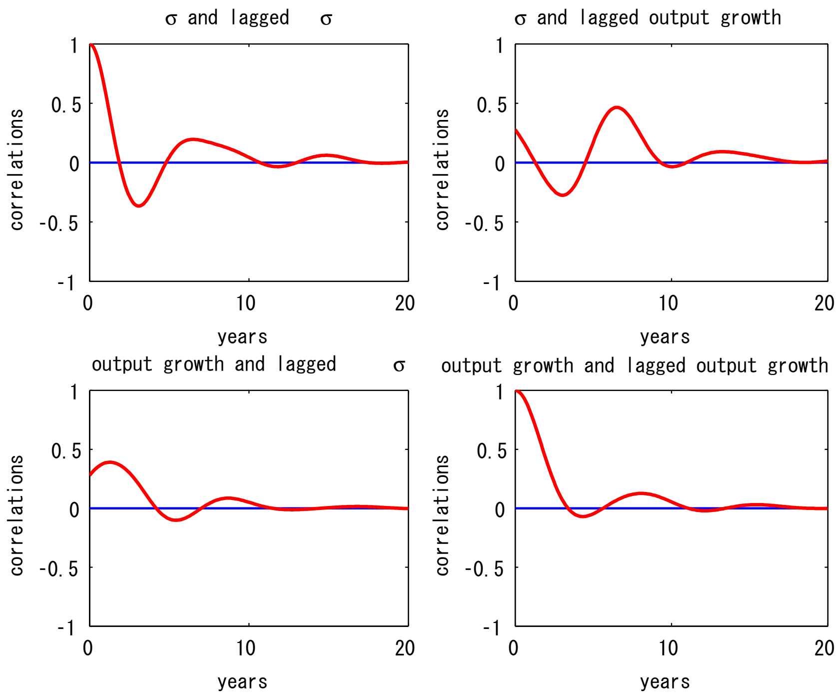


Figure 5: Vector Auto-Correlation Functions: HP Trend



correlations between structural changes and economic growth in the short run by Figure 9. Contrary to the case of the short run, we find that there are positive dynamic correlations between σ and economic growth in the long run in Figure 5. The (2,1) component of the figure especially shows that high σ in the past implies a high future economic growth. Past structural changes are related to economic growth for a perild of about 5 years. This result is consistent with the theory that the entry of a new industry leads to economic growth. In summary, we find that there is no clear dynamic correlation between economic growth and structural changes in the short run; however, the dynamic relationship between structural changes and economic growth is positively correlated in the long run as in the case of contemporary relationships.

4 Concluding Remarks

In this paper, we investigated the relationship between structural changes of the economy and economic growth using Japanese sectoral monthly data. We found that (i) there is no clear relationship between structural changes and business cycles in the short run; however, (ii) the long-run movements of structural changes are positively correlated with economic growth. Our result is consistent with the neoclassical view in the short run, and it is also consistent with the Schumpeterian view of economic growth in the long run.

Appendix: Vector Autocorrelation Functions

Here, we explain how to calculate the vector autocorrelation functions according to Fuhrer and Moore (1995).

The Companion Form of the Model: First, we define the structural form of the p-th order vector autoregressive process such that

$$\boldsymbol{B}_0\boldsymbol{x}_t = \sum_{i=1}^{p} \boldsymbol{B}_i\boldsymbol{x}_{t-i} + \boldsymbol{\varepsilon}_t, \tag{4}$$

where $\boldsymbol{x}_t$, $\boldsymbol{B}_k$, and $\boldsymbol{\varepsilon}_t$ denote a vector of economic variables, a coefficient matrix, and a vector of fundamental shocks, respectively. We can only estimate the following reduced form;

$$\boldsymbol{x}_t = \sum_{i=1}^{p} \boldsymbol{C}_i\boldsymbol{x}_{t-i} + \boldsymbol{u}_t, \tag{5}$$

where $\boldsymbol{C}_i \equiv \boldsymbol{B}_0^{-1}\boldsymbol{B}_i$ and $\boldsymbol{u}_t \equiv \boldsymbol{B}_0^{-1}\boldsymbol{\varepsilon}_t$. The companion form of this system is

$$\boldsymbol{Y}_t = \boldsymbol{F}\boldsymbol{Y}_{t-1} + \boldsymbol{\eta}_t, \tag{6}$$

where

$$\boldsymbol{Y}_t = \begin{bmatrix} \boldsymbol{x}_t \\ \boldsymbol{x}_{t-1} \\ \boldsymbol{x}_{t-2} \\ \vdots \\ \boldsymbol{x}_{t-p} \end{bmatrix}, \quad \boldsymbol{\eta}_t = \begin{bmatrix} \boldsymbol{u}_t \\ \boldsymbol{0} \\ \boldsymbol{0} \\ \vdots \\ \boldsymbol{0} \end{bmatrix}, \quad \boldsymbol{F} = \begin{bmatrix} \boldsymbol{C}_1 & \boldsymbol{C}_2 & \boldsymbol{C}_3 & \cdots & \boldsymbol{C}_p \\ \boldsymbol{I} & \boldsymbol{0} & \boldsymbol{0} & \cdots & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{I} & \boldsymbol{0} & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \boldsymbol{0} \\ \boldsymbol{0} & \cdots & \boldsymbol{0} & \boldsymbol{I} & \boldsymbol{0} \end{bmatrix}. \tag{7}$$

Vector Autocorrelation Functions: Recursive substitution of (6) induces

$$\boldsymbol{Y}_{t+k} = \boldsymbol{F}^k\boldsymbol{Y}_t + \sum_{i=0}^{k} \boldsymbol{F}^i\boldsymbol{\eta}_{t+i}, \tag{8}$$

Since $\boldsymbol{\eta}_t$ is uncorrelated over time, the covariance matrix of the k-period forecasts is

$$\boldsymbol{V}_t(\boldsymbol{Y}_{t+k}) = \sum_{i=0}^{k-1} \boldsymbol{F}^i\Psi\left[\boldsymbol{F}^i\right]', \tag{9}$$

where Ψ is the covariance matric of $\boldsymbol{\eta}_t$. In a stationary model, the *conditional* covariance matrix $\boldsymbol{V}_t(\boldsymbol{Y}_{t+k})$ converges to $\boldsymbol{\Gamma}_0$, and the *unconditional* covariance matrix of $\boldsymbol{Y}_t$ as k goes to infinity. Following Fuhrer and Moore (1995), we treat the sum in (9) as $\boldsymbol{\Gamma}_0$.

Then, the vector autocovariance matrix is calculated recursively according to

$$\boldsymbol{\Gamma}_k = \boldsymbol{F}\boldsymbol{\Gamma}_{k-1}, \quad k > 0. \tag{10}$$

Finally, dividing each row and column of $\boldsymbol{\Gamma}_k$ for $k \geq 0$ by the squared root of the corresponding diagonal element of $\boldsymbol{\Gamma}_0$ yields the model's vector autocorrelation functions.

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