Structural Change and Business Cycle: Evidence from Taiwan and Korea

Hsin-Fu Tsai, Professor of Accounting, Tamkang University, Taiwan, R.O.C.
Wei-Chuan Wang ,Ph.D. Postgraduate, Tamkang University,Taiwan,R.O.C.

ABSTRACT

This paper explores the feature of business cycle across breaks in Taiwan and Korea. We employed tests devised by Bai and Perron (2003) to show that, for Taiwan's business cycle, two breaks are present. In contrast, one break is revealed in the economic restructuring process in Korea. Moreover, the feature of business cycle process across breaks is congruent with the real business cycle theory.
Keywords: *Structural change; business cycle.JEL classification: J16; J21*

INTRODUCTION

Theoretical and empirical research examining business cycle dynamic has grown rapidly since Hamilton (1989) introduced a new approach, the so-called Markov-switch model. The MS model has successfully characterized the behavior of macroeconomic fluctuations (Kim, 1994; Cruz, 2005). Nevertheless, the MS model fails to capture some non-linearity features for some economies (Goodwin, 1993; Krolzig, 2001). Among the prior studies, in particular, Li et al. (2005) simultaneously examines the performance of MS model on business cycle identification for three different groups: (1) the USA and Japan serving as the industrialized economies; (2) Taiwan and South Korea serving as the newly industrialized economies (or NIE hereafter); and (3) Malaysia and Indonesia serving as the developing countries. They found the MS model performs well to depict the business cycles for IEs and DEs. However, the MS model fails to depict the post-1990 period business cycle for Taiwan and South Korea, for which they suggest the existence of the structural breaks.

The aim of this paper extends the study of Li et al. (2005) to detect the number of breaks in Taiwan and Korea. In particular, we are interested the number of structural breaks and their locations, especially the period of post-1990. The econometrics literature holds a vast amount of work related to structural change, but the empirical studies of structural change have received less but an increasing attention. Recently, Bai and Perron (1998, 2003) developed a linear model to estimate multiple structural changes by least squares. Moreover, they proposed a set of tests to estimate consistently the number of structural change. In the context of estimating multiple structural changes, Yao (1988) consider estimating the number of breaks based on Bayesian Information Criterion (BIC) while Liu et al. (1997) suggest the use of the modified Schwarz criterion (LWZ). The tests proposed by Bai and Perron (1998, 2003) provide the distinct advantage to examine the multiple structural changes for accounting the possible serial correlation in the errors and heterogenous variances across segments. Although Jouini and Boutahar (2003) suggest the procedure method is more power than the information criteria in detecting changes, both of the procedure method and information criteria are employed in the present study for comparison purpose.

Once these breaks are determined, this article further explores the events associated with the structural breaks. One central and long-standing controversial issue in business cycle research is that what are the shocks cause business fluctuations. Theories that advocate business cycle process as driven from monetary disturbance have been challenged by real business cycle theory which model changes in productivity to explain the cyclical ups and downs in economic activity (Kydland and Prescott, 1982). The general idea is that some changes occur that directly changes the effectiveness of capital and labor. This in turn affects the decisions of workers and firms, who in turn change what they buy and produce and thus eventually affect output. Although Prescott (1986) emphasize the technology shock as the main section account for more than half the fluctuations in U.S. business cycle has been challenged (e.g. Basu, 1996;

Burnside et al., 1996; Jaimovich, 2004), alternatives (e.g. oil shock and fiscal shock) to technology shocks has inspired the development of the RBC model.

The paper is organised as follows. Section Ⅱ outlines structural change model and a sequence of tests proposed by the Bai and Perron (1998, 2003). In Section Ⅲ we explore the empirical results. Conclusions are in Section Ⅳ.

THE STRUCTRAL CHANGE MODEL AND TESTS

The model

Following Bai and Perron (1998, 2003), a multiple linear regression with m breaks (m+1 regimes) is considered as below:

$$y_t = x'_t \beta + z'_t \delta_j + u_t \qquad t = T_{j-1}+1,...,T_j \tag{1}$$

where $j = 1,...,m+1$; y_t is the explained variable; x_t ($p \times 1$) and z_t ($q \times 1$) are vectors of explanatory variables; β and δ_j (j=1,…,m+1) are the vectors of coefficients; u_t is the error term at time t. Equation 1 indicates a partial structural change model because the coefficient β is not subject to change; while p=0, a pure structural model is arrived since all parameters are subject to change. The method of estimation for coefficients (β and δ_j) is based on minimizing the sum of squared residuals.

A test of no break versus so me fixed number of break

Bai and Perron (1998, 2003) introduces the supF type test for no structural change (m=0) versus m=k breaks. **Define**

$$F_T(\lambda_1,...,\lambda_k;q) = \frac{1}{T}\left(\frac{T-(K+1)q-p}{kq}\right)\hat{\delta}' R'[R\hat{v}(\hat{\delta})R']^{-1} R\hat{\delta} \tag{2}$$

Where (T_1,…,T_K) be the partition; R be the conventional matrix so that $(R\delta)' = (\delta'_1 - \delta'_2,...,\delta'_k - \delta'_{k+1})$; $\hat{V}(\hat{\delta})$ is the variance covariance matrix of $\hat{\delta}$ which is robust to serial correlation and heteroscedasticity[1]. The test is $supF_T(k;q)=F_T(\hat{\lambda}_1,...,\hat{\lambda}_k;q)$ where $\hat{\lambda}_1,...,\hat{\lambda}_k$ is the estimator by minimizing the global sum of squared residuals. The asymptotic distribution relies on a trimming parameter through the minimal length h of a segment ($\varepsilon = \frac{h}{T}$). Bai and Perron (2003) provide several specifications for different scenarios, such as serial correlation in the errors, different distributions for data and errors across segments for both partial structural change and pure structural change models. However, these issues are less crucial when the sample size is larger and/or the trimming ε is large. Bai and Perron (1998, 2003) also supplement the crucial value for $\varepsilon = 0.10, 0.15, 0.20, 0.25.$

Double maximum tests

In case of researchers which to consider tests of no structural break against an unknown number of breaks. Bai and Perron (1998, 2003) proposed two classes of tests, namely double maximum tests:

$$UD\max F_T(M,q,a_1,...,a_M) = \max_{1\le n\le M} a_m \; F_T(\hat{\lambda}_1,...,\hat{\lambda}_m;q) \tag{3}$$

$$WD\max F_T(M,q) = \max_{1\le m\le M} \frac{c(q,\alpha,1)}{c(q,\alpha,m)} F_T(\lambda_1,..,\lambda_m;q) \tag{4}$$

The first is an equal weighted version $(a_1,...,a_M)$; while the second test employs weights to the individuals tests so that the marginal p values are equal across values of m.

[1] To do so, Bai and Perron (1998, 2003) employ Andrews (1991) data dependent method with the Quadratic Spectral Kernel and an AR(1) approach to select the bandwidth.

A test of m verus m+1 breaks

Bai and Perron (1998, 2003) propose a test of the null hypothesis of m breaks against the alternative m+1 breaks. A rejection in favor of a model with m+1 breaks if the overall minimal value of the sum of squared residuals is sufficiently smaller than the sum of squared residuals from the m break model. Moreover, they also suggest a sequential algorithm for multiple breaks model. In a case of m breaks, while the first break point is identified, the sample is separated into two sub-samples by the first break point. The same procedure is employed for each sub-sample until the m breaks are arrived.

DATA AND EMPIRICAL RESULTS

This section investigates the structural breaks and phases of business cycle in Taiwan and korea. The data are drawn from the AREMOS data bank from 1962:1 to 2006:2 conducted by the Statistical Bureau of Taiwan and the Bank of Korea, respectively.

Figure 1 shows the time series graphs of the Taiwan's business cycle. Note that the Taiwan's business cycle in the period of 1962-2006 has endured two significant shocks, which forces the economic growth move backward. The first is the international energy crisis in 1973-74; while the second shock is the great depression in 2000-02. Before the event of international energy crisis, Taiwan has experienced a period of high growth, for which the average economic growth rate is 10 per cent during 1962-73. Moreover, the economic growth also has a downward tendency after the international energy. Only in 1982 the economic growth rate falls around 3 per cent because of the second international energy crisis. After the two briefly booms in 1983-84 and 1986-87, the economic growth in Taiwan seems switch to low growth regime, for which the average economic growth is 6.5 per cent during 1988-2000.

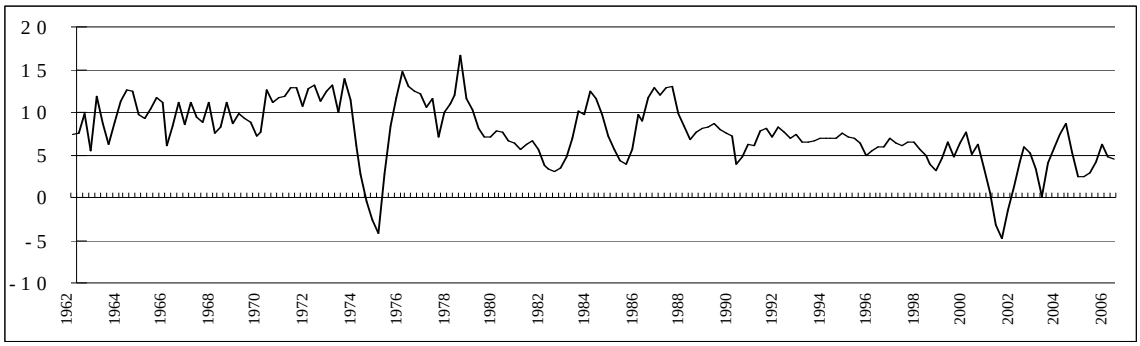

Figure 1 The quarterly real GDP growth in Taiwan, 1962:1-2006:2

Figure 2 depicts the time series behavior of Korean business cycle from 1971:1 to 2006:2.

Note that Korean economy also suffered from two significant shocks, which associated with the second international energy crisis and the Asian financial crisis. The Korean economy seems recovery quickly from the second international energy crisis but damaged from the Asian financial crisis. Korea has experienced two period of high growth in 1971-1979 and 1980-1997, for which the average economic growth rate is 8.1 and 7.9 per cent, respectively. After the Asian financial crisis, the Korean economy also switch to low growth period, for which the average economic growth is 5.6 per cent during 1999-2006.

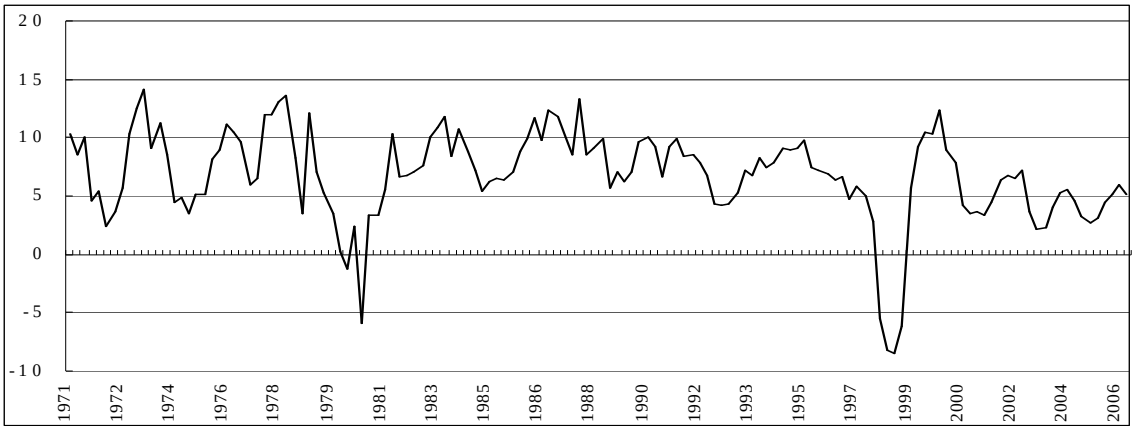

Figure2 The quarterly real GDP growth in Korea, 1971:1-2006:2

Table 1 reports the estimation results of Taiwan's business cycle based on the tests developed by Bai and Perron (1998, 2003). We impose 15% trimming on the end of the sample and allow a maximum of five breaks. Note that the $SupF_T(k)$ tests are all significant for k between 5 and 1. This evidence suggests at least one structural break is present. The $SupF_T(2 \mid 1)$ test takes the value 36.31 and suggests the rejection of null hypothesis for only one structural break. Moreover, the $SupF_T(3 \mid 2)$ test is rejected at 5 per cent level. Two structural breaks are also arrived by the sequential procedure as well as information criteria of the BIC and LWZ. Thus, based on the $SupF_T(k \mid k+1)$ test, sequential procedure, BIC and LWZ, two breaks is concluded for the Taiwan's business cycle. The coefficient estimates point to the timing of structural change behavior of Taiwan's business cycle. The coefficient δ_1 varies from 1.39 to 2.66 in 1974:4 and then fall to 4.59 in 1988:3.

Table 1 Empirical results for real GDP growth in Taiwan 1962:1-2006:2.

$\{z_t\}$	q=1	p=0	h=26	M=5		
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	UDmax	WDmax
7.09[b]	26.02[a]	18.33[a]	19.36[a]	16.16[a]	26.02[a]	35.47[a]
$SupF_T(2\|1)$	$SupF_T(3\|2)$					
36.31[a]	3.82					
Break number[1]		Estimates with Two Breaks[2]				
Sequential	2	$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{\delta}_3$	$\hat{T}_1$	$\hat{T}_2$
BIC	2	1.39	2.66	1.67	1974:4	1988:3
LWZ	2	(0.09)	(0.15)	(0.07)	(1972:4-1975:3)	(1987:4-1992:1)

Notes:

[1] 5 per cent size is used for the sequential test.

[2] The standard errors, which robust to serial correlation, and 95 per cent confidence intervals for $\hat{T}_i$ (i=1,2) are in parentheses.

[a,b] Significance at the 5 % and 10% levels, respectively.

Table 2 reports the result of BP tests for Korean business cycle. Similar to Table 1, the $SupF_T(k)$, UDmax and WDmax tests for Korean all significant for k between 5 and 1 and suggest the existence of at least one structural break. Moreover, the sequential procedure, BIC and LWZ tests suggest only one structural break for Korean business cycle. This evidence shows that the restructuring activity in Taiwan is more dynamic than Korea.

We next look at the timing of the estimated break of business cycles for Taiwan and Korea. For Taiwan's business cycle, the first break date is located in 1974, which is linked to the first international energy crisis. The second break is detected in 1988, which is associated with change of exchange rate system. In contrast, the beak for Korean business cycle is estimated at 1996:4, which is associated with the Asian financial crisis.

Based on the break test results, the business cycle process in Taiwan and Korea is partitioned into three and two distinct time periods, respectively. In Taiwan, the first period ends in 1974, and the third period begins in 1988. In contrast, the first period in Korea ends in 1996. The average growth rate decreases from 9.54 per cent to 8.72 per cent in 1974, and another falling of 38 per cent in 1988. The Korean economic growth shifts from 7.69 to 4.17 per cent in 1996. Moreover, the volatility of annual growth rate, which measured as the standard deviation, is examined. In Taiwan, the volatility of annual growth rate increases from 2.78 to 4 in 1974, but falls to 2.6 in 1988. In contrast, the standard deviation estimates of Korea are 3.22 and 4.54, respectively. The combination of these two results is congruent with the real business cycle theory, which emphasize the business fluctuation is initiated from exogenous changes.

Table 2 Empirical results for real GDP growth in Korea 1971:1-2006:2.

$\{z_t\}$	q=1	p=0	h=21	M=5		
$SupF_T(1)$	$SupF_T(2)$	$SupF_T(3)$	$SupF_T(4)$	$SupF_T(5)$	UDmax	WDmax
19.23	14.02*	10.11*	11.42*	17.60*	19.23*	38.61*
$SupF_T(2\|1)$						
3.31						
Break number			Estimates with one Break			
Sequential	1		$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{T}_1$	
BIC	1		7.69	4.17	1996:4	
LWZ	1		(0.31)	(0.73)	(1993:2-1998:2)	

Notes:
*Significance at the 5 % level.

CONCLUSTION

The objective of this paper is to identify the breaks in the business cycle process in Taiwan and Korea. Once the breaks dividing the different business cycle period, a further objective is to use the results to analysis the implications of the real business cycle theory. We employed tests devised by Bai and Perron (2003) to show that, for Taiwan's business cycle, two breaks are present. In contrast, one break is revealed in the economic restructuring process in Korea. Moreover, the feature of business cycle process across breaks is congruent with the real business cycle theory.

REFERENCES

Bai, J., and P. Perron(1998). *Estimating and testing linear models with multiple structural changes*, Econometrica 66, 47-78.

Bai, J., and P. Perron.(2003). *Computation and analysis of m*ultiple *s*tructural *c*hange *models*, *Journal of Applied Econometrics* 18, pp. 1-22.

Basu, S.(1996). Procyclical productivity, increasing returns or cyclical utilization?, *Quarterly Journal of Economics* 111, 719–51.

Burnside, C. and Eichenbaum, M.(1996). Factor-hoarding and the Propagation of Business cycle shocks, *American Economic Review* 86, 1154–1174.

Cruz, M.(2005). A three-regime business *c*ycle model for an emerging economy, Applied Economics Letters, 12, 399-402.

Goodwin, T. H.(1993). Business-Cycl*e* Analysis with a Markov-Switching Model, *Journal of Business and Economic Statistics*, 11, 331-39.

Hamilton, J. D.(1989).A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle, Econometrica, 57, 357-84.

Jouini, J. Boutahar, M.(2003). Structural Breaks in the U.S. Inflation Process: A Further Investigation, Applied Economics Letters, 10, 985-88.

Jaimovich, N.(2004). Firm Dynamics, Markup Variations, and the Business Cycle, mimeo, University of California, San Diego.

Kim, C. J.(1994). Dynamic Linear Models with Markov-Switching, *Journal of Econometrics*, 60, 1-22.

Krolzig, H.M.(2001). Business cycle measurement in the presence of structural change: international evidence, *International Journal of Forecasting*, 17, 349-68.

Kydland, F. E. and Prescott, E. C.(1982). Time to Build and Aggregate Fluctuations, Econometrica 50, 1345–1370.

Li, M-Y, Lin, H-W and H-h Rau.(2005). The Performance of the Markov-Switching Model on Business Cycle Identification Revisited, Applied Economics Letters, 12, 513-20.

Liu J. Wu S, Zidek JV.(1997). One segmented multivariate regressions. Statistical Sinica 7, 497-525.

Prescott, E.(1986). Theory Ahead of Business-cycle Measurement, Carnegie-Rochester Conference Series on Public Policy 25, 11–44.

Yao Y-C.(1988). Estimating the number of change-points via Schwarz' criterion. Statistics and Probability Letters 6, 181-89.