E C O N O M I C S   B U L L E T I N

Using Regional Cycles to Measure National Business Cycles in the U.S. with the Markov Switching Panel Model

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Abstract

This paper measures the accuracy of using regional cycles to identify national business cycle turning points in the U.S. with the Markov Switching Panel (MSP) model. Based on the MSP model, it is determined that regional cycles are highly capable of identifying national business cycle turning points in the U.S., but the duration of recessions of regional cycles are longer than those of national business cycles.

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1 Introduction

The United States is made up of diverse regions that respond differently to changing economic conditions. But, in point of fact, national business cycles are amalgams of regional cycles. Because of the transmission of cyclical impulses in the national economy to the regional level, to some extent, regional cycles tend to mimic national business cycles.

A substantial volume of literature has examined various issues related to regional cycles. One important outcome of previous studies is that, because state and regional economy-watchers are perhaps in greater need of applied work on indexes than are their national counterparts, they have constructed the leading and coincident indexes for states or regions based on Stock and Watson's (1989, 1991) methodology (see, for example, Crone, 1994; Crone and Babyak, 1996; Clayton-Matthews et al., 1994; Clayton-Matthews and Stock, 1998/1999; Phillips, 1988, 2005). If regional cycles were concurrent with and were of the same intensity as the national economy, then national indexes would suffice. But, by no means is this the case. Some studies have mostly looked at co-movement or synchronization among regional business cycles. See, for example, Carlino and DeFina (1995), Carlino and Sill (1997), Crone (1998/1999) and Rissman (1999) for details. Domazlicky (1980) provided a comprehensive survey of the literature on early regional business cycle, while Selover et al. (2005) provides a good literature review of more recent studies.

National business cycles are broadly defined as common fluctuations of such aggregate economic variables as personal income, employment and output around trend values. Burns and Mitchell (1946, p.3) formally defined business cycles as, "... expansions occurring at about the same time in many economic activities, followed by similar general recessions, contractions and revivals..." That is, they established two defining characteristics of the business cycle. The first is the presence of *nonlinearity* in the evolution of a business cycle, that is, regime switching at a specific the turning point. Selover et al. (2005) also emphasize that nonlinearity is important for business cycle fluctuations because linear models are unable to generate sustained cyclical behavior and tend to either die out or diverge to infinity over time. The second characteristic is *co-movement* among economic variables throughout the cycle.[1] This is an integral part of the long-standing view that stresses the coordination of activities among various economic sectors and the resulting co-movement in sectoral outputs. Clark (1992) claimed that one of the key stylized facts about national business cycles is that the economies of various regions of the United States tend to move together over time. Carlino and DeFina (1995) also found a high degree of co-movement among different U.S. regions, without such co-dependence being limited to regions adjacent to each other.

Quah (1996, p. 157) reported that a business cycle might best be viewed as a 'wave' of regional dynamics rippling across the national economy. However, a number of factors may cause regional and national cycles to differ. See Guha and Banerji (1998/1999) for a review. Thus, practitioners have long questioned the usefulness of regional cycles in terms of identifying or predicting national business cycle turning points in the U.S.? This paper answers this. That is, this paper measures national business cycles based on regional cycles in the U.S.

We employ the Markov Switching Panel model to achieve the work. Under the assumption that the fixed effect holds, we can add the regime switching mechanism to the panel model and easily estimate it using Hamilton's (1989) procedure. To the best of our knowledge, the panel model with regime switching has never been used in studies of regional business cycles.[2] We find that by using the Markov Switching Panel model, regional cycles can accurately identify national business cycle turning points in the U.S., and these are very close to the business cycle dates defined by the National Bureau of Economic and Research (NBER). Basically, the recessionary periods of regional cycles are longer than those of national business cycles.

We discuss the methodology, i.e., the Markov Switching Panel model in Section 2. We then present the results in Section 3 and the concluding remarks and an important policy implication in Section 4.

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[1]This was underscored by Lucas (1976) who drew attention to a key fact about business cycles: outputs of broadly-defined sectors move together.

[2]The study by Asea and Blomberg (1998) was the first to use the Markov Switching Panel model, but it was not in a study of business cycles.

2 Methodology

Suppose that we have sample observations with $K(k = 1, ..., K)$ features for $N(i = 1, ..., N)$ individuals over $T(t = 1, ..., T)$ time periods. Consider the following equation:

$$y_{it} = c_i + \sum_{k=1}^{K} \beta_k X_{kit} + \varepsilon_{it}; \tag{1}$$

Let

$$\boldsymbol{y}_i = \begin{bmatrix} y_{i1} \\ y_{i2} \\ \vdots \\ y_{iT} \end{bmatrix}; \ \boldsymbol{X}_i = \begin{bmatrix} X_{1i1} & X_{2i1} & \dots & X_{Ki1} \\ X_{1i2} & X_{2i2} & \dots & X_{Ki2} \\ \vdots & \vdots & \vdots & \\ x_{1iT} & X_{2iT} & \dots & X_{KiT} \end{bmatrix}, \ \boldsymbol{j}_T = \begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{bmatrix}; \ \boldsymbol{\varepsilon}_i = \begin{bmatrix} \varepsilon_{i1} \\ \varepsilon_{i2} \\ \vdots \\ \varepsilon_{iT} \end{bmatrix},$$

where $\boldsymbol{y}_i$, $\boldsymbol{j}_T$ and $\boldsymbol{\varepsilon}_i$ are $T \times 1$ column vectors and $\boldsymbol{X}_i$ is a $T \times K$ matrix; we can then re-write equation (1) as follows:

$$\begin{bmatrix} \boldsymbol{y}_1 \\ \boldsymbol{y}_2 \\ \vdots \\ \boldsymbol{y}_N \end{bmatrix} = \begin{bmatrix} \boldsymbol{j}_T & \mathbf{0} & \dots & \mathbf{0} \\ \mathbf{0} & \boldsymbol{j}_T & \dots & \mathbf{0} \\ \vdots & & \vdots & \\ \mathbf{0} & \dots & \mathbf{0} & \boldsymbol{j}_T \end{bmatrix} \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_N \end{bmatrix} + \begin{bmatrix} \boldsymbol{X}_1 \\ \boldsymbol{X}_2 \\ \vdots \\ \boldsymbol{X}_N \end{bmatrix} \boldsymbol{\beta} + \begin{bmatrix} \boldsymbol{\varepsilon}_1 \\ \boldsymbol{\varepsilon}_2 \\ \vdots \\ \boldsymbol{\varepsilon}_N \end{bmatrix},$$

or to be more compact:

$$\boldsymbol{Y} = \boldsymbol{D}\boldsymbol{c} + \boldsymbol{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}, \tag{2}$$

where

$$\boldsymbol{D} = \begin{bmatrix} d_1 & d_2 & \dots & d_N \end{bmatrix} = \begin{bmatrix} \boldsymbol{j}_T & \mathbf{0} & \dots & \mathbf{0} \\ \mathbf{0} & \boldsymbol{j}_T & \dots & \mathbf{0} \\ \vdots & & \vdots & \\ \mathbf{0} & \dots & \mathbf{0} & \boldsymbol{j}_T \end{bmatrix};$$

$\boldsymbol{\beta} = [\beta_1 \ \beta_2 \ \dots \ \beta_k]$ is a $K \times 1$ column vector; and D is an $NT \times N$ matrix. Equation (2) is the so-called Least Squares Dummy Variable (LSDV) model. The specification of the Markov Switching Panel model (hereafter the MS-LSDV model) requires adding the regime switching mechanism to the LSDV model and it is written as follows:

$$\boldsymbol{Y} = \boldsymbol{D}\boldsymbol{c}(j) + \boldsymbol{X}\boldsymbol{\beta}(j) + \boldsymbol{\varepsilon}(j), \ \text{for} \ S_t = j, \tag{3}$$

where $\varepsilon(j) \sim N(0,\ \sigma^2(j))$ and the unobserved state variable S_t follows a first order Markov chain:

$$G = \begin{bmatrix} \text{prob}(S_t = 1|S_{t-1} = 1) & \text{prob}(S_t = 1|S_{t-1} = 2) \\ \text{prob}(S_t = 2|S_{t-1} = 1) & \text{prob}(S_t = 2|S_{t-1} = 2) \end{bmatrix}. \tag{4}$$

We consider an unobserved latent variable S_t which takes on the value 1 when the economic state is in expansion and 2 when it is in contraction. Because the data in equation (3) are stacked and the data are just like those in the univariate Markov Switching model, we can use the well-known straightforward procedure proposed by Hamilton (1989) for the MS-LSDV model. We do not discuss that algorithm here as it is well documented in the extant literature. In order to evaluate the ability of the MS-LSDV model to measure business cycle turning points, we calculate the "average" filtered probability across N individuals as follows:

$$\text{ave}Pr(S_t = j|\Phi^t) = \frac{1}{N}\sum_{1}^{N} Pr(S_t = j|\Phi^t), \tag{5}$$

where Φ^t is the information set consisting of the history of all of the variables up to date t.

3 Data and Results

We use seven coincident variables of regional cycles and employ the Markov Switching Panel model to the identify national cycle turning points in the U.S. The seven coincident indexes published by the Federal Reserve Bank of St. Louis are summarized in Table 1.[3] Let $y_{it} = [y_{1t}\ y_{2t}\ y_{3t}\ y_{4t}\ y_{5t}\ y_{6t}\ y_{7t}]'$ be the growth rate of the seven coincident variables. The sample covers 1979:m2 to 2006:m9 for a total of 332 observations. In sum, we have $N = 7$ and $T = 332$ in our Markov Switching Panel model.

The parameter estimates from the LSDV model and the MS-LSDV model are summarized in Table 2.[4] The first point to note is that the result from the likelihood ratio test is $-2 \times (441.963 - 524.940 = 165.954) > \chi^2_{0.01} = 18.48$, which indicates that the null hypothesis of the linear LSDV

[3]We download the data from the website: `http://research.stlouisfed.org/fred2/search/coincident+index/1`.

[4]Here, we perform a numerical estimation of the unknown parameters using the OPTIMUM module of GAUSS 3.2 with a combination of the Broyden-Fletcher-Goldfarb-Shanno (BFGS) algorithm.

model is rejected at the 1% level of significance in favor of the MS-LSDV model. There is one econometric issue when LR is used, however. Because the parameters are not identified under the null, the conventional LR test does not yield the standard asymptotic distribution.[5] Although most researchers still use the LR for useful supporting evidence, it may not be suitable when it comes to providing the sole evidence for the rejection or non-rejection of the null hypothesis. Throughout this paper, our LR test is considered in this way.

We observe that the parameter estimates for $c(1)$, $d1(1)$, $d2(1), \ldots$ and $d6(1)$ are 0.422, -0.075, $-0.024, \ldots$, and -0.069, respectively, while those for $c(2)$, $d1(2)$, $d2(2), \ldots$ and $d6(2)$ are -0.011, -0.022, -0.201,... and -0.062, respectively. These estimates indicate that the estimated mean growth rate of y_{1t}, y_{2t}, $y_{3t}, \ldots$, and y_{7t} in the expansionary state are 0.422, 0.347, 0.398,.., and 0.353, respectively. These estimates are greater than the estimated mean growth rates in the contractionary state, which are -0.011, -0.033, $-0.212, \ldots$, and -0.073, respectively. Moreover, the parameter estimates of the transition probabilities are $p_{11} = 0.982$ and $p_{22} = 0.954$, indicating that the duration of the expansionary periods is longer than that of the contractionary periods.

Fig. 1 shows the model-identified turning points, as determined by the Markov Switching Panel model based on the average filtered probabilities. The shaded areas are the officially-defined recessionary dates. Once we generate the conditional regime probabilities, the rule to translate these probabilities into binary regime predictions must be determined. The horizon line in Fig. 1 designates the 0.5 rule, as suggested by Hamilton (1989). This means that a recession is plausible in the future if the predictive probability exceeds 0.5.[6] Some other interesting findings emerge from Figure 1. First, there is no question that the contractionary dates identified by the MS-LSDV model are able to capture the officially-identified recessionary periods (the shaded areas) for the

[5] The problem could come from one of two sources. First, under the null hypothesis, some parameters are not identified. Secondly, the values of some parameters are identified as zero. Hansen (1992, 1996) proposed a bound test that addresses these problems, but its computational difficulty has limited its applicability. See Hansen (1992, 1996) and Garcia (1998) for a detailed explanation of these problems.

[6] Birchenhall et al. (1999) suggested using the sample rule to convert a predicted probability into a predicted classification. Our results are unchanged when we apply the Birchenhall et al. (1999) criterion.

U.S. although some noise remains.[7] Second, the MS-LSDV model identifies two recessions, one in 1979 and one in 1982, as one. Third, the duration period estimated by the MS-LSDV model in the 2001 recession is longer than that of the recession identified by the NBER. Overall, our results show that the recessionary periods of regional cycles are longer than those of national business cycles.[8] As reported in Guha and Banerji (1998/1999, pp164–165), a number of factors may account for differences in regional and national cycles. One prime factor could be the severity of a national downturn. Marked national contractions are usually accompanied by corresponding regional downturns in most regions, but less pronounced national downturns are not. Borts (1960) pointed out that differences also stem from the variations in the industrial base in each region, with differences diminishing when there is greater industrial diversification. Another factor could be rooted in differences in consumer sentiment from one region to another. Other reasons might include regional differences in fiscal and monetary policy, which likely exist between different U.S. states as well.

4 Concluding Remarks

This paper uses the Markov Switching Panel model to identify national business cycle turning points using the seven coincident indicators of regional cycles in the U.S. The empirical results indicate that the Markov Switching Panel model can accurately identify national business cycle turning points in the U.S. and that these are very close to the NBER-defined business cycle dates. Nevertheless, as a general rule, the recessionary periods for regional cycles are longer than those of national business cycles.

The main policy implication of this study is that when attempting to identify business cycle

[7]Two types of error signals could have occurred in our predictions. The first is a missed signal failure, i.e., when there is a recession, but the model fails to predict it. The other is a false signal failure, i.e., when the model predicts there is a recession, but one does not actually occur.

[8]The business cycle chronologies identified by the NBER and the MS-LSDV model are summarized in Table 3. The model-identified peak (trough) dates from the MS-LSDV model lead ahead (lag behind) the officially-identified peak (trough) dates by 2 (5) months on average.

turning points, the National Bureau of Economic and Research of the U.S., the public as well as business leaders should not simply rely on their official method and traditional statistical models. The findings here strongly suggest that the Markov Switching Panel model should also be taken into account as a means to secure complementary data.

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Table 1: Coincident Indicators of Regional Cycles

Definition of the Variables	
INPHCI	Coincident Economic Activity Index for Indiana
ARPHCI	Coincident Economic Activity Index for Arkansas
ILPHCI	Coincident Economic Activity Index for Illinois
KYPHCI	Coincident Economic Activity Index for Kentucky
MOPHCI	Coincident Economic Activity Index for Missouri
TNPHCI	Coincident Economic Activity Index for Tennessee
MSPHCI	Coincident Economic Activity Index for Mississippi

Table 2: Estimates from the Markov Switching Panel Model

	LSDV Model		MS-LSDV Model	
Parameter	Estimate	Std. Err.	Estimate	Std. Err.
$c(1)$	0.296*	(0.016)	0.422*	(0.012)
$d1(1)$	−0.045*	(0.022)	−0.075*	(0.016)
$d2(1)$	−0.081*	(0.022)	−0.024	(0.016)
$d3(1)$	−0.073*	(0.022)	−0.054*	(0.016)
$d4(1)$	−0.062*	(0.022)	−0.046*	(0.016)
$d5(1)$	−0.087*	(0.022)	−0.025	(0.018)
$d6(1)$	−0.081*	(0.022)	−0.069*	(0.017)
$c(2)$			−0.011	(0.024)
$d1(2)$			−0.022	(0.034)
$d2(2)$			−0.201*	(0.032)
$d3(2)$			−0.233*	(0.035)
$d4(2)$			−0.128*	(0.033)
$d5(2)$			−0.160*	(0.034)
$d6(2)$			−0.062*	(0.033)
$\sigma(1)$	0.294	(0.002)	0.168*	(0.003)
$\sigma(2)$			0.201*	(0.006)
p_{11}			0.982*	(0.003)
p_{22}			0.954*	(0.005)
Log-L	441.963		524.940	

* denotes significance at the 5% level.

Table 3: Dates of the Turning Points Identified by the NBER and the MS-LSDV model

NBER	MS-LSDV Model	
Peak (Trough)	Peak (Error)	Trough (Error)
1980:m1 (1980:m7)	1979:m9 (−3)	—
1981:m7 (1982:m11)	—	1982:m12 (+1)
1990:m7 (1991:m3)	1990:m11 (+4)	1991:m5 (+2)
2001:m3 (2002:m2)	2000:m8 (−7)	2003:m7 (+18)

+A denotes the lag behind the officially identified dates A months.

−A denotes the lead ahead of the officially identified dates A months.

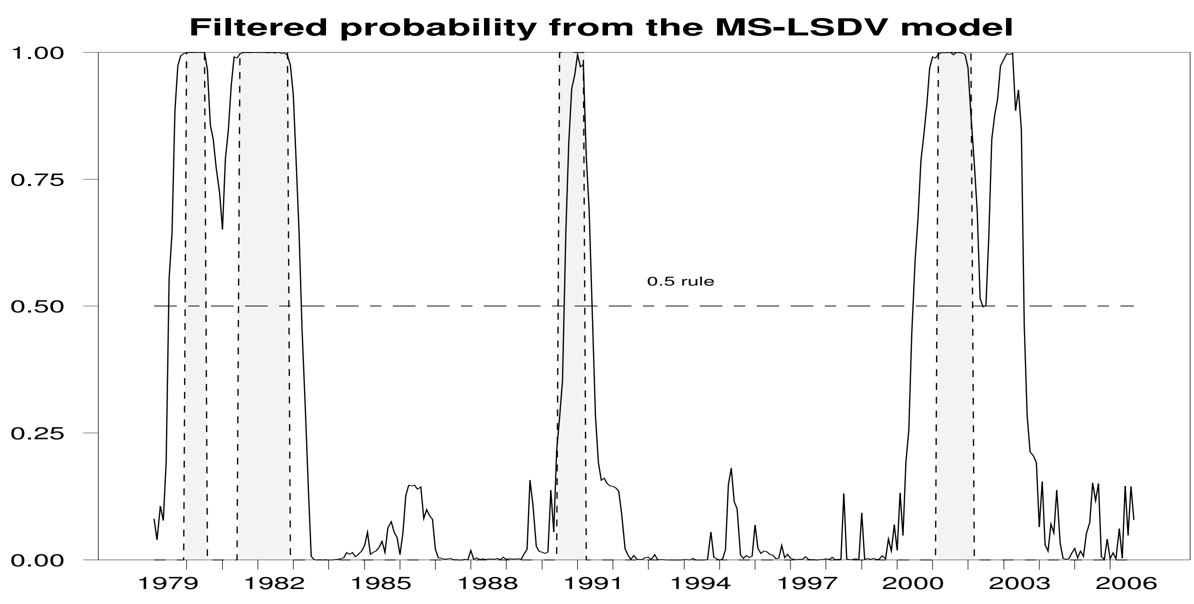

Fig. 1: Average filtered probabilities from the Markov Switching Panel model. The shaded areas are the NBER-defined recessionary periods.