

Regional Business Cycle and Real Estate Cycle Analysis and
The Role of Federal Governments in Regional Stability

by

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A dissertation submitted to the Graduate Faculty in Economics
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Abstract

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Advisor: Dr. Christos Giannikos

A question how should federal government policy be optimally conducted when the economy is composed of multitude of states with their own industrial structure is not a trivial one. Each economy in a multi-state region is characterized by its own dynamics that, in principle, may be quite different from that of the union in aggregate. While being quite relevant for the conduct of federal government policy, i.e., monetary authority, in the United States, the question of optimal monetary policy in a multi-state economy was disregarded by the modern monetary literature. The objective of this study is three folds. First, we show that United States is composed in different economic or multi-state regions. Second, theoretically we show that a uniform policy by the federal government may not work optimally for each state in multi-state region. Third, we show that the U.S. is a multi-state region not only in terms for economic cycles but also in terms of real estate cycles.

This dissertation consists of three essays. Depending on the state level business cycles similarity and differences, the first essay, “The U.S. Regional Business Cycles Analysis”, divides U.S. into four cyclical regions. The essay shows that some

of the U.S. states have similar business cycles as the nation, while some states have the opposite cycle patterns. Most U.S. states fall somewhere in between. Economically dominant states have the similar business cycle patterns as the nation. States with specialized industries often lead the national business cycle patterns. We also observe that states around the economically dominant states follow or get influenced by the economically dominant states's business cycles. Thus, economically not dominant states' geographic proximity from the economically dominant states play quite a significant role in the formation of the business cycle patterns of the former group of states. The business cycle patterns of the major oil supply states are distinctly different from the national business cycle patterns.

The second essay of this dissertation, "Optimal Monetary Policy in a Multi-State Economy", is a theoretical piece. The results of this essay suggest that when the goal of the monetary authority is to minimize the variance of some aggregate measure such as real GDP without explicitly taking the output variance in each region or correlation structure between states into account, it may achieve its goal but may increase the output variation in regional economies. On the contrary, when the output variance in each region or correlation structure between states is explicitly included in the objective function, the model not only successfully reduces the output variances in the states but also reduces the national output variation.

The third essay, "Are U.S. States Economic and Real Estate Cycles Related", found that there are no distinct and persistent patterns between real estate cycles and

state level economic fluctuations. We observe that real estate downturns are more persistent and severe than economic recessions. Comparison of the national and state level business and real estate cycle patterns suggest that only two out of four recent NBER dated national recessions were accompanied by predominance of real estate downturns in most of the U.S. states. Our results also suggest that nearly forty U.S. states as well as the U.S. on aggregate exhibited distinct downturn of the real estate cycle between the third quarter of 2006 and the first quarter of 2007. Finally we found that the state level economic and real estate growth rate diverges during the period of recession.

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Chapter 1

Introduction

When the National Bureau of Economic Research (NBER) announces recession for the country what does it really mean? Does this recession picture true for every regions of the country? In another word, when Macroeconomic data show a picture of economic expansion for a country, do every regions of that country share the same expansion or do certain regions suffer recessions that the government ignores? For example, from 1990 to 1993, during the national recession, state of Michigan experienced economic expansion; where as, from 1993 to 2000, when the U.S. economy started picking up, the Michigan's economy went into recession. The similar outcome we experienced in Pennsylvania during 1995 – 2000. The U.S. economy was in expansion while, the Pennsylvania's economy was facing a recession.

What causes regional business cycle? Is it specific to a type of industry in a state or general government policy implication? How different these cycles are in state to state? Let us assume that during national recession, to stabilize the over all economy, the federal government chooses a set of economic policy. Does this unique national policy adversely affect the growth of states like Michigan and Pennsylvania because those states have state specific business cycles which always do not coincide with the national business cycles? Do government policies for a national recession

worsen the economic condition of the state like Michigan and Pennsylvania in the subsequent period? Then, to what extent should the highest level of government get involve with the regional economy? Are there any relationships between state level business cycles and federal government policy implications, which may affect national growth in the long run?

These are very obvious questions for a Multi-state region like the United States. In recent years a considerable research had been conducted specially on the European regions in the application of if the European Union is an optimal currency area. However, there is very few, if any, research on the U.S. optimum currency area in recent years which deals with regional economic fluctuations. We believe that revisiting the topic of if the U.S. is an optimal currency area and finding the similarities and the differences in regional business cycle patterns are important areas to explore for three notable reasons: 1) it will give a vivid idea about regional business cycles to the future economists and researchers; 2) we can re-explore the question if an unique monetary policy decision works optimally in each regions of the United States; 3) it will assists future government policy makers to come up with a better monetary policy goal function to reduce regional economic fluctuations.

This dissertation is consists of three essays. The first essay is presented in chapter two which, focuses on the regional business cycles. We define the U.S. states as a region. Using Hamilton's Markov Switching estimation technique on the U.S. fifty states coincident indexes, we calculate the turning points of the state level busi-

ness cycles. We observe that the state level business cycle varies not only from each other but it also varies from the national business cycle. Depending on the pattern of the state level business cycle we divide the U.S. into four major cyclical regions. In one extreme we found that economically dominant states, e.g., New York and California, have similar business cycle patterns as the U.S. On the other extreme, some states have opposite business cycle patterns compared to the national business cycle patterns. States with specialized industries often lead the national business cycle patterns. Further, we observe that states around the dominant economic states follow or get influenced by the dominant economic state's business cycles. Thus, economically not dominant states' geographic proximity from the economically dominant states plays quite a significant role in the formation of the business cycle patterns of the former group of states. The business cycle patterns of the major oil supply states are distinctly different from the national business cycle patterns.

The second essay of this dissertation is a theoretical piece, which is presented in the chapter three. In the first essay we observe that each state in the United State has state specific business cycles, which may or may not coincide with the national level business cycles. Thus we pose a question that what should be the optimum monetary goal function for an economy which is composed of a multitude of states with own industrial structure. This essay sets forward a formal analysis of optimal monetary policy in a multi-state economy by using a simple IS-LM model. For simplicity of analysis we assume a two-states economy. Therefore, our model modifies the

Hicksian IS-LM framework by using two IS curves – one for each regional economy – and one LM curve for the nation. We suggest a new monetary policy goal function that is more suitable for the case of a multi-state economy. This modified framework not only takes into account the regional output variance but also allows for more in-depth analysis of the correlation structure between states. The results of this essay suggest that when the goal of the monetary authority is to minimize the variance of some aggregate measure such as real GDP without explicitly taking the output variance in each region or the correlation structure between states into account, it may achieve its goal but may increase the output variation in regional economies. Unlike this, when the output variance in each region or the correlation structure between states is explicitly included in the objective function the model not only successfully reduces the output variances in individual states but also reduces the national output variation. In fact the later model outperforms the former one as long as the correlation factor between state outputs is greater than negative one.

In chapter four we present the third essay. In the third essay we try to analyze if certain industrial cycle has specific contribution towards states level economic cycles and the U.S. national business cycles. As a representation of a random industry, we analyze real-estate industry of the United States for two main reasons: one, real estate is one of the dominant industry sectors of the United State; and two, a recent U.S. housing market fluctuation triggered a question about what is the impact of fluctuations in the real estate market on the U.S. economy. This essay uses Markov Switch-

ing estimation technique on U.S. state level coincident index and housing price index to indicate state as well as national business and real estate cycles. The analyses in this essay suggest that there are no distinct and persistent patterns between real estate cycles and state level economic fluctuations. We observe that real estate downturns are more persistent than economic recessions. Comparison of the national and state level business and real estate cycle patterns suggest that only two out of four recent NBER dated national recessions were accompanied by predominance of real estate downturns in most of the U.S. states. Our results also suggest that nearly forty five U.S. states as well as the U.S. on aggregate exhibited distinct downturn of the real estate cycle between the third quarter of 2006 and the third quarter of 2007. Severity of state level real estate fluctuations, measured in this paper as a difference between growth rates in expanding and declining phases, varied remarkably across states. We, however, observe relatively greater dispersion of the growth rates of the state housing index when the states economies are in recessionary phase of the business cycle. This suggests that the housing market across states converges during periods of expansions. The same outcome holds for the state coincident index.

Chapter 2

The U.S. Regional Business Cycles Analysis

2.1 Introduction

The National Bureau of Economic Research (NBER) calculates and produces business cycle turning points for the U.S. economy at the aggregate level¹. According to the business cycle studies, a country's economic condition can be divided into two phases of a business cycle – expansion and recession. Many economic studies and policy makers take this aggregate business cycle phases² by NBER as given while making policy decisions for the nation. Some evidences, however, show that when central policy makers, namely the Central Bank, make uniform decisions for the nation based on the aggregate business cycle conditions, these policies may or may not work uniformly throughout the U.S. regions. For example, during 1985 the U.S. economy was in expansionary phase of the business cycle whereas some states, i.e., Idaho, Iowa, Louisiana, Oklahoma and some other states were in a recessionary phase. During that time, from 1985:I quarter to 1985:IV quarter the Central Bank chose contractionary monetary policy and the fed-funds rate went up gradually

¹ <http://www.nber.org/cycles.html>

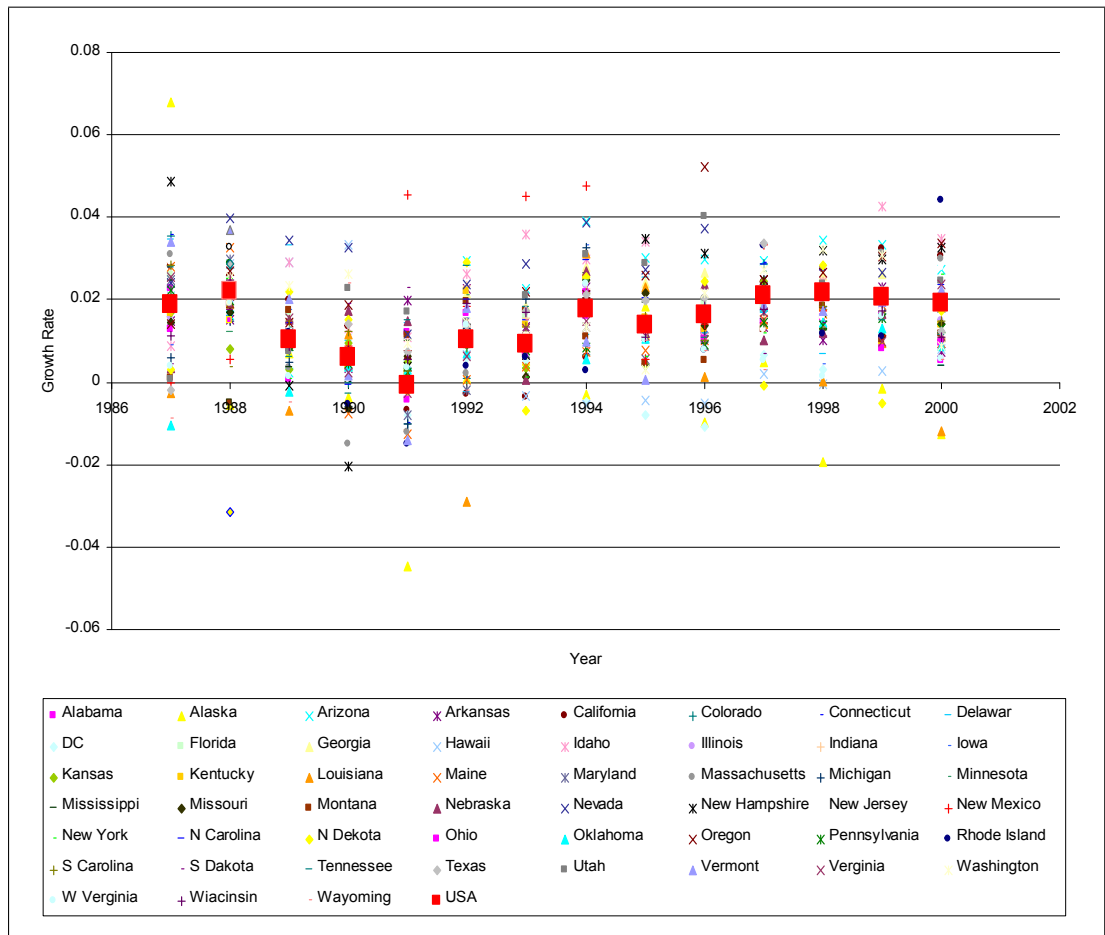
² Lag indicator

throughout the expansionary period³. High fed-funds rate made recession worse in states and regions which were facing recessionary phase of the business cycle. Some recent business cycle studies start questioning about the aggregate measures of the business cycles and start looking into the state level and the regional level economic conditions, i.e., Crone [14]; Kouparitsas and Nakajima [22]; Owyang, and Piger [27].

In this essay we used Markov Switching estimation technique on the U.S. fifty state coincident index to calculate the business cycle turning points for all fifty states. In this way we will have state level business cycles, which can be compared with the national business cycle. This is an important study, especially for a nation consisting of multiple regions, e.g., the U.S., Canada, EU, China, and Russia, for two reasons. First, without having a clear idea about the regional business cycles, a uniform decision by the national government based on GDP data may adversely affect some regions, which may have different business cycles than that of the nation. Second, a clear understanding about the state/ regional level business cycles will help various governments to take appropriate measures to reduce the impact of recession. To justify our point, that the different regions in a multi-state economy may face different phases of the business cycles we plot Figure: 2.1. In other words, some regions may experience positive growth, while other regions may experience negative growth. In Figure: 2.1, we plot growth rate of GDP and Gross State Product (GSP) for U.S. fifty states from the 1987 to the 2002 time period. The Figure: 2.1, shows that the growth

³ <http://www.newyorkfed.org/markets/statistics/dlyrates/fedrate.html>

Figure 2.1: 50 U.S. States GSP Growth rate, 1987 - 2002



rate throughout the states varies and the state level growth rates are different from the national growth rate. For example, during the 1987 and the 1988, the U.S. was facing positive growth rate while the state of Alaska was facing negative growth rate. Later, from the 1988 to the 1989 the U.S. economy started facing negative growth rate, while Alaska started experiencing the opposite.

In the following sections, first we go over some related literatures; second, we explain the data used in this essay; third, we present the model and methods; fourth, we provide results; and we conclude in section five.

2.2 Literature Review

Exuberant researches by the Federal Reserve Bank and the Bureau of Economic Analysis (BEA) indicate that the U.S. can be divided into six, eight, or twelve economic regions depending on their geographical locations, population density, socio-economic conditions, and industry structures and the like. Until early 1990's, these regional groupings were used heavily by the monetary and fiscal authorities for decision making purposes and by the researchers for economic analysis. Applying cluster analysis on Stock and Watson's coincident indexes [31], recently Crone [12] observed monthly changes in economic activities in all fifty different states. His research shows that states economic conditions vary a lot compared to each other and from the aggregate economy. While many researchers still use the eight or twelve di-

visions of economic - geographical regions, most researchers these days treat states as a complete economic region in the United States.

Starting from mid 1990's many researchers used the Vector Autoregression (VAR) models to analyze the different effect of monetary and fiscal policy on the regional economies. Carlino and DeFina [5], [6]; Clark [10]; Owyang and Wall [28]; and Crone [14] found that due to various industry structures, banking systems, shock absorbing mechanisms, different regions act differently when the Federal Reserve Bank changes the interest rates. Most of these studies took the BEA classification of regions as given and analyzed regional business cycles phenomena based on similarities at a point in time.

From the other perspective a study by Wall and Zoega [34] tried to show that aggregate figures may not reflect all the regions in the United State at the same time. For example during the 1981-82 recession the U.S. unemployment rate rose by about 3.3 percentage points from the third quarter of 1981 to the fourth quarter of 1982. During the same period, twenty nine states had smaller increases, fourteen states had almost no change, one state decreased, and six states had a rise more than 4.8 percentage points in their unemployment rate. Similarly, they showed that during the 1990 – 1991 recession aggregate unemployment rate rose by 2.3 percentage points from the second quarter of 1990 to the third quarter of 1992. Regional data, however, show that only California, New York, North Carolina, and Washington faced similar rise in the unemployment, whereas thirty six states experienced very mild increase in

unemployment, and for the rest of the states unemployment rate decreased. Similarly, during the 2001 recession, which began in the fourth quarter of 2000 and continued until the end of 2002, aggregate unemployment rose 1.6 percentage points, although thirty five states experienced smaller increase than the aggregate figure and six experienced a decline in the unemployment rate. Thus, Wall and Zoega [34] conclude that each state may vary differently from the nation.

Boldin [3] compares five different business cycles turning point dating methods on the U.S. economy and concludes that the Stock and Watson's [31], [32] experimental business cycles indicators based on Kalman filter algorithm and Hamilton's [20] Markov Switching estimation technique outperform all other business cycles dating techniques. Following Boldin [3], using Markov Switching estimation technique on Crone's [13] state indexes, Owyang, Piger, and Wall [27] in their recent paper ⁴ showed that each state experiences its own business cycles, while state level business cycles not necessarily coincide with the national business cycles. Further, they show that the recession growth rates are related to the industry mix, whereas the expansion growth rates are related to education and age composition.

⁴ This study is very close to the Owyang, Piger and Wall (2005) paper. We started writing this paper in 2004 without knowing the work of Owyang, et al.'s paper. In 2005, we found out that Owyang, et al. had already gotten their paper published. Nevertheless, our basic Markov Switching model is slightly different from the model suggested by Owyang, et al. Also we extended the time period until 2007:IVQ. Finally, our findings and the way we conclude this study is different from the study done by Owyang, et al.

A recent study by Crone [14] also estimates the U.S. state level business cycles using the diffusion indexes. His study concludes that the diffusion indexes are better data sets to track or to forecast regional business cycle turning points.

2.3 Data

We used the U.S. 50 states coincident indexes provided by the Federal Reserve Bank of Philadelphia dating from 1979:IQ – 2007:IVQ. This data set is developed by Crone [12] estimating four latent dynamic factors of each state. The four variables are: the total number of jobs in nonagricultural establishments, average weekly hours in manufacturing, the unemployment rate, and the real wage and salary disbursements. This is one of the most comprehensive monthly data set available for the state level economic analysis. The reason for using the state level coincident indexes for the study is that there is no monthly Gross State Product (GSP) data available for the U.S. states. The available GSP data are in the annual basis, but the state level recession can begin and end within a year.

In addition to the state level business cycles, we also re-estimate the turning points of the national business cycles for two notable reasons. First, we want compare our estimated national business cycles turning points using Markov Switching estimation technique to the national business cycles turning points dates given by the National Bureau of Economic Research (NBER). This comparison will prove the authenticity of the measuring technique. Second, we want to compare the national

business cycles with the state level business cycles and check if two cycles coincide with each other. For the national business cycles analysis we used the GDP data from 1979:IQ – 2007:IVQ provided by the NBER.

2.4 Model and Estimation Method

Hamilton [20] Markov switching estimation technique is an extension of Goldfield and Quandt's [17] study of structural changes in the parameters to a non-linear alternative to the class of linear-stationarity models⁵. In the Hamilton [20] Markov-switching model business cycles phases shift with the mean growth rate of a parametric time-series model for economic output:

$$(\Delta y_t - \mu_{S_t}) = \phi_1(\Delta y_{t-1} - \mu_{S_{t-1}}) + \phi_2(\Delta y_{t-2} - \mu_{S_{t-2}}) + \dots + \phi_4(\Delta y_{t-4} - \mu_{S_{t-4}}) + e_t$$

where, $e_t \sim N(0, \sigma_{S_t}^2)$ and $\mu_{S_t^*}$ indicates μ_1 when $S_t^* = 1$ and indicates μ_2 when $S_t^* = 2$, where S_t represents the different states of the economy – unobserved variable. For this paper, we use the simple version of the Hamilton [20] model, which can be written as:

$$y_t = \beta_0 + \beta_{S_t} + e_t, \quad t = 1, 2, \dots, T \quad (2.1)$$

$$e_t \sim N(0, \sigma^2) \quad (2.2)$$

⁵ First, Beveridge and Nelson (1981), Nelson and Plosser (1982), and Campbell and Mankiw (1987) assume the stationarity of the first log difference of the real GDP and emphasize on the usage of ARIMA models in an attempt to estimate the long-term trend of GDP. Harvey (1985), Watson (1986), and Clark (1987), explore the nature of real gross national product (GNP) by decomposing it into unobserved components using Kalman filter. King, Plosser, Stock, and Watson (1991), exploit cointegrating specification across number of macro time series.

regime, $S = 0$, or 1

Therefore, we can rewrite the model as:

$y_t = \mu_0 + e_t$, when $S_t = 0$ (expansionary state), which represents by:

$$\mu_0 = \beta_0 \quad (2.3)$$

or, $y_t = \mu_1 + e_t$, when $S_t = 1$ (recessionary state), which represents by:

$$\mu_1 = \beta_0 + \beta_1$$

If S_t , $t = 1, 2, \dots, T$, is known a priori, the above is a dummy variable model.

Therefore, the log likelihood function can be written as:

$$\ln L = \sum_{t=1}^T \ln(f(y_t | S_t)); \text{ where, } f(y_t | S_t) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{\{y_t - \beta_0 - \beta_{S_t}\}^2}{2\sigma^2}\right) \quad (2.4)$$

since, S_t , $t = 1, 2, \dots, T$ is not observed, we consider the joint density of y_t and the unobserved S_t variable:

$f(y_t, S_t | \Psi_{t-1}) = f(y_t | S_t, \Psi_{t-1})f(S_t | \Psi_{t-1})$, where $\{y_1, y_2, \dots, y_{t-1}\} \in \Psi_{t-1}$ and Ψ_{t-1} refers to information up to time $t - 1$.

The marginal density of y_t , which is a weighted average of the conditional densities given by $S_t = 0$ and $S_t = 1$, respectively written as:

$$f(y_t | \Psi_{t-1}) = \sum_{S_t=0}^1 f(y_t, S_t | \Psi_{t-1})$$

$$\begin{aligned}
&= \sum_{S_t=0}^1 f(y_t | S_t, \Psi_{t-1}) f(S_t | \Psi_{t-1}) \\
&= \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{\{y_t - \beta_0\}^2}{2\sigma^2}\right) \times \Pr[S_t = 0 | \Psi_{t-1}] \\
&\quad + \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{\{y_t - \beta_0 - \beta_1\}^2}{2\sigma^2}\right) \times \Pr[S_t = 1 | \Psi_{t-1}]
\end{aligned} \tag{2.5}$$

The log likelihood function of $f(y_t | \Psi_{t-1})$ is then given by:

$$\begin{aligned}
\ln L &= \sum_{t=1}^T \ln(f(y_t, S_t | \Psi_{t-1})) \\
&= \sum_{t=1}^T \ln\left(\frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{\{y_t - \beta_0\}^2}{2\sigma^2}\right) \times \Pr[S_t = 0 | \Psi_{t-1}] \right. \\
&\quad \left. + \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{\{y_t - \beta_0 - \beta_1\}^2}{2\sigma^2}\right) \times \Pr[S_t = 1 | \Psi_{t-1}]\right)
\end{aligned} \tag{2.6}$$

However, the series of probabilities $\Pr[S_t = 0 | \Psi_{t-1}]$ and $\Pr[S_t = 1 | \Psi_{t-1}]$, when $t = 1, 2, \dots, T$ are not known. Therefore, following Hamilton [20], we assume that the regime that governs the system follows a two-state Markov process with the following probabilities:

$$\Pr[S_t = 0 | S_{t-1} = 0] = p \tag{2.7}$$

$$\Pr[S_t = 1 | S_{t-1} = 0] = 1 - p \tag{2.8}$$

$$\Pr[S_t = 1 \mid S_{t-1} = 1] = q \quad (2.9)$$

$$\Pr[S_t = 0 \mid S_{t-1} = 1] = 1 - q \quad (2.10)$$

where p and q are coefficients estimated by MLE along with other coefficients. Then we use the following two steps to calculate the transitional probabilities.

Step 1. For the time period 1, for example, given the transition probability $\Pr[S_0 = 1 \mid \Psi_0]$ and $\Pr[S_0 = 0 \mid \Psi_0]$, the term $\Pr[S_1 = 1 \mid \Psi_0]$ is calculated in the following way:

$$\Pr[S_1 = 1 \mid \Psi_0] = \sum_{i=0}^1 \Pr[S_1 = 1, S_0 = i \mid \Psi_0] \quad (2.11)$$

$$= \sum_{i=0}^1 \Pr[S_1 = 1 \mid S_0 = i] \Pr[S_0 = i \mid \Psi_0] \quad (2.12)$$

In order to obtain the probabilities $\Pr[S_2 = 1 \mid \Psi_1]$ and $\Pr[S_2 = 0 \mid \Psi_1]$, however, we need to obtain $\Pr[S_1 = 1 \mid \Psi_1]$ and $\Pr[S_1 = 0 \mid \Psi_1]$. For that purpose we deploy the following procedure:

Step 2. Once y_t is observed at the end of time t , the probability term can be updated in the following way:

$$\Pr[S_1 = 1 \mid \Psi_1] = \Pr[S_1 = 1 \mid \Psi_0, y_1]$$

$$= \frac{f(S_1 = 1, y_1 | \Psi_0)}{f(y_1 | \Psi_0)} = \frac{f(y_1 | S_1 = 1, \Psi_0) \Pr[S_1 = 1 | \Psi_0]}{\sum_{j=0}^1 f(y_1 | S_1 = j, \Psi_0) \Pr[S_1 = j | \Psi_0]} \quad (2.13)$$

where, $\Psi_t = \{\Psi_{t-1}, y_t\}$. Then $\Pr[S_1 = 1 | \Psi_1]$ is plugged into the Step 1 to obtain $\Pr[S_2 = 1 | \Psi_1]$, etc. Similarly, the series of $\Pr[S_t = i | \Psi_{t-1}]$, for $t = 1, 2, \dots, T, i = 0, 1$ can be obtained. The above two steps are then iterated in order to get $\Pr[S_t = j | \Psi_{t-1}]$, $t = 1, 2, \dots, T$. To start the above filter at time $t = 1$, however, we need $\Pr[S_0 | \Psi_0]$ at the beginning. We can employ the following steady-state or unconditional probabilities of S_t (in Appendix: 4A: 4.10-4.16):

$$\pi_0 = \Pr[S_0 = 0 | \Psi_0] = \frac{1 - p}{2 - p - q} \quad (2.14)$$

$$\pi_1 = \Pr[S_0 = 1 | \Psi_0] = \frac{1 - q}{2 - p - q} \quad (2.15)$$

Rather than using only the previous information, it is possible to obtain the probability of the economy being in either recession or expansion $\Pr[S_t = j | \Psi_T]$ using the full set of information Ψ_t . Kim [21] introduces Kim's smoothing algorithm, which uses the entire period information to calculate the probability of the turning points.

The smoothing algorithm described bellow was first suggested by Cosslett and Lee [11]. Given the series of filtered probabilities obtained in the equations (2.5 -

2.15) and the probability for the last period $\Pr[S_T | \Psi_T]$, the smoothed probability for the previous period $\Pr[S_{T-1} | \Psi_T]$, can be obtained in the following way:

$$\Pr[S_T, S_{T-1} | \Psi_T] = \Pr[S_{T-1} | S_T, \Psi_T] \times \Pr[S_T | \Psi_T]$$

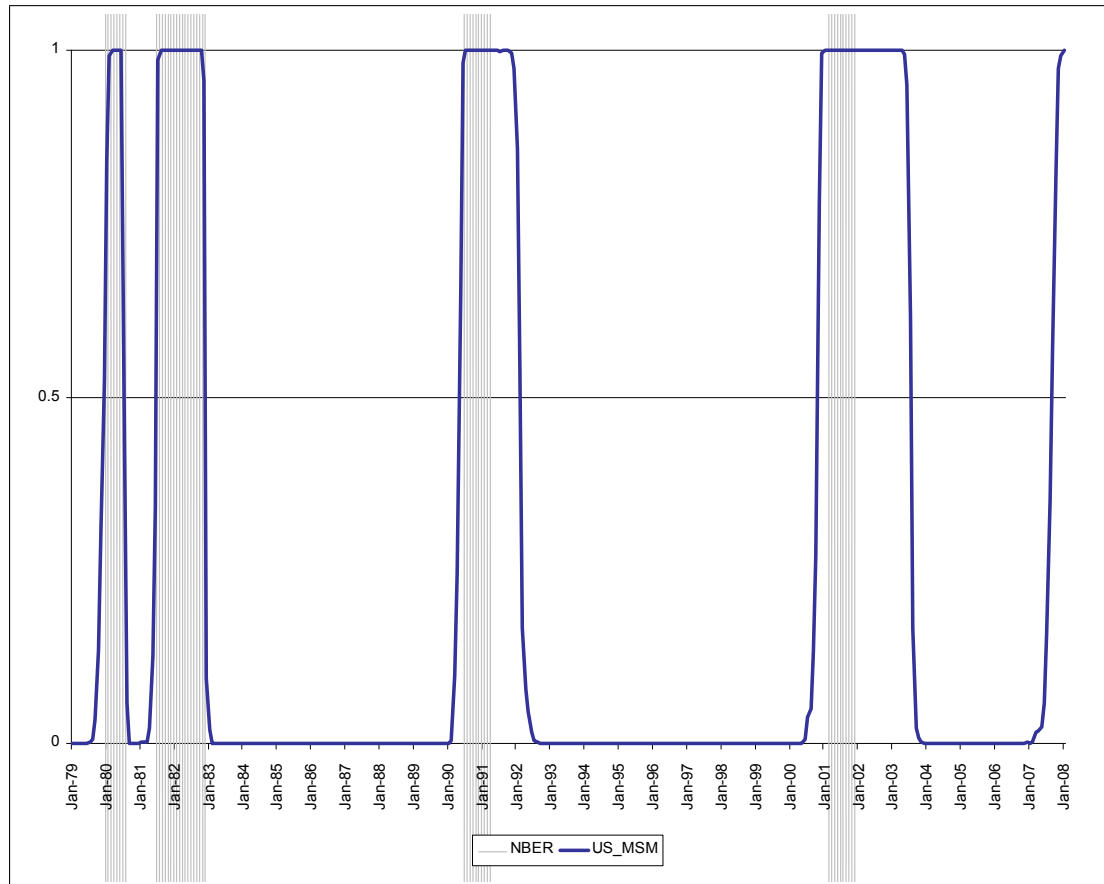
$$\frac{\Pr[S_T | \Psi_T] \times \Pr[S_T, S_{T-1} | \Psi_{T-1}]}{\Pr[S_T | \Psi_{T-1}]} = \frac{\Pr[S_T | \Psi_T] \times \Pr[S_{T-1} | \Psi_{T-1}] \times \Pr[S_T | S_{T-1}]}{\Pr[S_T | \Psi_{T-1}]}$$

Thus, we can rewrite the above expression as: $\Pr[S_{T-1} | \Psi_T] = \sum_{S_T} \Pr[S_T, S_{T-1} | \Psi_T]$. The above smoothing algorithm is iterated backward to obtain series of probabilities of states given the full information.

2.5 Results

Our result shows that the state level business cycles are not only different from the national business cycles, but they also differ from each other. The comprehensive result is given in the Appendix: 2.A.1-2.A.4. For an easier analysis we present and compare some striking results of the five state level economies. Figures: 2.3 – 2.7, compare the national and state level business cycles of California, Colorado, Wyoming, Maryland, and Pennsylvania. In Figures: 2.2 – 2.7, the national recessions are indicated by the vertical shaded lines, and the state recessions are indicated by any probability between 0 and 1. Probability 1 indicates that the probability that the state is in recession and probability 0 indicates that the probability that the state is in

Figure 2.2: The U.S. Business Cycle Turning Points



expansion. Thus, when the state level business cycles (curved lines) cross probability of 0.5 and move upward, we assume that the state enters into recessionary phase. In figures 2.1- 2.5, the national business cycles are in absolute terms. Therefore, probabilities do not apply to the national business cycles.

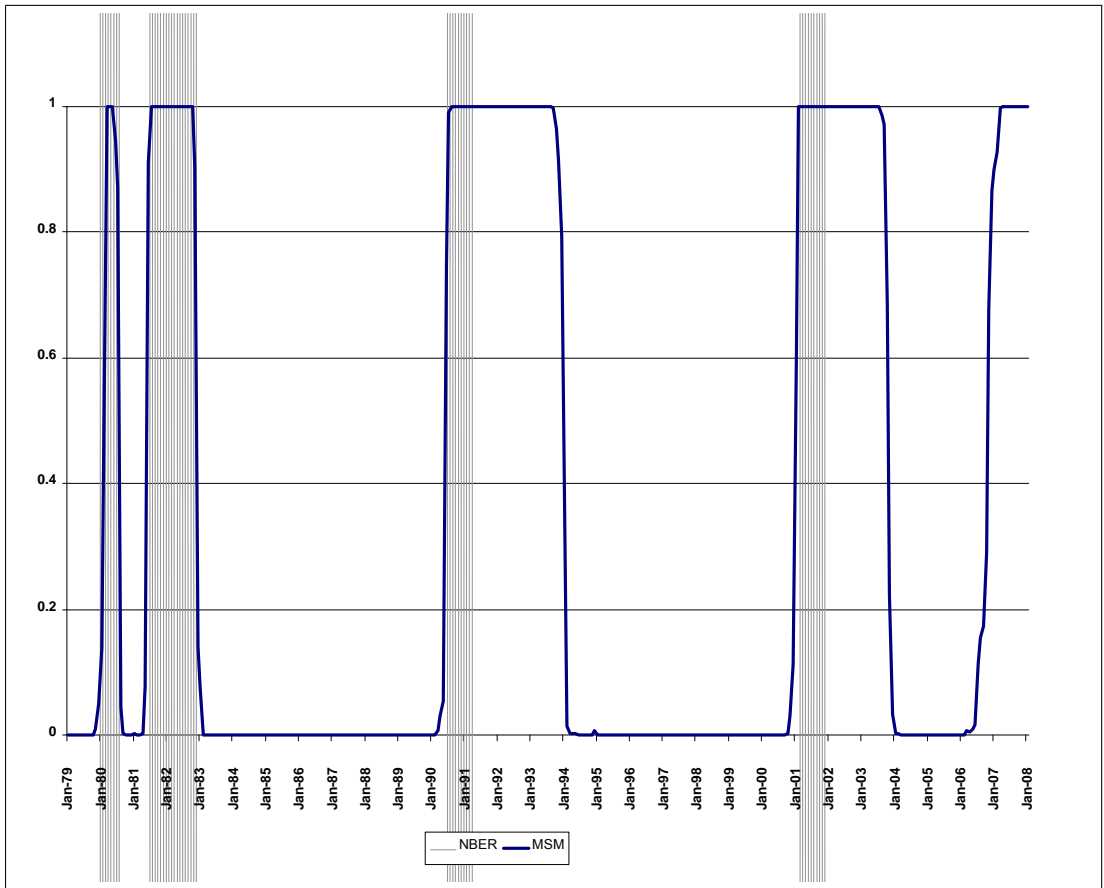
One notable point in our analysis is that our national business cycle turning point dates coincide with the business cycles turning point dates announced by the NBER, which proves the authenticity of the Markov Switching estimation

technique in detecting business cycles phases. Figure: 2.2 exhibits the national business cycle turning points. We observe that there were four major nationwide recessions between the 1979:IQ and 2007:IVQ. To make our illustration clear and simple, we focus on a smaller window in time or one full business cycle, e.g., the 1989:IQ to the 1991:IIQ time period. It is a reasonable period to analyze because the 1989:IQ to the 1991:IIQ represents a complete business cycle. The national economy was in expansion during the 1989:IQ until the 1990:IIQ, then it was in recession from the 1990:IIIQ to the 1991:IQ and went back to expansionary phase in the 1991:IIQ.

Additionally, in the figures 2.3 – 2.7, we notice that some state level recession may start much before the national recession and may persist for several periods more than the national recession. Based on the state level business cycle patterns, we divide states into four major groups. The first group contains states, which has the same business cycle patterns as the nation. According to our analysis, most economically dominant states, like California, New York, fall into this category. The second group consists of the states where the state level business cycles start after the national business cycles. In other words, the states level business cycles follow the patterns of the national business cycles with lags. The third group of states has distinct state level business cycles, which do not follow the pattern of the national business cycles. The fourth, or the last group, contains states where the state level business cycles form before the national business cycles. The most U.S. states fall into the fourth group. In the following we analyze and explain all the four groups of states.

As a representative state for the first group we present California in Figure: 2.3. The business cycle patterns of California coincide with the national business cycle patterns. One of the reasons for such similarity could be that California is one of the dominant economies in the United States; thus, it has a bigger impact on the national economy. In Figure: 2.3, we observe that in the 1989:IIQ California's economy was in expansion, which entered into recession during the 1990:IIIQ, as the nation. California's recession, however, persisted longer than the national recession during the 1990s and the 2001s. Appendix 2.A.1 shows that some other economies, such as Nevada and New Mexico, also have the same business cycle patterns as California and as the national business cycle patterns. It could be possible that due to geographical proximity the business cycles of Nevada and New Mexico got influenced by the California's business cycles. Similar business cycle patterns we observe in New York, Massachusetts, and New Hampshire. According to Appendix 2.A.1, it seems that economically dominant states have similar business cycle patterns as the nation and the adjacent states follow the same business cycle patterns as the dominant states business cycle patterns. The second group of states has a noticeable business cycle pattern, where the state level business cycles follow the national business cycles. In Figure: 2.4 Colorado, we observe that the state level economic cycles follow that national cycles three out of four times. It could be possible that these are comparatively not economically dominant states and the state level cycles follow the national economic cycles with lags. We observe the similar state level business cycle patterns

Figure 2.3: California



in Appendix 2.A.2, for Ohio and Oklahoma. Geographical similarity between Colorado and Oklahoma may explain the state level business cycles pattern similarities, but with that same argument we cannot explain why Ohio has the similar business cycle patterns as Colorado. Nevertheless, in Figure: 2.4, we observe anomalies in business cycles patterns. During the national expansionary period from the 1983:IIQ to the 1990:IIQ Colorado faced two state level recessions. It might be possible that Colorado has a state specific industry which is the cause for a unique business cycle patterns. To analyze the third group of states, we explore Figure: 2.5 Wyoming, which has very distinctive state level business cycle patterns and does not follow the national business cycle patterns. Some parts of the state level business cycles may seem similar to the national business cycles but when we compare all the parts of the state level business cycles, we conclude that the business cycles of Wyoming or the other states in this group Appendix 2.A.3 are not related to the national business cycles. In Figure: 2.5 Wyoming, we observe that none of the state recessions coincide with the national recession. Most of the oil producing states – Alaska, Louisiana, Montana, Texas, and West Virginia – fall into this category of states. Beside the oil producing states, Hawaii also shows very distinct state level business cycle patterns. In face, most of the time the state level business cycles of this group lay on the opposite side of the national business cycle. Most of the states fall into the fourth category where states enter into recession before the national recession occurs. This category can be divided into two subcategories, where first group of states enter into recession

Figure 2.4: Colorado

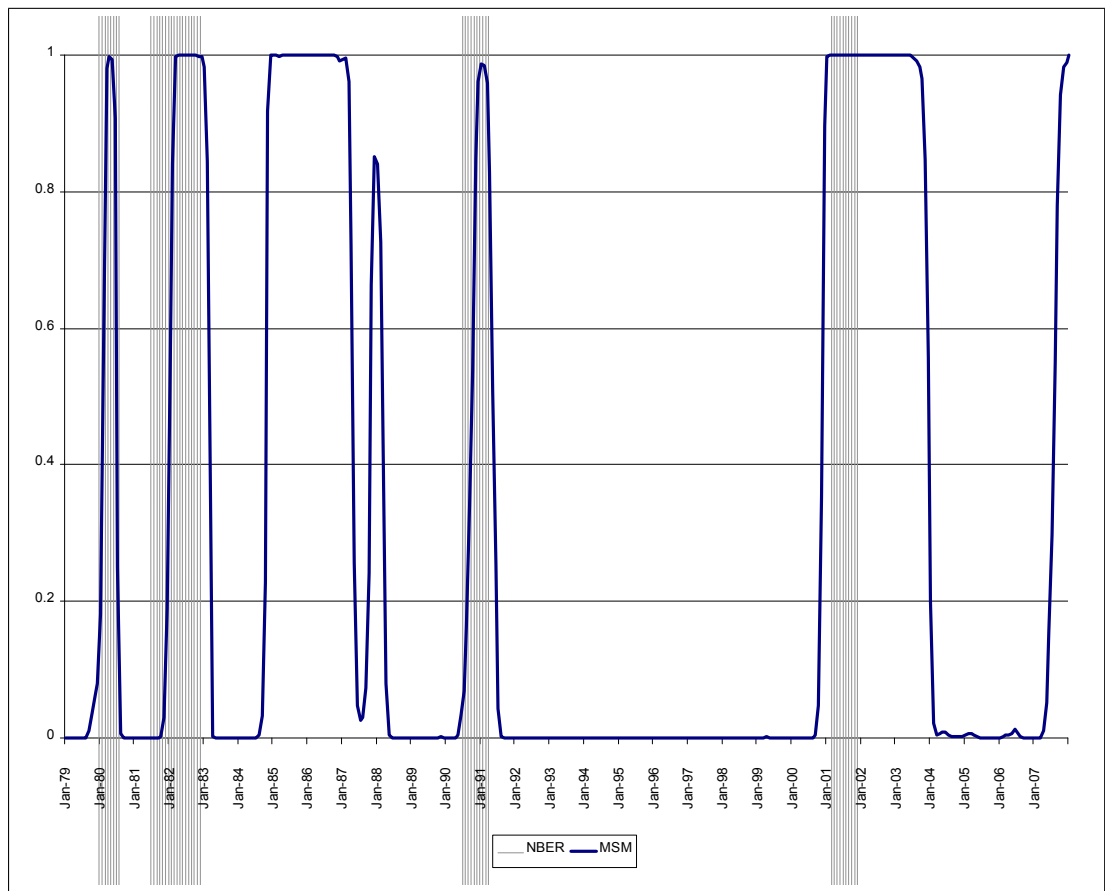


Figure 2.5: Wyoming

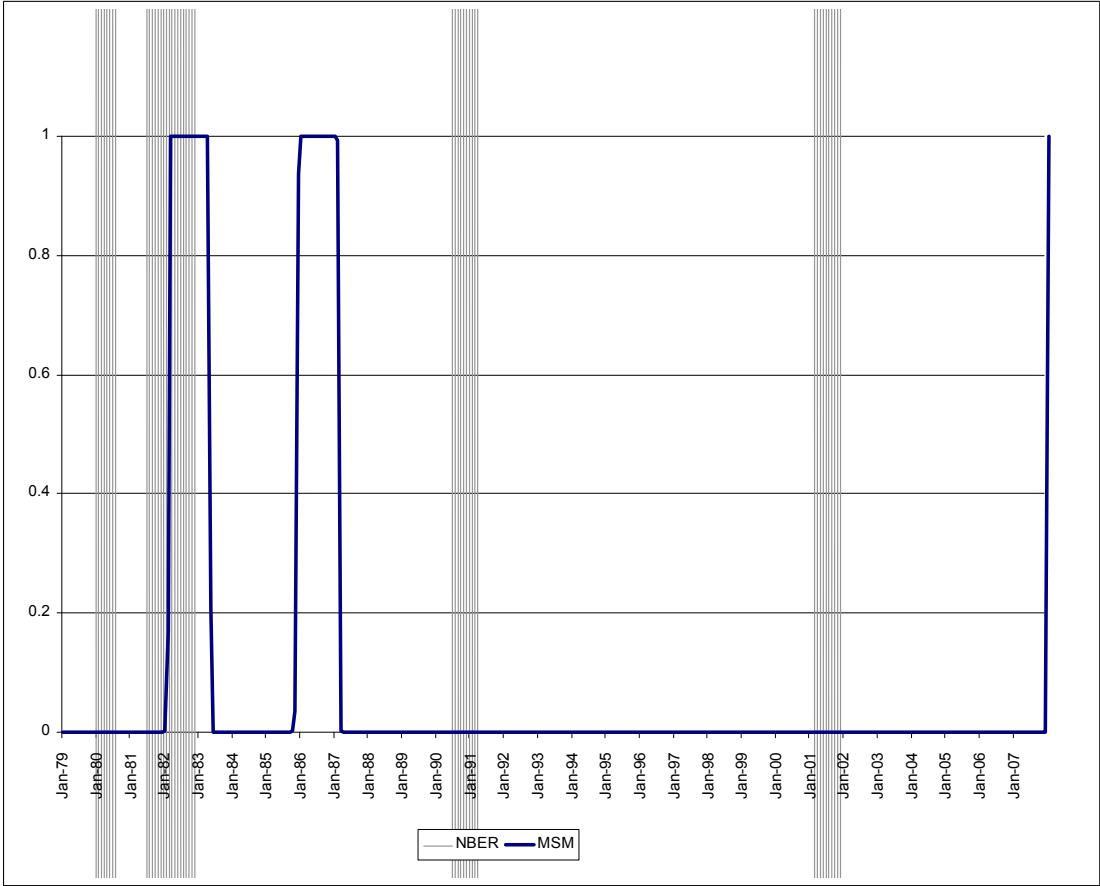
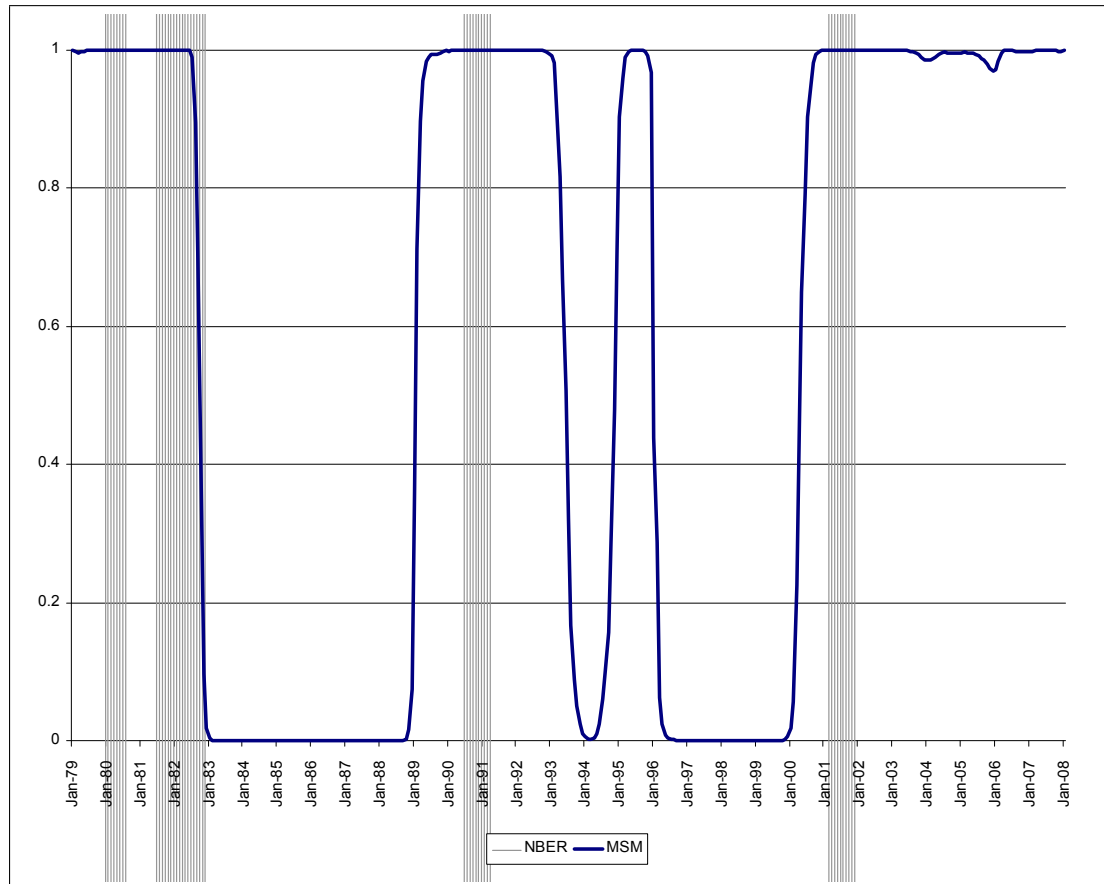


Figure 2.6: Maryland



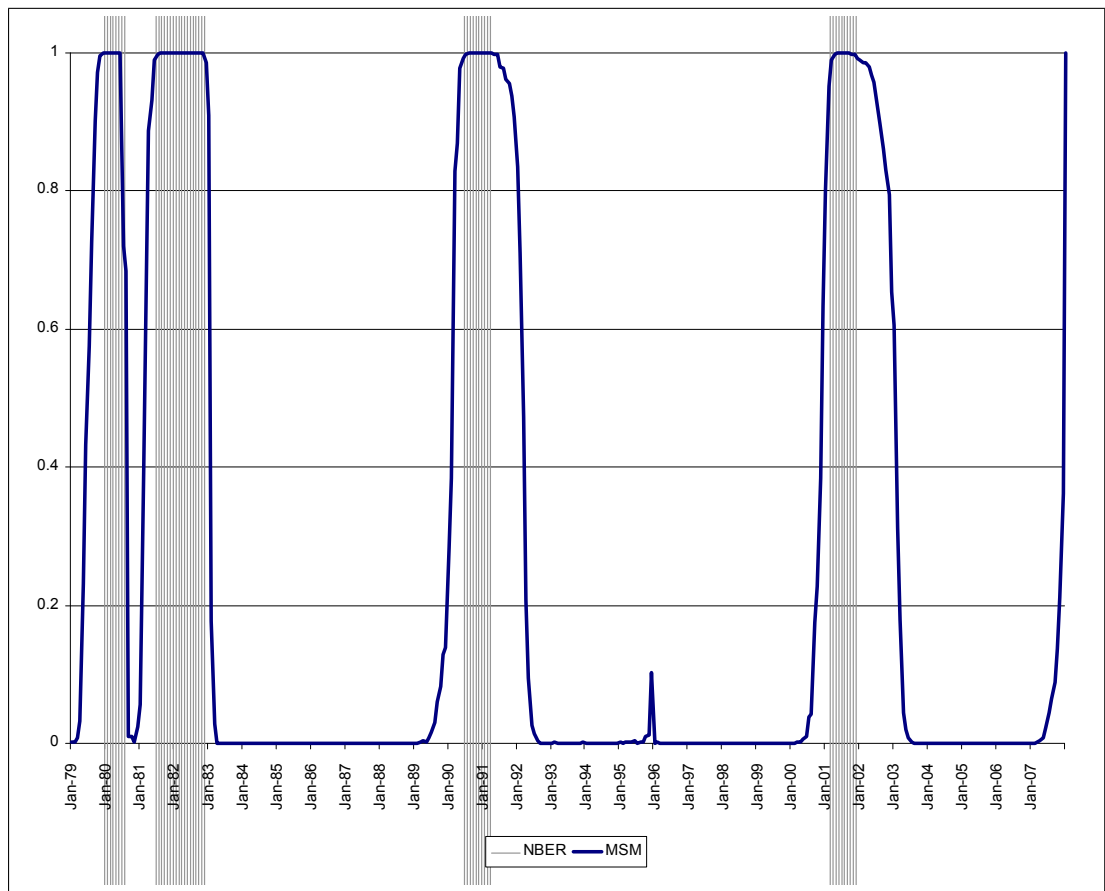
way before (approximately 4-6 quarters before) the national recession, and the second group of states enter into recession immediately (approximately 1-2 quarters) before the national recession. For example, between the 1989:IQ to the 1991:IIQ, Figure 2.6: Maryland, fell into recessionary phase about four to five quarters before the national recession.

In Figure: 2.6 Maryland, we also observe an additional own state recession from the 1995:IIIQ to the 1996:IQ. Arizona, Delaware, Maine, Alabama, Missis-

Mississippi, Arkansas Appendix 2.A.4 state level business cycles have similar patterns as Maryland, where the state level recession starts much before the national recession. One noteworthy feature here is that among the seven states Alabama, Mississippi, and Arkansas's state level business cycles patterns are comparatively similar. During the 1990s, all the three economies dragged into recession, rather than having recession before the nation.

Most states in the U.S. fall into the second subcategory, where these states enter into recession one or two quarters before the national recession. Figure: 2.7, explores Pennsylvania's business cycles, where all recessions including 1990s follow the same pattern as the national. New Jersey, North Carolina, Rhode Island, and South Carolina have very similar state level business cycle patterns as Pennsylvania, where states entered into recession right before the national recession and got out from recession shortly after (1 or 2 quarters) the national expansion. One of the explanations could be their geographical proximity. Interestingly, Illinois, Indiana, Kentucky, Kansas, Wisconsin, Minnesota, Michigan, and Oregon follow the similar pattern as Pennsylvania with an exception that during the 1990:IIQ to 1990:IVQ; it seems that all these states dragged into recession rather than face the recession beforehand. Vermont, Virginia, and Washington not only have the similar state business cycles patterns as Pennsylvania during the four national recessions, but they also have their own additional state level recessions Appendix 2.A.4. We put Florida and Georgia's business cycles into this category as well, even though both of these states

Figure 2.7: Pennsylvania



did not follow the national business cycle patterns during the 1980's. In Appendix 2A (2.A.4) we also observe that Florida and Georgia have strikingly similar business cycles patterns.

2.6 Conclusion

National authority, i.e., the Federal Reserve Bank makes a uniform decision to stabilize the national economy. Until recently, however, aggregate measures like GDP and GNP were the main measures of the economic performance of the nation. This research shows that each state has its own state level business cycles, which may or may not coincide with the national business cycles. Analyzing the state level business cycles, we draw four conclusions. First, national business cycles have almost the same pattern as economically dominating states, i.e., New York and California. In other words, when the Federal Reserve Bank makes policy decisions, those policies are more suitable for economically dominating states.

Second, most manufacturing states, i.e., Pennsylvania, Illinois, Indiana, Michigan, and the like, enter into recession way before the national recession, which indicate that recession can be transmitted from the manufacturing states to the nearby states and, thus, the nation enters into the recession gradually. Third, some states, specially, the oil producing states, such as Alaska, Texas, Louisiana, and Wyoming have minimum correlation between the state level business cycles and the national business cycles. Fourth, economically, not dominant states – mostly agricultural

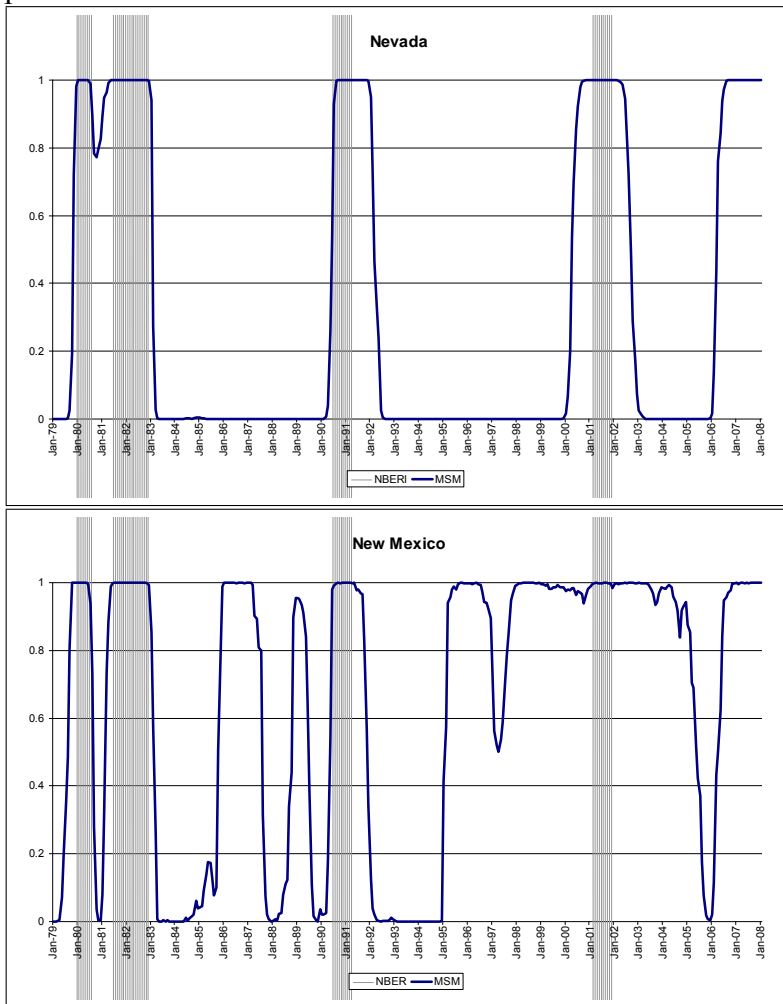
states – follow the national business cycle patterns. Finally, we can say that geographical proximity plays an important role in state business cycles. States closer to a dominant state have similar state level business cycles patterns as the dominant state.

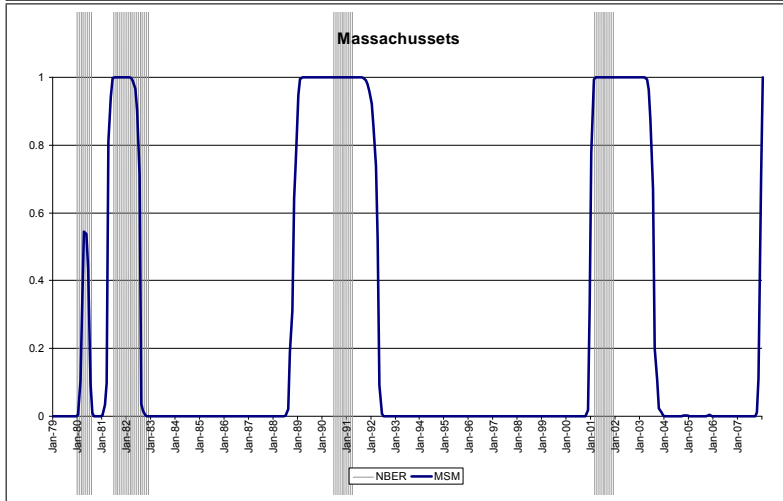
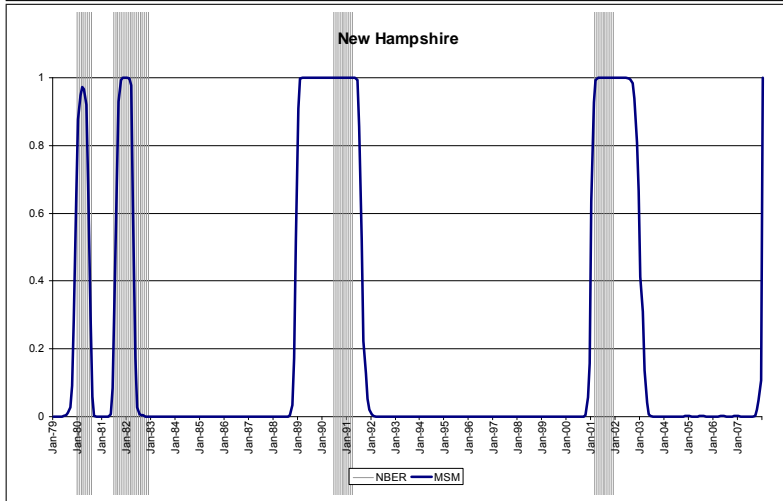
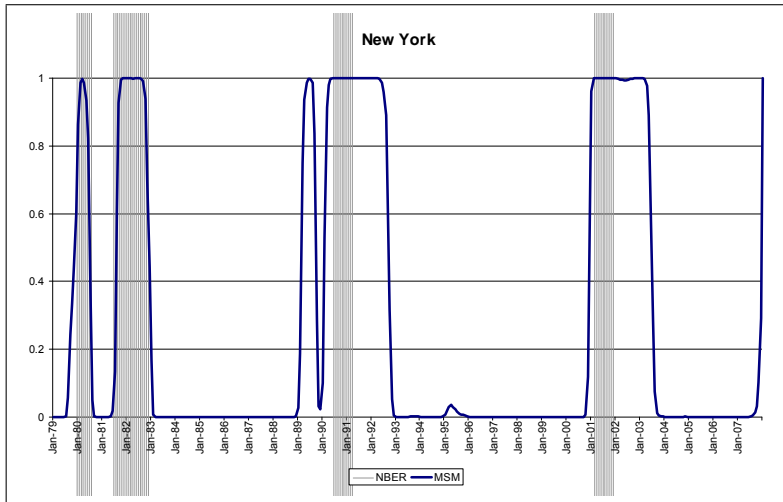
This essay answers only one question: whether the state level business cycles are similar to the national business cycles in the United States. This study can be extended in countless different ways. There are numerous unanswered questions, such as: what causes state level business cycles? How recession gets transmitted from one state to the others? What policy makers can do to prevent recession from transmitting? Additionally, a point we must investigate is that according to our analysis, many states seem to be in an expansionary phase in different time periods; however, in reality some states' expansion seems worse than some other states recessions. The question is why there are so many discrepancies among the states when we are part of the same nation? Similarly, sometimes we observe at the same time two states facing recession; we wonder if do this means that both states are facing recession for the same reason, or one may have recession due to a demand shock and the other may have recession due to a supply shock. These are all important questions for policy makers to consider, especially regarding the reasons behind the state level recessions because the aggregate policies they pick may have various effects in different states.

2.A Appendix

2.A.1 The First Group of States:

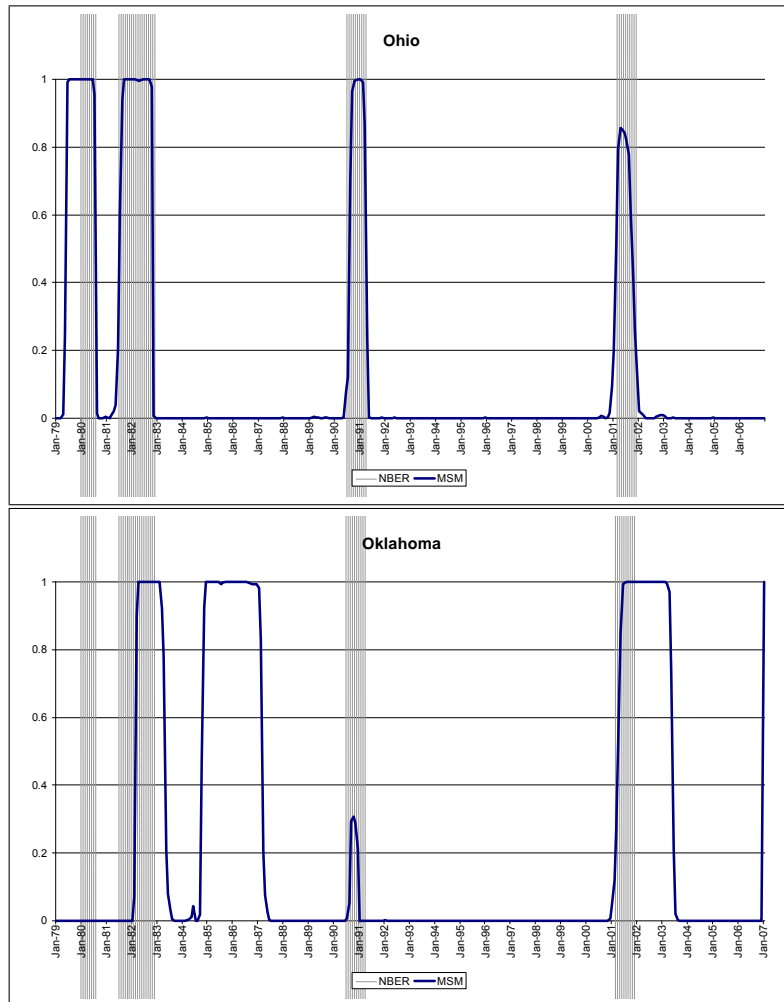
This group of states has the same business cycle patterns as the national business cycle patterns.





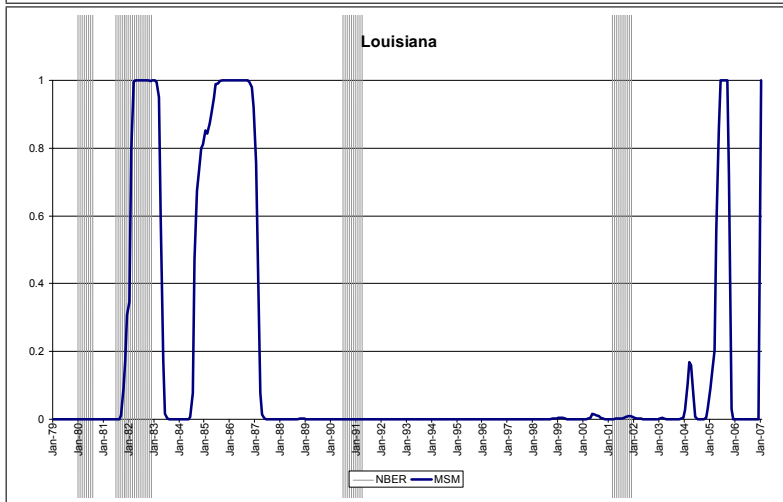
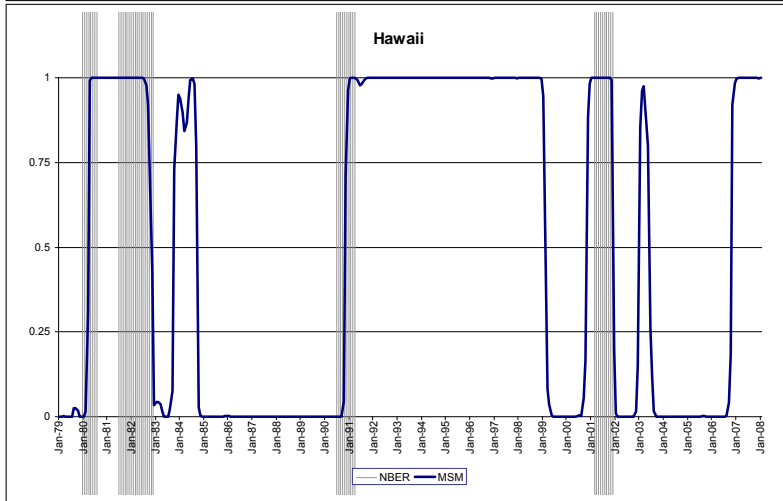
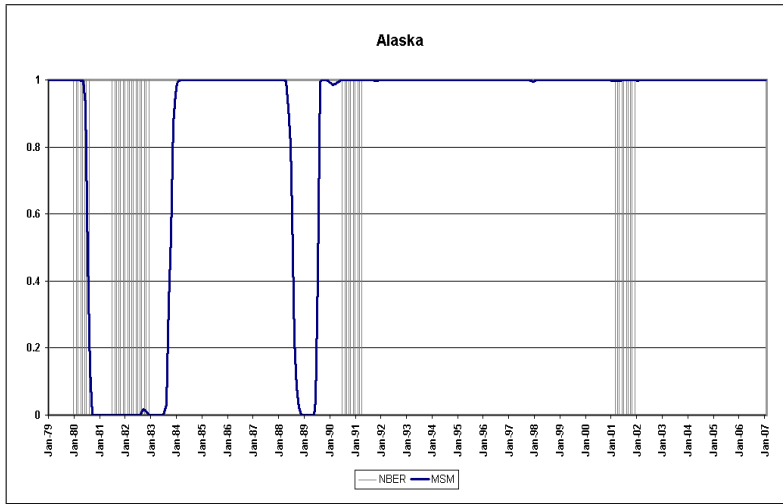
2.A.2 The Second Group of State

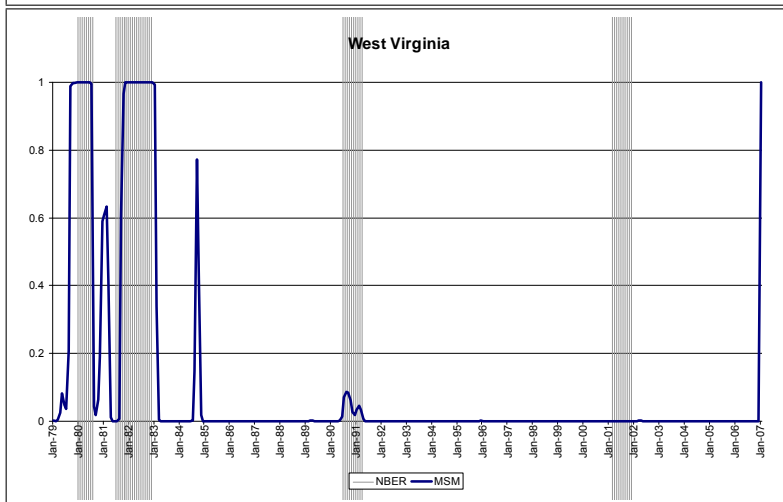
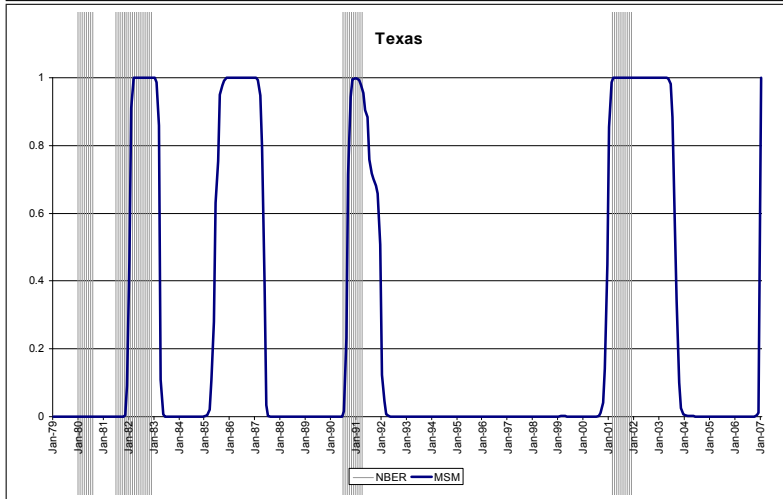
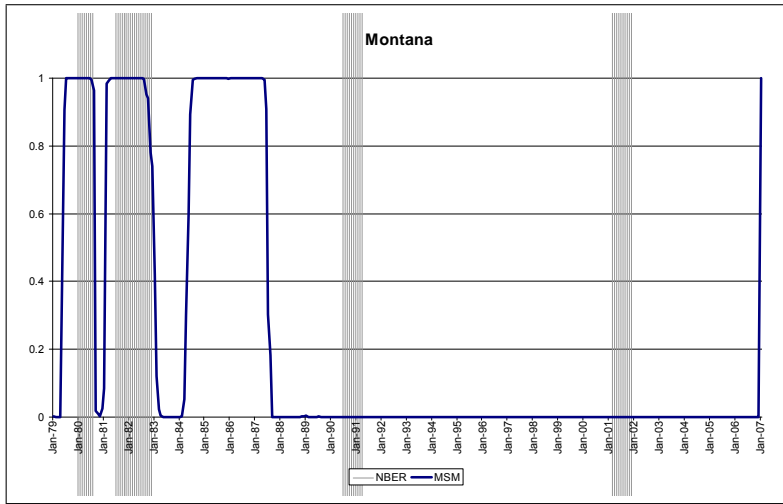
This group of states' state level business cycle start after the national business cycle.



2.A.3 The Third Group of States

The third group of states has a unique state level business cycle patterns, which do not follow the pattern of the national business cycles.

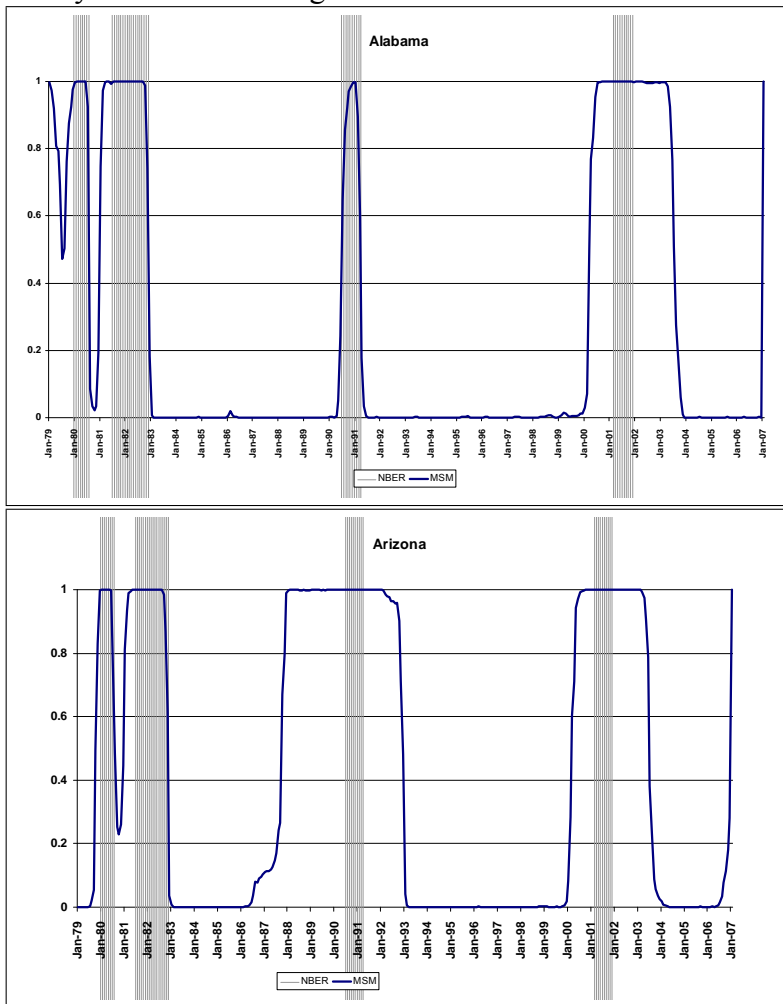


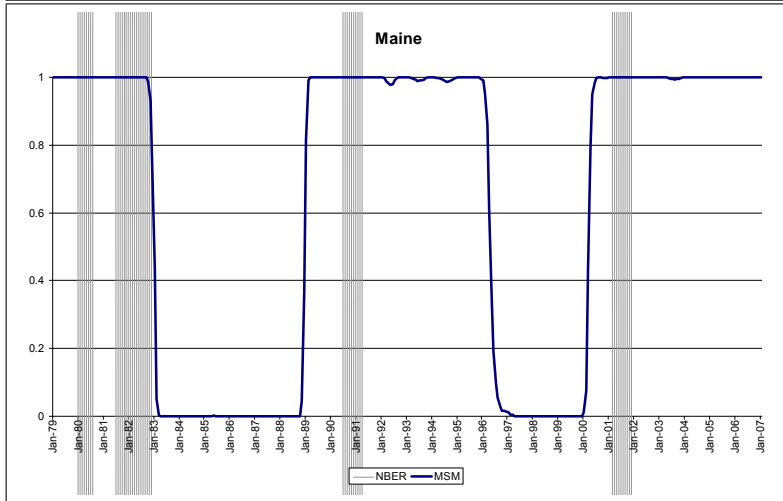
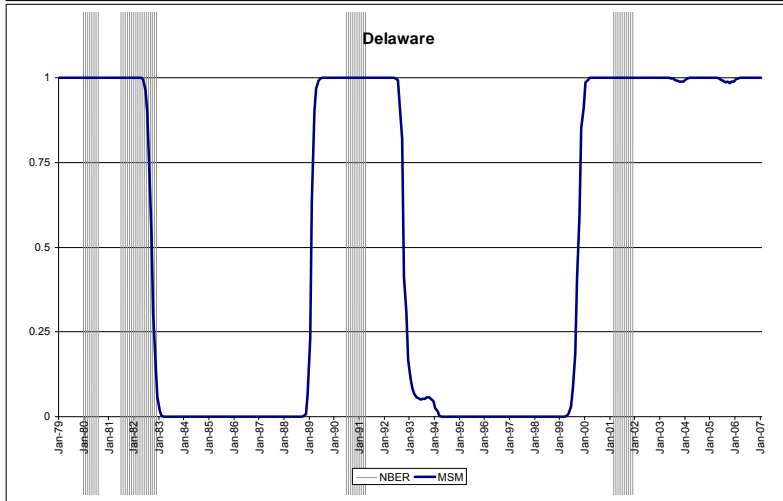
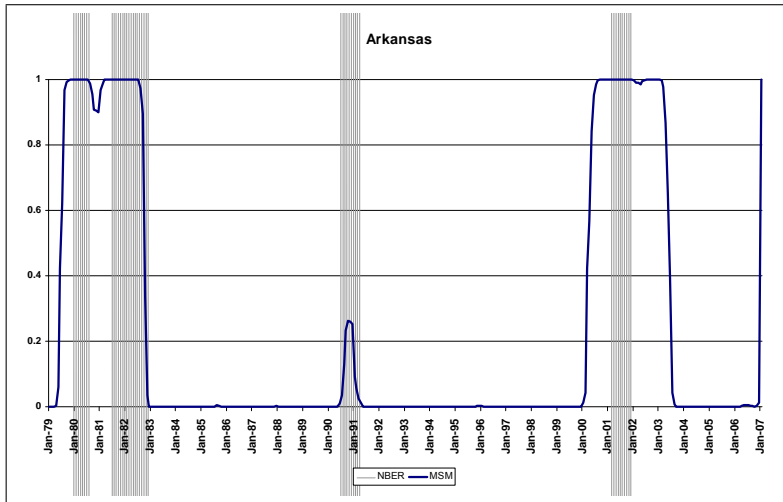


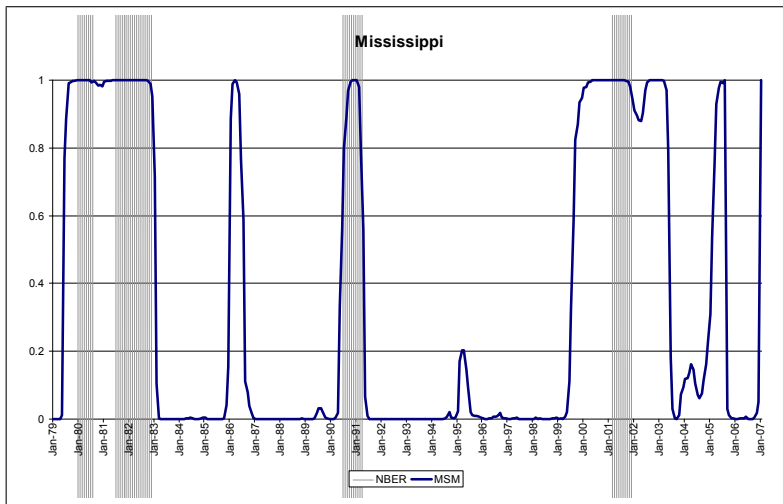
2.A.4 The Fourth Group of States

For this group the state level business cycles form before the national business cycles.

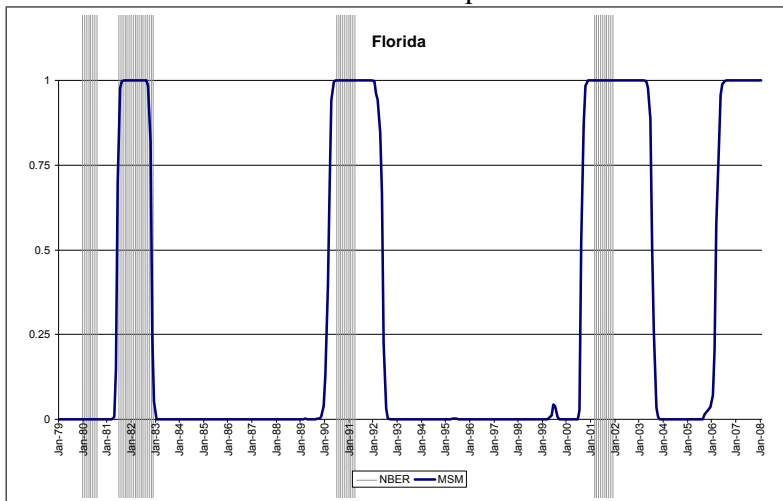
The national business cycles follow the first six states' business cycle patterns closely with a smaller lags.

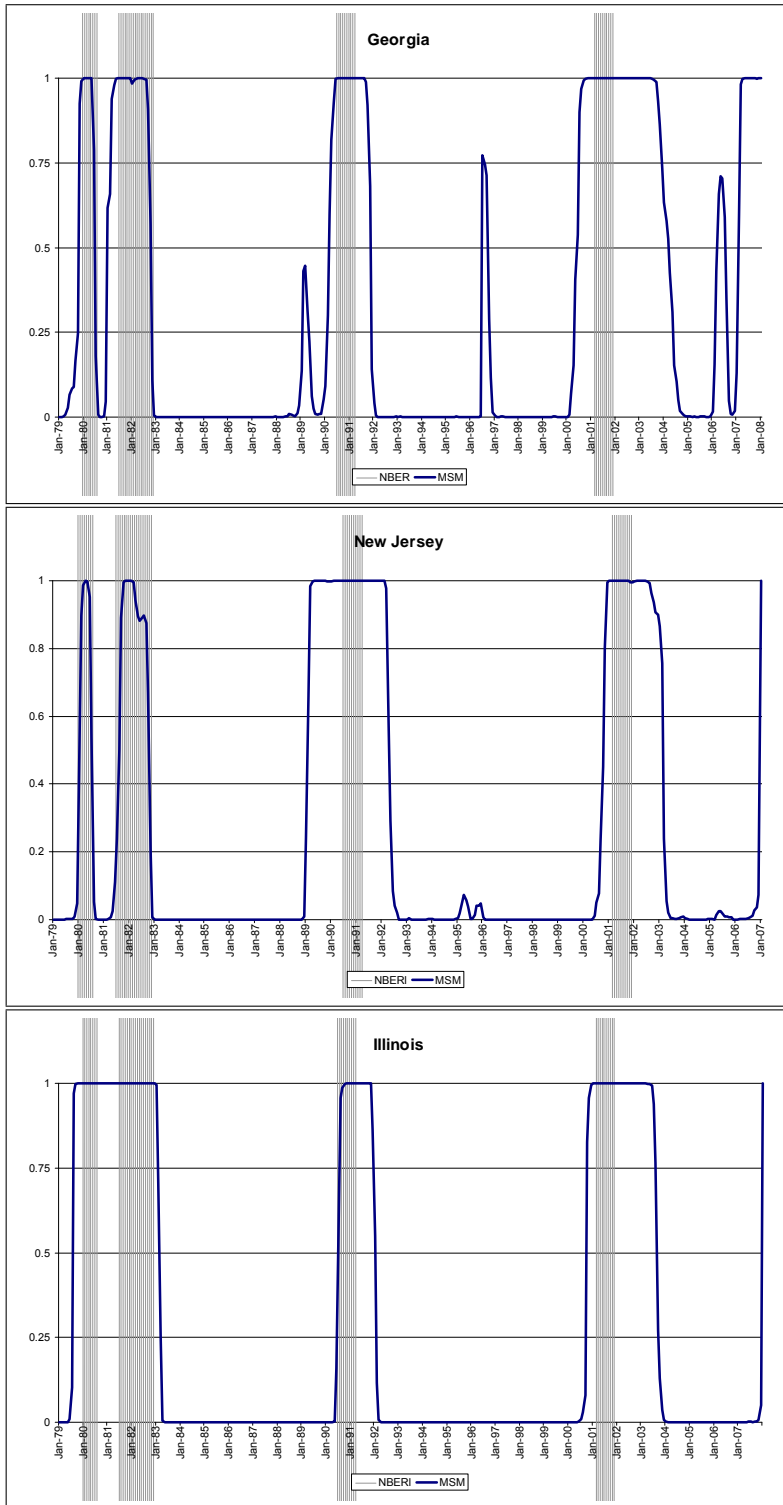


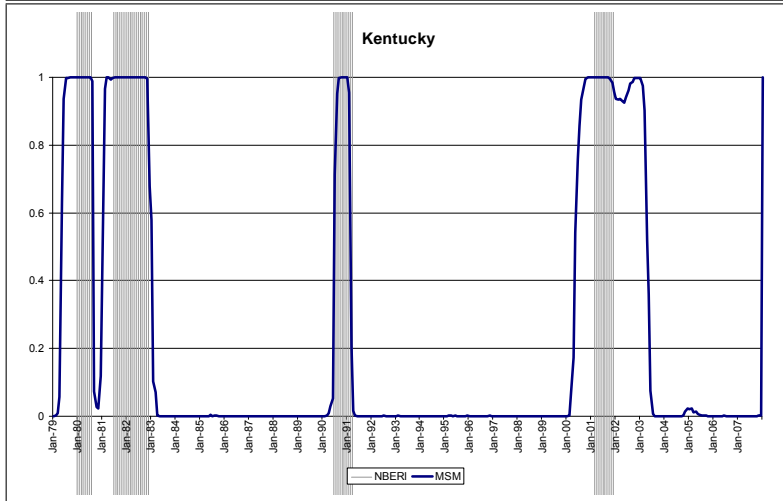
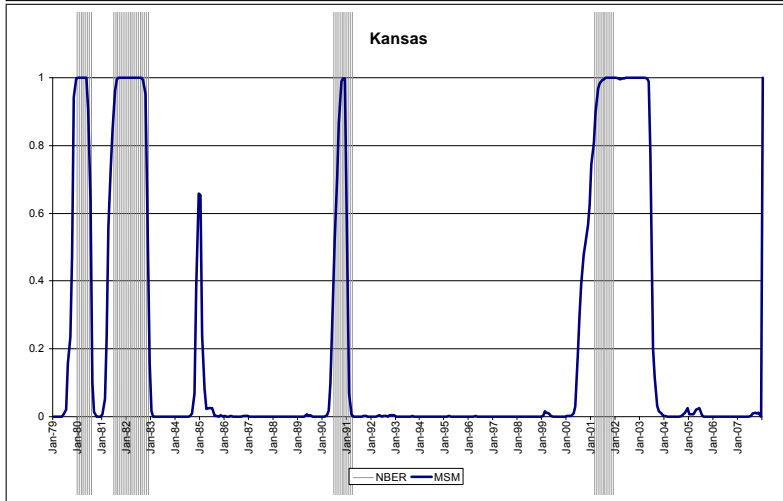
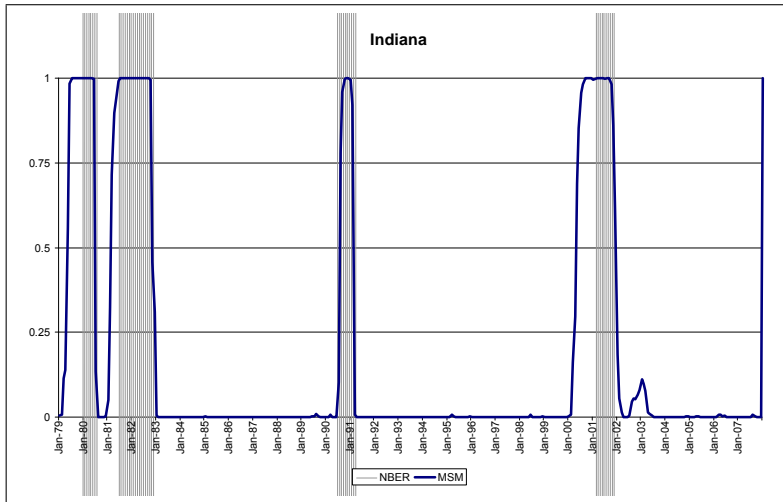


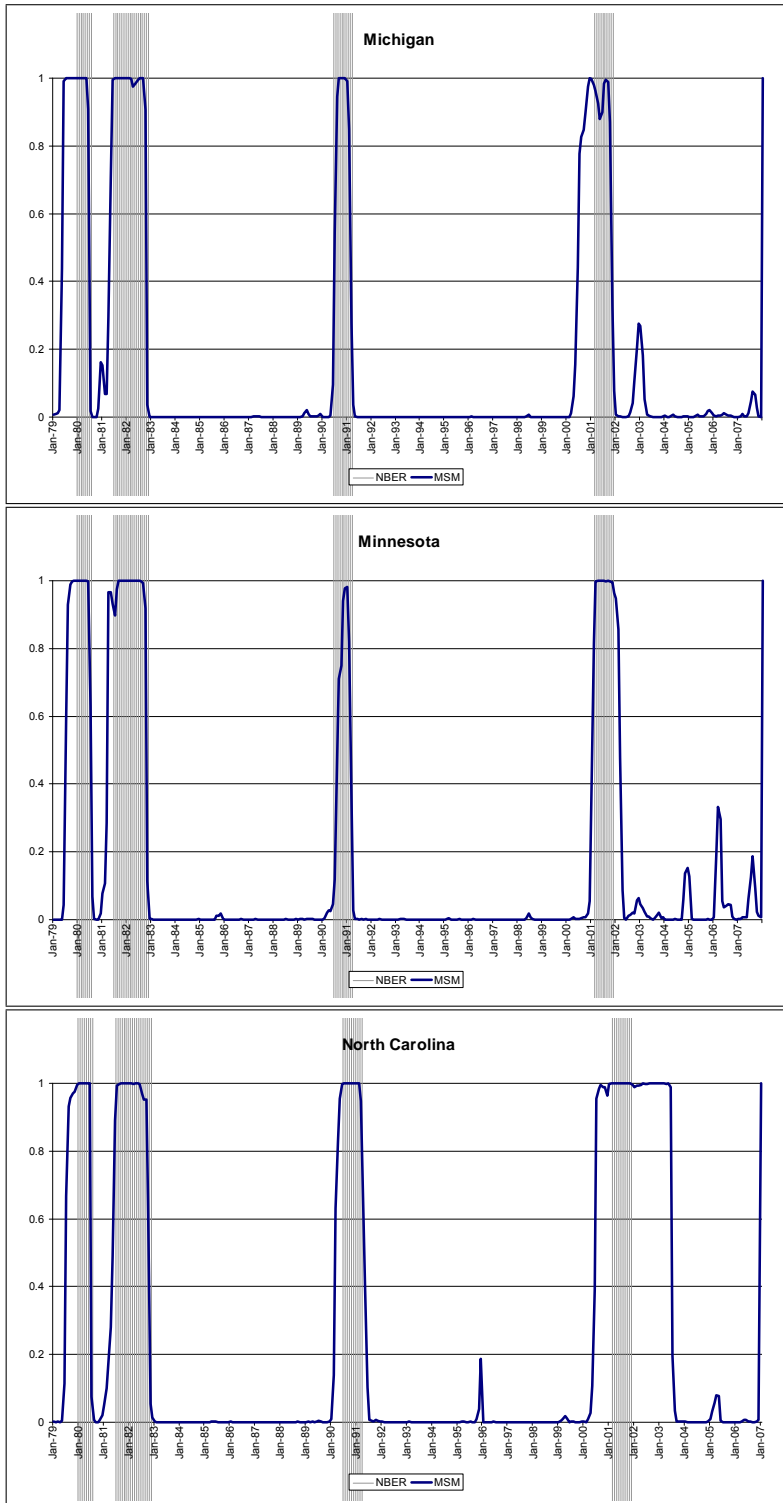


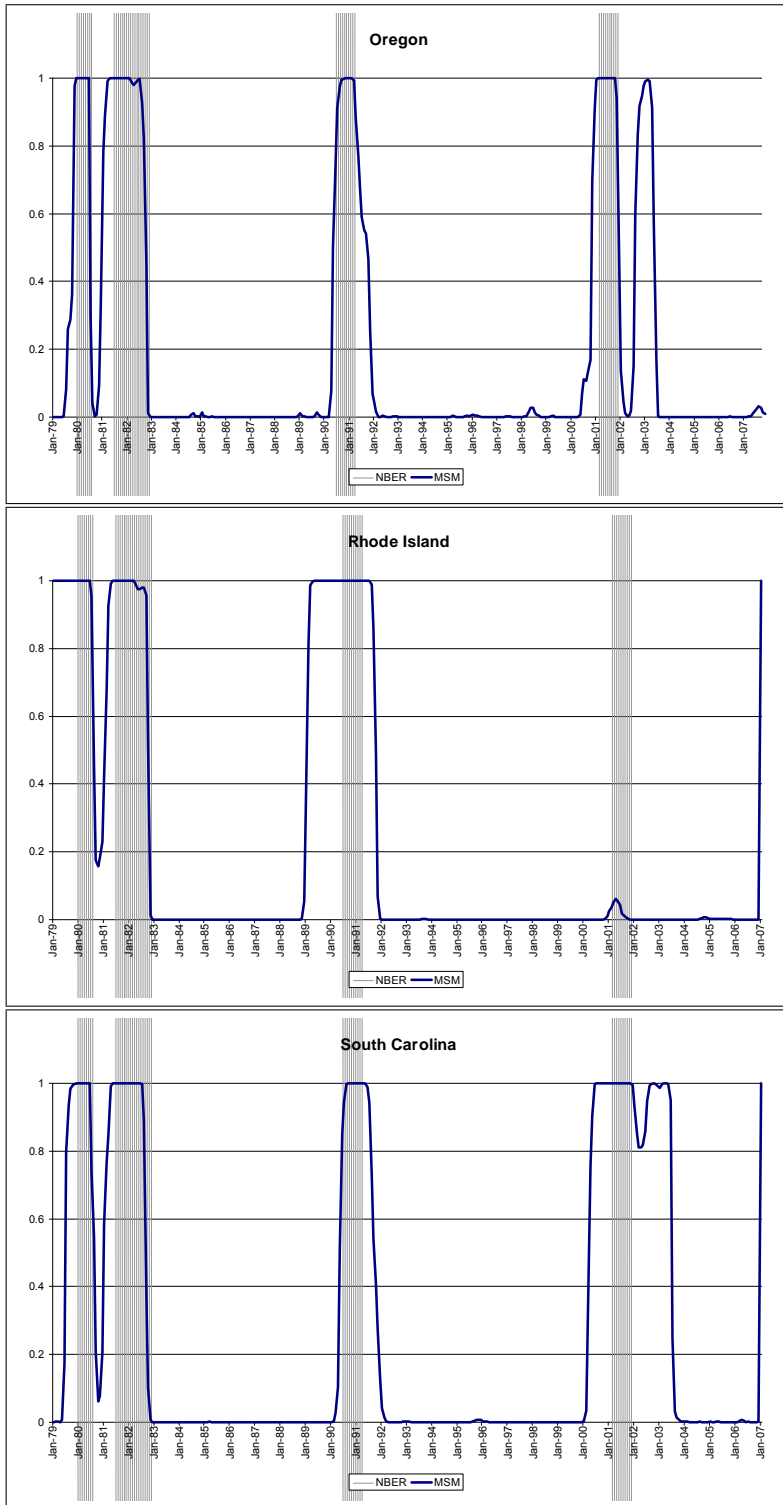
Most states in the U.S. belongs to this subcategory of states, where these states enter into recession more than two quarters before the national recession.

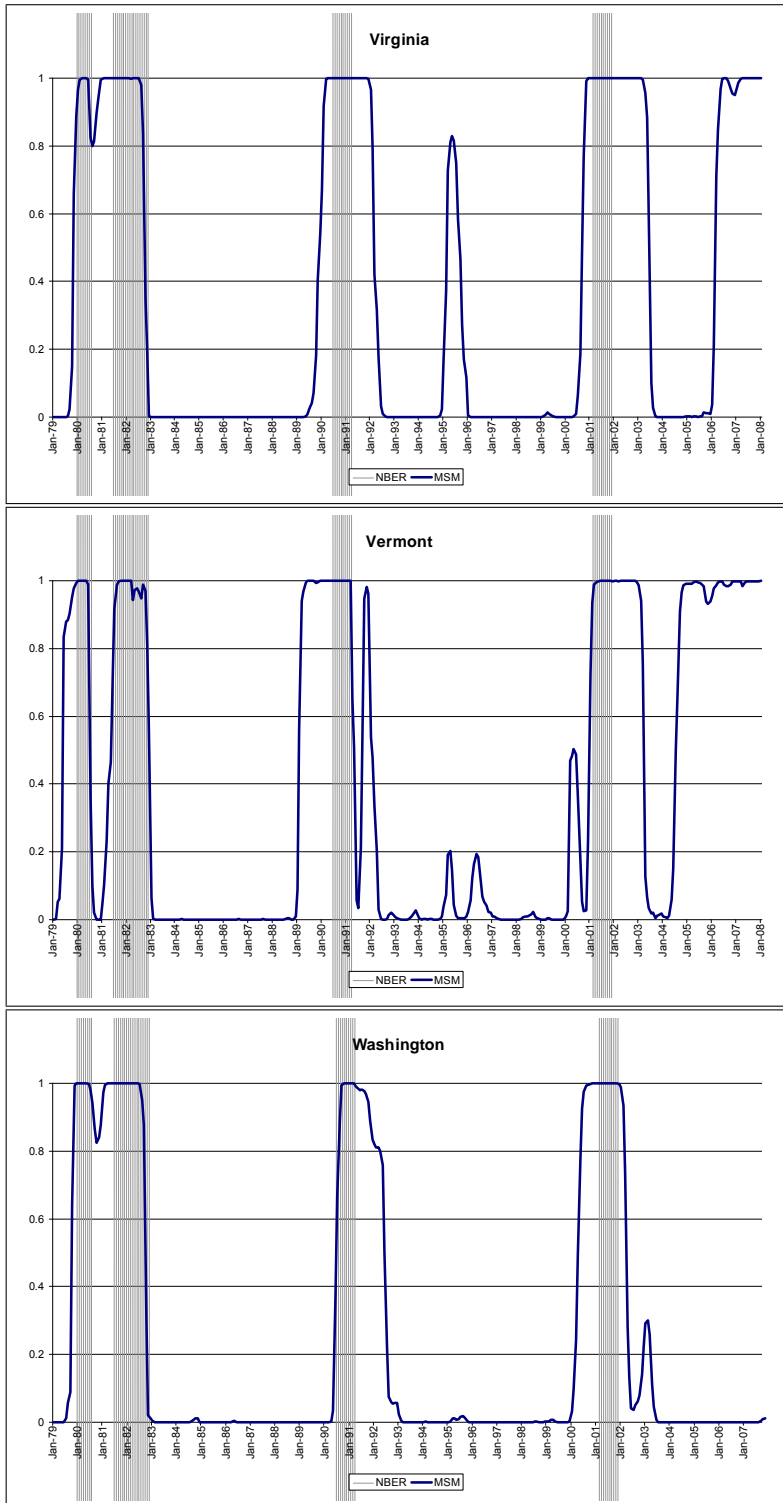


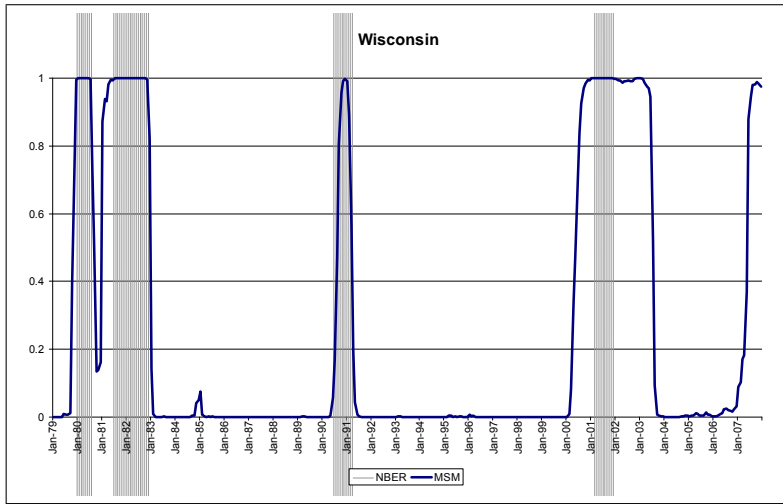












Chapter 3

Optimal Monetary Policy in a Multi-State Economy

3.1 Introduction

The questions of the optimal monetary instrument problem and optimal monetary policy were two major realms of monetary economics for the last four decades. Very few researches, however, showed interest around the question of how monetary policy should be optimally conducted when the economy is composed of a multitude of states with own industrial structure. This question is not a trivial one since each economy is characterized by own dynamics that, in principle, may be quite different from that of the union in aggregate. While being quite relevant for the conduct of monetary policy in the United States, the question of the optimal monetary policy in a multi-state economy is disregarded by the modern monetary literature. This paper sets forward a formal analysis of the optimal monetary policy in a multi-state economy by using a simple IS-LM model. For simplicity of analysis, we assume two states economy. Therefore, we will modify the traditional Hicksian IS-LM framework by using two IS curves - one for each state - and one LM curve for the nation. Our model is different from the previous models used in regional studies because it treats each region as a separate economy which may have its own economic shock.

Further, our model is useful for regional output variances comparison when the national authorities make a decision for the aggregate economy based on aggregate data, versus when the authorities consider the existence of multiple states in making aggregate decisions. The theoretical undertaking of this paper is to minimize the national output variances, as well as regional output variances. The results for this study is strictly theoretical, where we just analyze the output variances of the two cases.

This study is important because many world economies, including the U.S., are in fact multi-state economies. By multi-state economies we mean that a nation comprises of different economic regions, where different economic regions may face different phases of the business cycle at a given time period. In the multi-state economy, it may also be possible that when the nation is facing one phase of the business cycle, some regions or states inside the nations may face the opposite phase of the business cycle. This is the case when national and state level business cycles do not coincide. Study by Partridge and Rickman [29], Clark [10], and Temple [33] found that the U.S. regional business cycles exist due to regional industry shocks, rather than national shocks. Therefore, aggregate stabilization policies may not work efficiently for those states, which are in a different phases of the business cycle than that of the nation. For example, in 1990 – 1993 the state of Michigan was facing an expansion where as the U.S. on aggregate was in recession – conventional uniform national policies may increase output variances of regions which have different busi-

ness cycle dynamics than that of the nation. Thus, the optimal monetary policies, that minimize the output variance of the nation on aggregate may not successfully reduce the output variances of all the regions as well as the nation's. The studies by Owyang, Piger, and Wall [27], Wall and Zoega [34], and Giannikos and Mona [16] show that at a point in time different U.S. states may face different phases of a business cycle. Using the shift share analysis, Grobar [19] showed that even though two regions in a nation may simultaneously face similar phases of a business cycle, they may be in that for different reasons. She explains that one economic region in a nation may be in recession due to supply shocks and the other region may simultaneously be in recession due to demand shocks. Therefore, one uniform aggregate policy may not successfully reduce the output variations in both regions.

This paper has two goals. First, we compare the national output variance (1) when the national authorities make a decision based on aggregate data versus (2) when the national authorities consider economic condition in each state to make policy decisions. Second, we investigate if the optimal monetary policy based on regional data can successfully reduce output variations in each state as well.

In the next section we summarize the monetary policy literature that focuses on regional as well as national economies. Section three discusses our model and methodology. We state the results in section four and we conclude in the last section.

3.2 Literature Review

Most of the existing literature focuses on the effect of national government policies on national growth and national growth convergence. By the same token, many analyze the impact of national business cycles on regional convergence. Some literature explores the effect of national policies on regional convergence. Few, however, study the impact of national government policies on regional economic stability. Researchers and governments of the European Community studied economic growth and regional convergence as a consequence of adopting of a unified currency under unified regulations. These are some of the key areas of research about national and regional policy implications and economic stability. Despite burgeoning literature on national and regional policies, confusions and unanswered questions are widespread.

Studies on optimum currency area discuss the effect of monetary policies on regional economic variability. A famous study by Mundell [26] concludes that a region (state) is the optimal currency area and questions the effectiveness of flexible exchange rate system in a multiregional country such as Canada. By estimating magnitude of various monetary policy shocks, Bayomi and Eichengreen suggest that it is very difficult to maintain fixed exchange rate throughout the European Community. Demand shocks are more difficult to interpret when exchange rates are fixed across regions. For the U.S. regions, Bayomi and Eichengreen [2] found that demand shocks are somewhat larger in the EC countries due to specialization. Furthermore, they found that the standard deviations of output fluctuations are somewhat smaller

across the EC countries than across the US regions, while the inflation variability is higher in Europe. They explain that the differences between EC countries and U.S. regions can be due to labor mobility. Perfect labor mobility inside the currency area can stabilize the inflation rate. In a word, the study of the optimum currency area establishes the link between exchange rates, balance of payments, and capital and labor mobility in economic stabilization, whereas our model gives a simple theoretical explanation behind the national output variability.

A macroeconomic study by Gottschalk and Hoppner [18] showed that monetary policy can respond to demand shocks in a countercyclical manner to stabilize the economy. By using an appropriate monetary policy, the government can make the cycle shorter vis-à-vis the aggregate demand fluctuations. Evidence shows that using systematic monetary policies, the U.S. government successfully pulled the economy up from the slump of the late eighties and stabilized the economy during the boom of the early nineties. In contrast, monetary policy responds in a roughly pro-cyclical manner to supply conditions, albeit with a considerable time lag. Because of the large time lags supply shocks are very difficult to identify and interpret. In sum, Gottschalk and Hoppner's research focuses on the effectiveness of the national stabilization policy in the face of various shocks.

Carlino and DeFina [5], [6] find that the effect of monetary policy on regional stability can be different across regions because regions are a mix of various interest sensitive industries, various types of banking systems, and various types of borrow-

ers. For example, construction or manufacturing are interest sensitive industries; changes in interest rates affect people's house buying decisions or businesses' willingness to acquire new infrastructure or invest in manufacturing sectors. Hence, changes in interest rate have more serious impact on regions with larger concentration of construction and/or manufacturing industry. A contractionary monetary policy affects smaller banks more than larger banks because larger banks have more funding options than smaller banks. Thus, higher interest rate will affect Southern regions more, for Southern states have smaller banking systems than do the rest of the U.S. (i.e., North-Eastern banks have diversifying banking systems). Similarly, when the Federal Reserve bank changes the reserve requirement ratio or the law of overnight borrowing, the regions comprised of smaller borrowers get affected more because they have fewer alternative non-bank sources of funds. Thus, such uniform policies may create regional output variations, specially for those regions, that are on the opposite sides of the national business cycle, and eventually may destabilize the overall economy,. Most of these studies are empirical and show the link between a change in the monetary policy variable and the effect on the regional economies.

3.3 The Model

Using stochastic IS-LM framework we propose optimal monetary policy which minimizes the national as well as regional output variation. This model is different from the Poole [30] model in two notable ways. One, the Poole model solves the

monetary instrument problem, whereas our model compares the regional and national output variabilities for given monetary policy. Two, Poole's analysis is based on national economy using one IS and one LM curve, where Poole [30] assumes that the central government picks optimal policy instrument which minimizes national output variations. Our model assumes a two different economic regions in a nation rather than one aggregate economy. Additionally, two regions may face different phases of the business cycle and be subject to different shocks. The novelty of our analysis is the analytical comparison of the output variance of the nation in the case when the monetary authorities choose an optimal policy objective that relies on aggregate economic indicators with the case when the policy objective is stated in terms of regional economic indicators. Each of the two regions are characterized by their own IS curve, and one LM curve is shared by both regions of the nation.

We compare two versions of the model. First version assumes that the monetary authorities make a policy decision based on an aggregate economic conditions. In other words, the central bank does not consider each regional economy separately. We call this first version of the model "National Variation Analysis". Some may argue that each Federal Reserve district consists of several U.S. states and when the Board of Governors makes monetary policy decisions, they consider the economic conditions in all individual states. Nevertheless, in reality the Federal Reserve bank mostly relies on the aggregate U.S. economic conditions to conduct monetary policy. Evidence shows that the Federal Reserve bank decisions regarding money supply and

interest rate is almost always biased towards stronger economic regions, which are more representative of the aggregate economic conditions. The second version of the model assumes that the central bank takes both regional economies in the nation into consideration and picks a policy that minimizes output variance of individual regions. In this paper we show that when the Central Bank follows this objective it also successfully minimizes the variance of the aggregate output. We call this second version of the model "Regional Variation Analysis".

3.3.1 National Variation Analysis

For the simplicity, we assume that there are only two economic regions in a nation. Two regions of the nation are described by two IS curves - (3.1) and (3.2). Since a single monetary authority makes monetary policy decisions for the nation on aggregate, both regions face the same interest rate regardless of the regional business cycles phase they are in. We assume the price level is fixed in the short run. The IS curve of region one is defined as:

$$y_1 = -\alpha_1 i + u_1 \quad (3.1)$$

The IS curve of region two is defined as:

$$y_2 = -\alpha_2 i + u_2 \quad (3.2)$$

Thus, the IS curve of the aggregate economy can be written as:

$$y = -(\alpha_1 + \alpha_2)i + u_1 + u_2 \quad (3.3)$$

Equation (3.3) is an IS curve, that represents an aggregate-demand relationship for the nation in which output is a decreasing function of the interest rate. y is the economy's level of output gap in log. Demand also depends on exogenous disturbances u_1 and u_2 of both regional economies.

The LM curve for the nation can be represented by:

$$m = -ci + y_1 + y_2 + v \quad (3.4)$$

Equation (3.4) is a LM curve – demonstrating the demand for money as a decreasing function of the interest rate and an increasing function of output and subject to a random shock v . We also assume, that both shocks, u and v are mean-zero, serially and mutually uncorrelated processes. Equilibrium requires that the demand for money equals the supply of money. All other variables are interpreted as deviations from the trend values; thus, y is a measure of the output gap.

As it is the case in the United States and elsewhere in the world, one monetary authority makes uniform policy decisions for the aggregate economy by following a policy reaction function that in these simple settings can be expressed as:

$$m = \mu i \quad (3.5)$$

Where money supply decision of the central bank depends on the current interest rate and μ represents the optimal relationship between money supply and the interest rate. Hence we define μ as an optimal policy variable.

A common policy objective of a monetary authority is to minimize the variance of the output deviation from its full employment level, $\min E(y_1 + y_2)^2$, where the economy's equilibrium level of the output gap in the absence of shocks is $y = -(\alpha_1 + \alpha_2)i$. Using equations (3.3), (3.4), and (3.5), for this aggregate objective can be stated as:

$$E(y_1 + y_2)^2 = \frac{(\alpha_1 + \alpha_2)^2 \sigma_v^2 + (\sigma_{u1}^2 + 2\sigma_{u1u2} + \sigma_{u2}^2)(c + \mu)^2}{(\alpha_1 + \alpha_2 + c + \mu)^2} \quad (3.6)$$

The above equation represents the variance of the aggregate output deviation of the nation. Policy makers pick a policy μ which minimizes the output variance (3.6), thus minimizing the above objective with respect to μ :

$$\mu_{aggregate} = -c + \frac{(\alpha_1 + \alpha_2)\sigma_v^2}{\sigma_{u1}^2 + 2\sigma_{u1u2} + \sigma_{u2}^2} \quad (3.7)$$

$\mu_{aggregate}$ is the optimal aggregate policy variable that minimizes the aggregate output variance (3.6). It can be shown that the second derivative of the objective function (3.6) with respect to μ is positive for all the valid values of parameters; which implies that $\mu_{aggregate}$ indeed minimizes the objective function (3.6). In the above equation, $\mu_{aggregate}$ depends on the variance of the LM shock, variances of the both state level IS shocks, and the covariance of the IS shocks of both regions. The state output covariances in the United States are found to be positive.

3.3.2 Regional Variation Analysis

For all regional variation analysis, we assume that the central bank considers the output variance of each state separately before making stabilization policy decision. In that sense, the central monetary authority attempts to choose a uniform for both states policy that has the minimization of the output variance in each state as an objective.

Therefore, for the state one we write the IS curve as:

$$y_1 = -\alpha_1 i + u_1 \quad (3.8)$$

Here, the output of the region one gets affected by the state one's disturbance u_1 and α_1 is assumed to be positive.

The LM curve for the nation can be written as:

$$m = -ci + y_1 - \alpha_2 i + u_2 + v \quad (3.9)$$

Equation (3.9) represents the LM curve, where, c is a positive constant.

For the regional variation analysis, we again introduce the policy variable μ , and write the relationship between money supply and interest rate as:

$$m = \mu i \quad (3.10)$$

The final goal of a policy maker is to find the optimum μ which minimizes the output variance of each state. Thus, the objective function can be written as:

$$\min[E(y_1)^2 + E(y_2)^2] \quad (3.11)$$

For the region one we use equations (3.8), (3.9) and (3.10), and solve for the output variance of the region one in terms of both regional variances and the μ . Taken separately, the output variance of the region one can be written as:

$$E(y_1)^2 = \frac{(\alpha_2 + \mu + c)^2 \sigma_{u1}^2 - 2\alpha_1(\alpha_2 + \mu + c)\sigma_{u1u2} + \alpha_1^2(\sigma_v^2 + \sigma_{u2}^2)}{(\alpha_1 + \alpha_2 + c + \mu)^2} \quad (3.12)$$

Similarly, it can be shown that the output variance of the state two is:

$$E(y_2)^2 = \frac{(\alpha_1 + \mu + c)^2 \sigma_{u2}^2 - 2\alpha_2(\alpha_1 + \mu + c)\sigma_{u1u2} + \alpha_1^2(\sigma_v^2 + \sigma_{u1}^2)}{(\alpha_1 + \alpha_2 + c + \mu)^2} \quad (3.13)$$

By adding both states variances we get to an explicit expression for the objective two (3.11):

$$E(y_1)^2 + E(y_2)^2 = \frac{(\alpha_2 + \mu + c)^2 \sigma_{u1}^2 - 2\alpha_1(\alpha_2 + \mu + c)\sigma_{u1u2} + \alpha_1^2(\sigma_v^2 + \sigma_{u2}^2)}{(\alpha_1 + \alpha_2 + c + \mu)^2} + \frac{(\alpha_1 + \mu + c)^2 \sigma_{u2}^2 - 2\alpha_2(\alpha_1 + \mu + c)\sigma_{u1u2} + \alpha_1^2(\sigma_v^2 + \sigma_{u1}^2)}{(\alpha_1 + \alpha_2 + c + \mu)^2} \quad (3.14)$$

Since the policy goal is to minimize the output variances of each region as well as the nation, we minimize the output variances in the above expression with respect to μ . Here μ is the optimal policy variable, which determines the optimal monetary policy response to the changes in the interest rate. Thus, $\mu_{separate}$ is the optimum policy variable which minimizes the objective two (3.11):

$$\mu_{separate} = -c + \frac{\sigma_v^2(\alpha_1^2 + \alpha_2^2) - (-\alpha_1 + \alpha_2)(\sigma_{u_1}^2\alpha_2 + \sigma_{u_1u_2}(\alpha_1 - \alpha_2) + \alpha_1\sigma_{u_2}^2)}{\sigma_{u_1}^2\alpha_1 + (\alpha_1 + \alpha_2)\sigma_{u_1u_2} + \sigma_{u_2}^2\alpha_2} \quad (3.15)$$

According to the equation above, $\mu_{separate}$ depends on the IS-LM slope terms α_1, α_2 , the constant term c and variances of both regional shocks, $\sigma_{u_1}^2$ and $\sigma_{u_2}^2$, covariance of the regional shocks, $\sigma_{u_1u_2}$, and the variance of the monetary shocks, σ_v^2 . One can immediately note differences and similarities between $\mu_{separate}$ (3.15) and $\mu_{aggregate}$ (3.7).

3.4 Results

To check the performance of both policies (3.7) and (3.15) in terms of minimizing the objective function (3.11), we separately evaluate the objective, $E(y_1)^2 + E(y_2)^2$, (3.11) at $\mu_{separate}$ given by (3.15), and $\mu_{aggregate}$ given by (3.7). Thus, we get the following expression:

Replacing $\mu_{aggregate}$ given by (3.7) into (3.11), we get the following:

$$E(y_1)^2 + E(y_2)^2 = \frac{[\{(\sigma_{u_1}^2 + \sigma_{u_2}^2)\sigma_v^2 + 2\sigma_{u_2}^2(\sigma_{u_1}^2 + 2\sigma_{u_1u_2} + \sigma_{u_2}^2)\}\alpha_1^2 + \{2(\sigma_{u_1}^2 + \sigma_{u_2}^2)\sigma_v^2 - 4\sigma_{u_1u_2}(\sigma_{u_1}^2 + 2\sigma_{u_1u_2} + \sigma_{u_2}^2)\alpha_1\alpha_2\} + \{(\sigma_{u_1}^2 + \sigma_{u_2}^2)\sigma_v^2 + 2\sigma_{u_1}^2(\sigma_{u_1}^2 + 2\sigma_{u_1u_2} + \sigma_{u_2}^2)\}\alpha_2^2]}{[(\alpha_1 + \alpha_2)^2(\sigma_{u_1}^2 + 2\sigma_{u_1u_2} + \sigma_{u_2}^2 + \sigma_v^2)]} \quad (3.16)$$

Replacing $\mu_{separate}$, given by (3.15) into (3.11), we get the following:

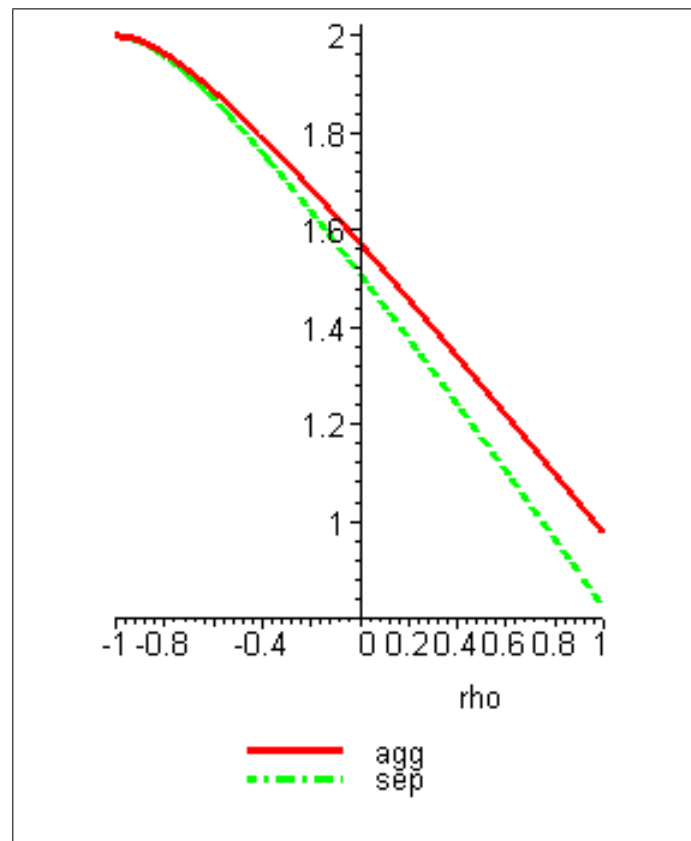
$$E(y_1)^2 + E(y_2)^2 = \frac{[(\sigma_{u1}^2 + \sigma_{u2}^2)(\alpha_1^2 + \alpha_2^2)\sigma_v^2 + \{\sigma_{u2}^2(\sigma_{u1}^2 + 2\sigma_{u1u2} + \sigma_{u2}^2) + \sigma_{u1}^2(\sigma_{u1u2} + \sigma_{u2}^2) - \sigma_{u1u2}(\sigma_{u1u2} + \sigma_{u1}^2)\}\alpha_1^2 - 2(\sigma_{u1u2} + \sigma_{u2}^2)(\sigma_{u1u2} + \sigma_{u1}^2)\alpha_1\alpha_2 + \{\sigma_{u1}^2(\sigma_{u1}^2 + 2\sigma_{u1u2} + \sigma_{u2}^2) + \sigma_{u2}^2(\sigma_{u1u2} + \sigma_{u1}^2) - \sigma_{u1u2}(\sigma_{u1u2} + \sigma_{u2}^2)\}\alpha_2^2]}{[(\alpha_1^2 + \alpha_2^2)(\sigma_{u1}^2 + 2\sigma_{u1u2} + \sigma_{u2}^2 + \sigma_v^2)]} \quad (3.17)$$

Equations (3.16) and (3.17) represent the sum of the output variances of both regions under two different policies: (3.16) represents the sum of the state output variances when the policy objective is to minimize the variance of the aggregate output given by (3.6). (3.17), on the other hand, represents the sum of the state output variances where minimization of the sum of the state output variances is the monetary policy objective. It is difficult to compare the relative effectiveness of each policy in terms of minimizing the objective (3.11) by just looking at the cumbersome expression in (3.16) and (3.17). We, therefore, present the graphical analysis of both outputs.

For the graphical analysis of equations, (3.16) and (3.17), first we replace covariances σ_{u1u2} with the term $\rho\sigma_{u1}\sigma_{u2}$, where ρ (rho), represents the correlation between states and σ_{u1} and σ_{u2} are the standard deviation of state level shocks. Further, we assign some random values to the parameters $\alpha_1 = 0.2$, $\sigma_{u2} = 0.8$, $\sigma_{u1} = 1$, $\sigma_{u2} = 1$, and $\sigma_v^2 = 1$, and get the following graphical analysis:

Figure 3.1 shows correlation between state outputs and the objective function $E(y_1)^2 + E(y_2)^2$. The solid line represents the total output variance under the policy $\mu_{aggregate}$ and the dotted line represents the output variance under the policy $\mu_{separate}$.

Figure 3.1: Correlation Between State Outputs



According to the figure 1, as ρ (rho), the correlation between state outputs increases, the effectiveness of the policy $\mu_{separate}$ over the policy $\mu_{aggregate}$ becomes more pronounced. (Additional explanation is given in Appendix: 3.A.1)

3.4.1 Comparison of the national output variation

In order to ensure that the $\mu_{separate}$ policy unconditionally outperform the $\mu_{aggregate}$ policy, we show that the difference between the total output variance, or $E(y_1)^2 + E(y_2)^2$, (3.11) under the $\mu_{separate}$ policy and under the $\mu_{aggregate}$ is always low and negative. For the analytical expression, we subtract (3.17) from (3.16); thus, we get the following expression:

$$= \frac{(\alpha_2 - \alpha_1)^2 (-\alpha_2 \sigma_{u_1 u_2} - \alpha_2 \sigma_{u_1}^2 + \alpha_1 \sigma_{u_1 u_2} + \alpha_1 \sigma_{u_2}^2)^2}{(\alpha_1 + \alpha_2)^2 (\sigma_{u_1}^2 + 2\sigma_{u_1 u_2} + \sigma_{u_2}^2 + \sigma_v^2) (\alpha_1^2 + \alpha_2^2)} \quad (3.18)$$

which is always positive. This confirms that the sum of the state output variances (3.11) is indeed lower under the $\mu_{separate}$ policy than under the $\mu_{aggregate}$ policy.

3.4.2 Does $\mu_{separate}$ reduce one region's output variance?

The question arises, however, whether the policy $\mu_{separate}$, that minimizes the sum of variances of regional outputs, outperform the policy $\mu_{aggregate}$ in minimizing the variance of the output in each state taken separately. In other words, we inquire whether the policy $\mu_{separate}$ bypasses the performance of the policy $\mu_{aggregate}$ in minimizing either $E(y_1)^2$ or $E(y_2)^2$. To answer this question analytically, we first substitute the expression for the $\mu_{aggregate}$ in (3.7) into (3.12) to obtain $E\mu_{aggregate}(y_1)^2$

under the $\mu_{aggregate}$ policy. By the same token, we then substitute the $\mu_{separate}$ (3.15) in (3.12) to obtain $E\mu_{separate}(y_1)^2$. The expression bellow represents the difference [$E\mu_{aggregate}(y_1)^2 - \mu_{separate}(y_1)^2$]:

$$= \frac{(\alpha_1 - \alpha_2)(\alpha_1^2 + \alpha_1\alpha_2 + 2\alpha_2^2)(\alpha_1\sigma_{u1u2} + \alpha_1\sigma_{u2}^2 - \alpha_2\sigma_{u1u2} - \alpha_2\sigma_{u1}^2)\alpha_1}{(\alpha_1^2 + \alpha_2^2)^2(\sigma_{u1}^2 + 2\sigma_{u1u2} + \sigma_{u2}^2 + \sigma_v^2)(\alpha_1 + \alpha_2)^2}$$

By analyzing the above expression, we can tell that not always the $\mu_{separate}$ policy outperform the $\mu_{aggregate}$ policy. This expression may turn to be negative whenever $\alpha_2 > \alpha_1$, which implies that the $\mu_{aggregate}$ outperforms the $\mu_{separate}$ policy in minimizing the output variance in state i when the interest elasticity of output in that state α_i is less than that of state j . One way, we can interpret such result is, if the monetary government focuses on one state heavily and then certain sudden change happens in other states, the $\mu_{separate}$ policy may perform worse in that case.

3.4.3 Does $\mu_{aggregate}$ increase one region's output variance?

By proposing the $\mu_{separate}$ policy we show that the policy $\mu_{separate}$ not only successfully minimizes the output variances of each regions $E(y_1)^2$ and/or $E(y_2)^2$, but it also minimizes the variances in the over all economy [$E(y_1)^2 + E(y_2)^2$]. One obvious question may arise that if the $\mu_{aggregate}$ policy applied if it increases output variances of regional economy $E(y_1)^2$ and/or $E(y_2)^2$. To answer this question, we substitute the expression for $\mu_{aggregate}$ in (3.7) into (3.12) and obtain $E\mu_{aggregate}(y_1)^2$

under the $\mu_{aggregate}$ policy:

$$= \frac{(\alpha_1 + \alpha_2)^2 \sigma_{u1}^2 \sigma_v^2 + (\alpha_1^2 \sigma_{u2}^2 + 2\alpha_1 \alpha_2 \sigma_{u1u2} + 2\alpha_2^2 \sigma_{u1}^2)(\sigma_{u1}^2 + 2\sigma_{u1u2} + \sigma_{u2}^2)}{(\alpha_1 + \alpha_2)^2 (\sigma_{u1}^2 + 2\sigma_{u1u2} + \sigma_{u2}^2 + \sigma_v^2)}$$

The above expression is always positive regardless of the values of the parameters. In other words, the positive above expression indicates that the $\mu_{aggregate}$ policy increases the state level output variances. Figure 2: is the graphical analysis of the above expression, where we randomly assign values for the parameters as follows, $\alpha_1 = 0.8$, $\sigma_{u2} = 0.4$, $\sigma_{u1} = 1$, $\sigma_{u2} = 2$, and $\sigma_v^2 = 1$. The covariance between states σ_{u1u2} is rewritten in terms of correlation $\rho \sigma_{u1} \sigma_{u2}$, where ρ (rho) represents the correlation between states. In Figure 2: The horizontal axis represents the correlation between states ρ (rho), and the vertical axis is the output variance of the state one $E(y_1)^2$.

In Figure 3.2 output variance in state one with no policy, represented by a solid line and with $\mu_{aggregate}$ policy, represented by a dotted line. According to our assumption the output variance (σ_{u1}) in the state one is 1. Therefore, if there is no policy action taken the output variance in the state one will be 1, which is shown by the horizontal solid line in Figure: 2. The dotted downward sloping line represents the output variance of the state one when the $\mu_{aggregate}$ policy is applied. This implies that as the correlation between states becomes 1, the policy $\mu_{aggregate}$ can successfully reduce the output variance of all the states. However, as correlation between the states becomes zero or negative, the $\mu_{aggregate}$ policy increase the output

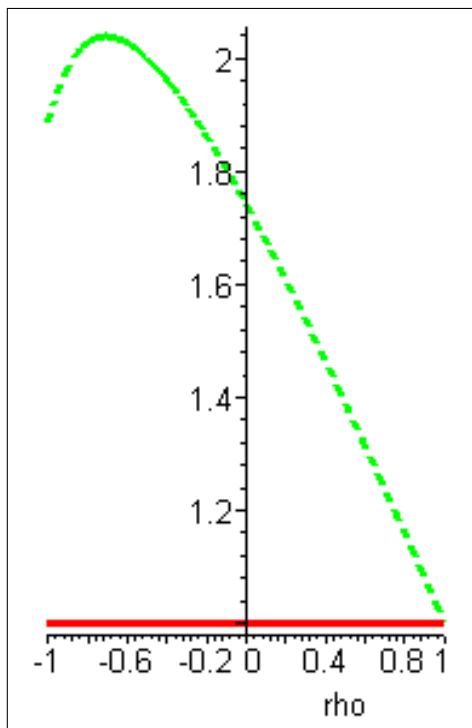


Figure 3.2: Output Variance in State One With No Policy

variance of each state. In that case no policy works better than the $\mu_{separate}$ policy. In other words, the $\mu_{aggregate}$ policy increases the state level output variances.

3.5 Conclusion

This study has shown that both regional and aggregate economy can reduce the output variances of the nation more effectively when the monetary authority considers each regional variation separately. In our suggested model, the $\mu_{separate}$ policy outperforms the conventional $\mu_{aggregate}$ policy, which reduces total output variances of the nation. However, this study also suggests that if the monetary authority focuses only on one state excessively and there are sudden changes in other states, the $\mu_{separate}$ policy may create more output variations than the $\mu_{aggregate}$ policy, depending on the state interest rate sensitivity. Further, we show that when the policy makers try to reduce the aggregate economic variations solely depending on aggregate data, the $\mu_{aggregate}$ policy, may increase the state level output variances.

3.A Appendix

3.A.1 National Analysis

Following is the output variances resulted from the difference in two policies ($\mu_{aggregate} - \mu_{separate}$). As long as the following expression is positive the $\mu_{separate}$ policy outperform the $\mu_{aggregate}$ policy. In other words, in the following expression α_1 must be greater than α_2 .

$$= \frac{(\alpha_1 - \alpha_2)^2(\alpha_1\sigma_{u_1u_2} - \alpha_2\sigma_{u_1}^2 - \alpha_2\sigma_{u_1u_2} + \alpha_1\sigma_{u_2}^2)^2}{(\alpha_1 + \alpha_2)^2(\sigma_{u_1}^2 + 2\sigma_{u_1u_2} + \sigma_{u_2}^2 + \sigma_v^2)(\alpha_1^2 + \alpha_2^2)}$$

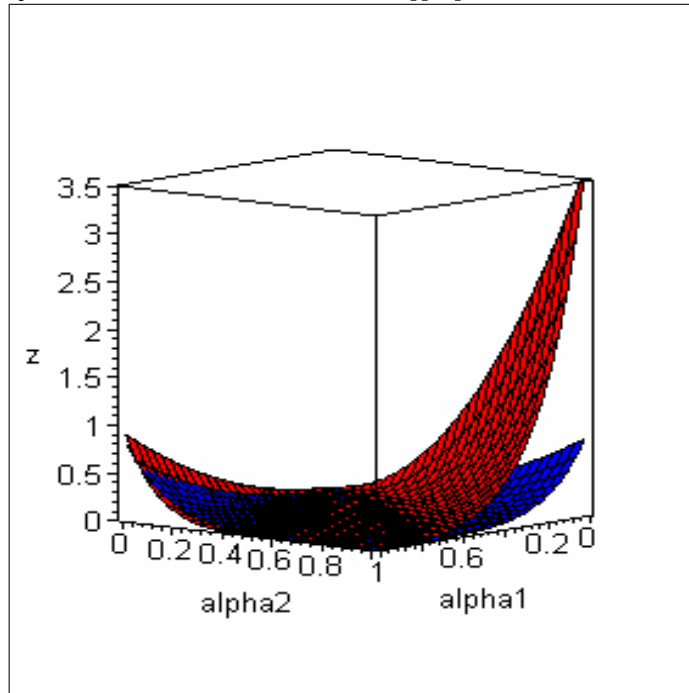
We can rewrite the above expression in terms of correlation as:

$$= \frac{(\alpha_1 - \alpha_2)^2(\alpha_1\rho\sigma_{u_1}\sigma_{u_2} - \alpha_2\sigma_{u_1}^2 - \alpha_2\rho\sigma_{u_1}\sigma_{u_2} + \alpha_1\sigma_{u_2}^2)^2}{(\alpha_1 + \alpha_2)^2(\sigma_{u_1}^2 + 2\rho\sigma_{u_1}\sigma_{u_2} + \sigma_{u_2}^2 + \sigma_v^2)(\alpha_1^2 + \alpha_2^2)}$$

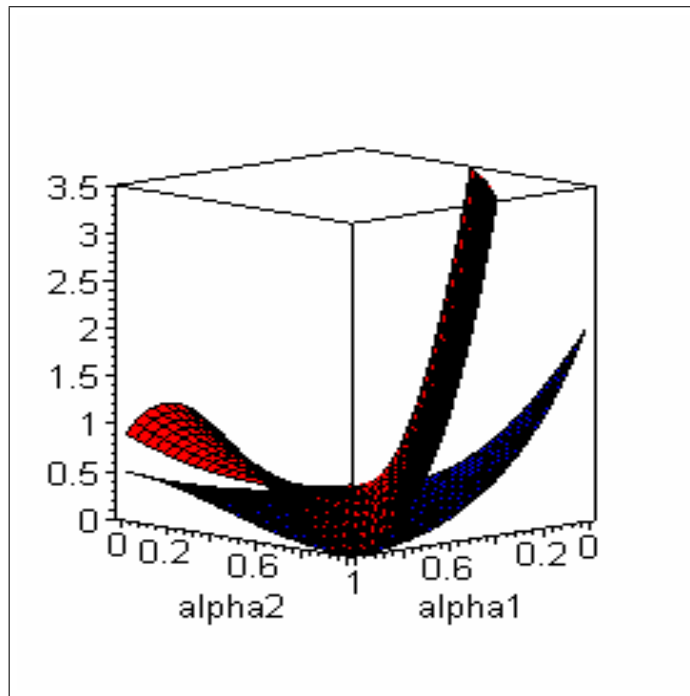
Now let assign any random values for σ_{u_1} , σ_{u_2} , and σ_v prove the above claim.

Let assume two states are perfectly correlated ($\rho = 1$) with variance of state one ($\sigma_{u_1} = 1$), variance of state 2 ($\sigma_{u_2} = 1$), and monetary variance ($\sigma_v = 1$). As we plot the values of σ_{u_1} , σ_{u_2} , and σ_v into the above equation we get the blue plate in the diagram below. This proves that $\alpha_1 > \alpha_2$, or the difference is always positive for all values of α s. In other words the $\mu_{separate}$ policy outperform the $\mu_{aggregate}$ policy. Now we can increase the variance in state one to ($\sigma_{u_1} = 2$), ceteris paribus, to demonstrate if the previous result holds. The result is demonstrated by the red plate

in the diagram, which shows that for all values of α the difference is positive. Thus, the $\mu_{separate}$ policy outperform the $\mu_{aggregate}$ policy.



Again, let assume if two states are not correlated ($\rho = -1$) and given variance of state one ($\sigma_{u1} = 2$), variance of state 2 ($\sigma_{u2} = 1$), and monetayr variance ($\sigma_v = 1$) we find that for any value of α s the difference is positive. In otherwords, the $\mu_{separate}$ policy outperform the $\mu_{aggregate}$ policy. This result is represented by the blue plate in the diagram below. Again we can assign another value for state one variance ($\sigma_{u1} = 4$), ceteris paribus and we can show that the previous result holds (represents by the red plate in the diagram below).



Chapter 4

Are U.S. States Economic and Real Estate Cycles Related?

4.1 Introduction

For the last two decades the topic of the real estate cycle has gained a lot of attention not only in the fields of micro and macro economics, but also in the field of finance and investment. Recently real estate became a lucrative investment option for investors (Leonhardt [23]; Dhar and Goetzmann [15]). Securitization of the real estate market was one important trend that attracted many investors into this field. Further, now there are more investors who can participate in the global real estate market than a decade ago (Case, Goetzmann, and Rouwenhorst, [9]). Nevertheless, in recent decades the world has experienced a couple of global real estate fluctuations including recent U.S. real estate crisis. This makes researchers and investors wonder about the structures of real estate cycles and how they are related to other economic activities in the nation as well as throughout the world.

Many studies show that the real estate cycle has a direct impact on the behavior of households, investors, banking systems, as well as on the national economy (Case [8], Wheelock [35], and Barlevy [1]). Very few studies, however, have compared and analyzed national and state level business cycles with the national and regional

real estate cycles. This comparison is important for at least three reasons: first, the clear idea about the national and state level real estate cycle will help home owners and real estate investors minimize their losses. Second, it will help proper authorities (government, mortgage brokers, banks, etc.) to make effective decisions. Third, future researchers will have vivid understanding of states' economic structures and better understanding of the behavior of the real estate cycles. This paper strictly focuses on macroeconomic perspective of real estate science and analyzes the patterns of real estate cycles. Thus, the study has three main objectives. First, using Markov-Switching estimation technique, this study compares the U.S. national and state level business cycles with the U.S. national and state level real estate cycles. Second, depending on the formation of the state level real estate cycles, this study categorizes different states, and finally it analyses the severity of the state level real estate cycles.

The rest of the paper is organized as follows. First, we discuss related literatures, second we explain the data descriptions, third we provide model and methods, fourth we give data description, fifth we state the results by presenting comparison of business cycles and real estate cycles, thus categorize states depending on the formation of real estate cycles. To give some idea how the U.S. states' real estate sector converges during the different phases of the real estate cycles, in section sixth we provide a convergence analysis and finally we conclude in the section seven.

4.2 Literature Review

In the United States national business cycles are calculated and dated by the National Bureau of Economic Research (NBER). Hamilton [20] used state space Markov Switching estimation technique on the U.S. GDP data to estimate business cycle turning points. Hamilton's estimated dates coincided with the dates provided by the NBER which confirms the validity of the Markov Switching estimation technique to measure business cycle turning points. Boldin [3] compared five different business cycles turning point dating methods in the U.S. economy. He concluded that the Stock and Watson's [20], [20] experimental business cycles indicators based on Kalman Filter algorithm and Hamilton's Markov Switching [20] estimation technique outperforms all other business cycles dating methods.

Crone [12], [13] used Kalman Filter estimation technique on the U.S. state level data and grouped U.S. into eight economic regions based on regional business cycles similarities. Using Hamilton's Markov Switching estimation technique on the state level coincident indexes⁶ Owyang, Piger and Wall [27] and later Giannikos and Mona [16] dated the turning points of the U.S. state level business cycles. Both studies show that the U.S. state level business cycles do not necessarily coincide with the national business cycles. A recent study by Crone [14] also estimates the U.S. state level business cycles using diffusion indexes. His study concludes that diffusion indexes are better data sets to track or to forecast regional business cycle turning points.

⁶ The state level coincident indices are provided by Crone 2000.

Exploring a threshold autoregressive (TAR) model Lizieri, Satchell, Worzala, and Dacco [24] found that regime switching model gives more accurate picture of real estate market performance than simple linear model. By using real interest rate⁷ as a state variable, they compare the behavior of the U.S. and the U.K real estate market. To measure the U.S. real estate market performance the authors used monthly data of the Real Estate Investment Trust (REIT) from December 1972 to March 1995. The U.K. real estate performance was measured by the monthly data of International U.K. property Price index from January 1975 to August 1995. They found distinct real estate regimes in the U.S. and in the U.K. Thus they concluded that the real interest rate plays a significant role as an indicator of real estate performance in both countries, i.e., the property prices fall sharply during the high interest rate regimes and the reverse happens during the lower interest rate regimes. Similarly, Carlino and DeFina [7], [5], [6] showed that changes in interest rate by the monetary authorities has differential effect on regions throughout the United State. The regions specialized in construction, housing, or real estate based industries get affected differently compared to manufacturing or service based industry regions.

Proposing a simple model of lagged supply response to price changes and speculation in housing market Malpezzi and Wachter [25] generated real estate cycles. They found that demand condition and speculation play major role in housing market and real estate cycles. Further, they showed that the price elasticity of supply

⁷ UK's real interest rate data was based on current inflation and short-term interest rates. Where inflation was measured by the changes in Retail Price Index (RPI).

is the dominant component of speculation. The largest effects of speculation were observed when supply is inelastic.

4.3 Data Descriptions

Three different data sets are used in this study: 1) the U.S. fifty states coincident indexes; 2) the housing price indexes for the fifty U.S. states and the nation; and 3) national business cycle turning dates. Following are the descriptions of the data sets we used for this study.

The U.S. fifty states' monthly coincident indexes are provided by the Federal Reserve Bank of Philadelphia dating from 1979:IQ – 2007:IIIQ. This data set is developed by Crone [12] estimating four latent dynamic factors of each state. The four variables are: the total number of jobs in nonagricultural establishments, average weekly hours in manufacturing, the unemployment rate, and the real wage and salary disbursements. This is one of the most comprehensive monthly data set available for state level economic analysis. The reason for using state level coincident indexes for this study is that there is no monthly Gross State Product (GSP) data available for the U.S. states. GSP data are in the annual basis, but state level recession or expansion can begin and end within a year.

The Housing Price Index (HPI) data used in this study is published by the Office of Federal Housing Enterprise Oversight (OFHEO)⁸. The HPI is a broad measure

⁸ The Office of Federal Housing Enterprise Oversight (OFHEO) was established as an independent entity within the Department of Housing and Urban Development by the Federal Housing Enterprises

of the movement of single-family house prices⁹, which measures weighted average changes in repeat sales, mortgage defaults, prepayments, refinancings, and housing affordability in specific geographic areas. The primary housing data are collected and provided by Fannie Mae and Freddie Mac to the OFHEO. The OFHEO generates HPI by using a modified version of the Case-Shiller geometric weighted repeat-sales procedure (Calhoun, [4]). The HPI by OFHEO is more accurate and complete measure of housing price change compare to S&P/ Case-Shiller indexes¹⁰ or Constant Quality Housing Price Index (CQHPI)¹¹. The HPI covers more transactions and geographic areas compared to other two data sets. We used quarterly HPI for fifty U.S. states from 1979:IQ to 2007:IIIQ.

For the national real estate cycle analysis, we also used quarterly HPI data for the U.S. provided by the OFHEO. National business cycles and its turning points dates are listed by the NBER from 1979:IQ to 2004:IQ.

4.4 Model and Estimation Method

Following is the Hamilton's Markov-switching model [20] to estimate business cycle turning points. In his model, he assumes the phases of business cycle shifts

Financial Safety and Soundness Act of 1992 (Title 13 of P.L. 102-550).

⁹ HIP does not cover condominiums, cooperatives, multi-unit properties, and planned unit developments.

¹⁰ S&P/ Case-Shiller indexes is available for only 38 states.

¹¹ Constant Quality Housing Price Index (CQHPI) is published by the Department of Commerce. The CQHPI covers sales of new homes and homes for sales. CQHPI is based on sample size of 14,000 annual house transactions. The HPI by OFHEO's covers repeated transaction of more than 32.4 millions houses over 32 years.

with the mean growth rate of a parametric time-series model for economic output:

$$(\Delta y_t - \mu_{S_t}) = \phi_1(\Delta y_{t-1} - \mu_{S_{t-1}}) + \phi_2(\Delta y_{t-2} - \mu_{S_{t-2}}) + \dots + \phi_4(\Delta y_{t-4} - \mu_{S_{t-4}}) + e_t$$

where, $e_t \sim N(0, \sigma_{S_t}^2)$ and $\mu_{S_t^*}$ indicates μ_1 when $S_t^* = 1$ and indicates μ_2 when $S_t^* = 2$, where S_t represents the different states of the economy – unobserved variable. For this paper, we use the simple version of the Hamilton (1989) model, which can be written as:

$$y_t = \beta_0 + \beta_{S_t} + e_t, \quad t = 1, 2, \dots, T \quad (4.1)$$

$$e_t \sim N(0, \sigma^2) \quad (4.2)$$

S_t represents different regimes of business cycles, where $S_t = 0$, or 1. y_t is the growth rate of GDP or some measure of economic activities, β_0 is an initial growth rate and β_{S_t} is the mean growth rate which can switch between regimes to indicate expansionary or recessionary phases. e is an iid a stochastic disturbance of the process.

The model can be rewritten as:

$y_t = \mu_0 + e_t$, when $S_t = 0$ (expansionary state), thus,

$$\mu_0 = \beta_0 \quad (4.3)$$

or, $y_t = \mu_1 + e_t$, when $S_t = 1$ (recessionary state), thus,

$$\mu_0 = \beta_0 + \beta_1 \quad (4.4)$$

However, S_t , $t = 1, 2, \dots, T$, is not observed. Thus we consider the joint density of y_t and the unobserved S_t variable and rewrite the log likelihood function of $f(y_t | \Psi_{t-1})$ as:

$$\begin{aligned} \ln L &= \sum_{t=1}^T \ln(f(y_t | S_t)) \\ &= \sum_{t=1}^T \ln\left(\frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{\{y_t - \beta_0\}^2}{2\sigma^2}\right) \times \Pr[S_t = 0 | \Psi_{t-1}] \right. \\ &\quad \left. + \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{\{y_t - \beta_0 - \beta_1\}^2}{2\sigma^2}\right) \times \Pr[S_t = 1 | \Psi_{t-1}] \right) \end{aligned} \quad (4.5)$$

The series of probabilities $\Pr[S_t = 0 | \Psi_{t-1}]$, and $\Pr[S_t = 1 | \Psi_{t-1}]$, where, $t = 1, 2, \dots, T$, and are not known, therefore, following Hamilton [20], we assume that the regime that governs the system follows a two-state Markov process with the following probabilities:

$$\Pr[S_t = 0 | S_{t-1} = 0] = p \quad (4.6)$$

$$\Pr[S_t = 1 | S_{t-1} = 0] = 1 - p \quad (4.7)$$

$$\Pr[S_t = 1 | S_{t-1} = 1] = q \quad (4.8)$$

$$\Pr[S_t = 0 | S_{t-1} = 1] = 1 - q \quad (4.9)$$

where p and q are coefficients estimated by MLE along with other coefficients¹².

¹² For the comprehensive derivation steps, please refer to the Hamilton's 1989 Markov Switching

Then we used the Kim's Smoothing Algorithm [21] which was first suggested by Cosslett and Lee [11]. Instead of using only the previous information, it is possible to obtain the probability of the economy being in either recession or expansion $\Pr[S_{t=j} | \Psi_T]$, using the full set of information Ψ_T .

4.5 Result

First, we compare the national business cycle with the national real estate cycle. We use business cycle phases (e.g., recession and expansion) for our comparison. In the following figures, vertical lines represent national recessions dated by the NBER. Recessionary states are measured in 0 to 1 scale, where 0 represents zero probability of recession, and 1 represents full probability of recession. Therefore if the cycles are under 0.5 probability scale we called these the state expansion; those above 0.5 probability scale we called the state recession. According to the following figures, the U.S. experienced four major national recessions¹³ during 1979:IQ to 2007:IIIQ time periods. Two recessions were at the beginning of the 1980s, the third one was at the beginning of the 1990s, and the last one was at the beginning of the 2000¹⁴.

Real estate recessions are marked by the solid (curve) lines in Figure 4.1. According to the Figure 4.1, the U.S. has experienced two major real estate recessions

estimation technique. The derivation of the steady-state or unconditional probabilities of S_t is given in Appendix 4A.

¹³ Confirmed by NBER announced date

¹⁴ Recession time periods: 1980:IQ – 1980:IIIQ; 1981:IIIQ – 1982:IVQ; 1990:IIIQ – 1991:IQ; and 2001:IQ – 2001:IVQ .

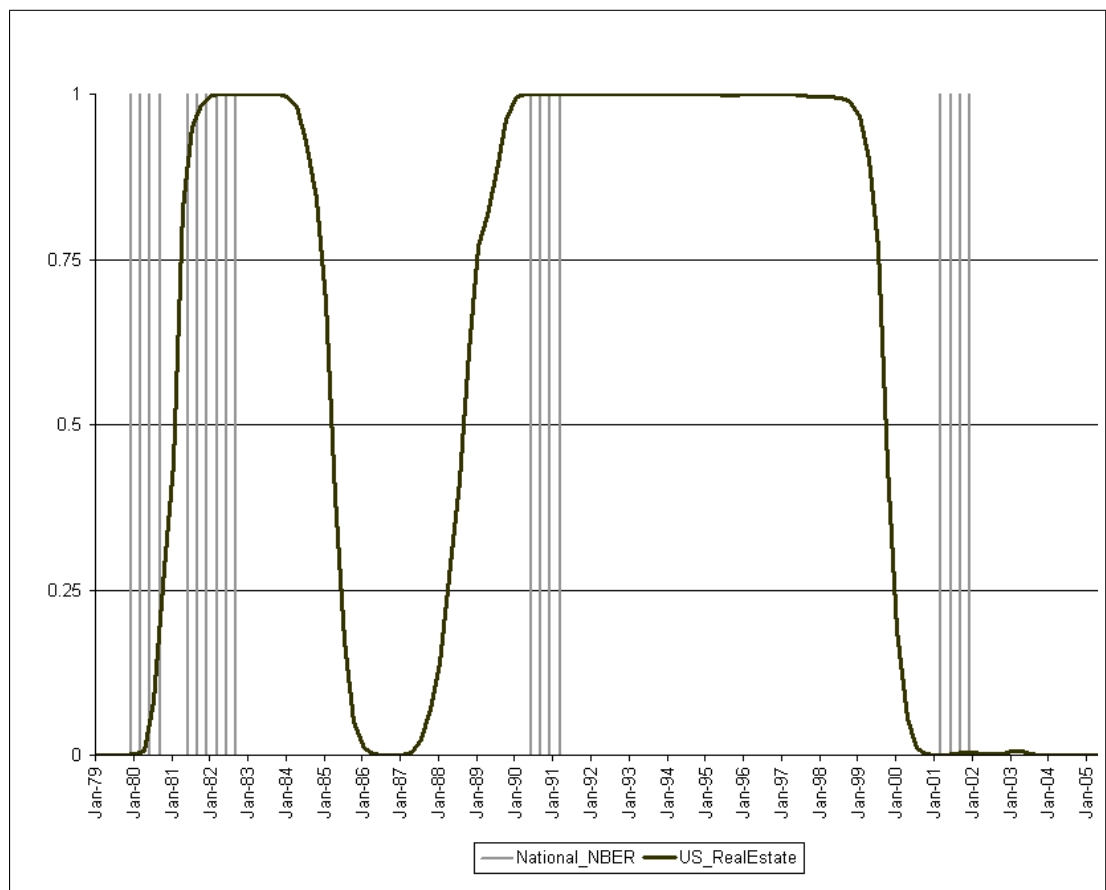
during 1979:IQ to 2006:IQ period. One started at 1981:IIQ and ended at 1985:IQ, and the second one started at 1989:IVQ and sustained until 1999:IIIQ. For both cases, the real estate recessions started before the national recessions, and continued several periods after the national recession ended.

The result indicates that even though the real estate is one of the biggest industries in the United States, not all national recessions are due to the real estate sector fluctuation. In many cases real estate fluctuations may play an important role in some national recessions. Nevertheless, just from the Figure 4.1 alone, we cannot confirm that real estate was the sole reason of two national recessions of the 1980s and the 1990s. Analyzing Figure 4.1, we also observe that in the recent years, starting from 2006:IIQ, the probability of another nation wide real estate recession is very high. A downturn in real estate in 2007:IIIQ occurred on the national level and on the state level in about forty five out of fifty U.S. states (Appendix 4.A.2). However, so far only nineteen states tend to have high probability of entering into state level economic recession, but there is no indication of national economic recession.

This paper also found that twenty two states¹⁵ have state level real estate cycle patterns similar to the national. In other words, these twenty two states experienced two real estate recessions as the nation during the 1980s and the 1990s; the span of recession, however, varied throughout the states. Nevertheless, the pattern of the cycle is not a sufficient condition for explaining the reasons behind similar real estate

¹⁵ AL, CA, CT, DE, FL, IL, KS, ME, MD, MI, MN, MO, NE, NH, NJ, NY, NC, PA, RI, TN, VA, and WA.

Figure 4.1: The U.S. Business and Real Estate Cycles

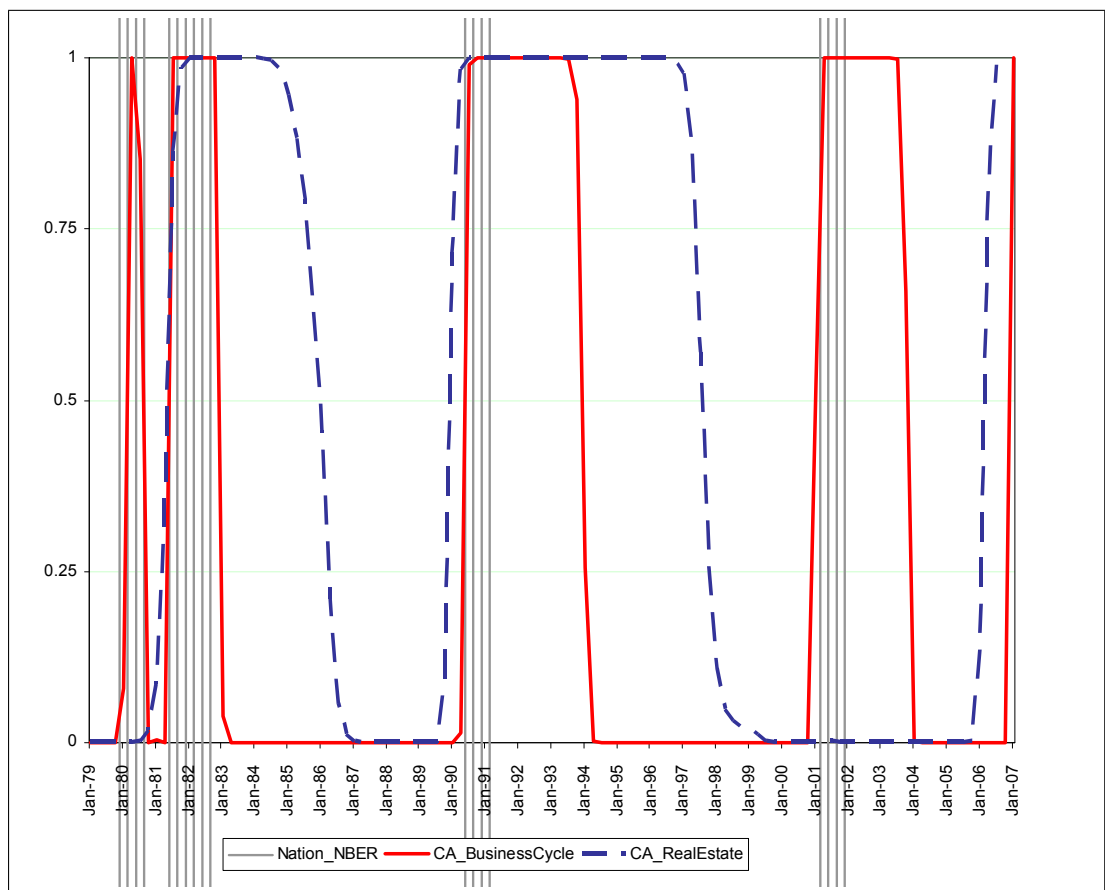


fluctuations. A study by Grobar (1996) showed that two regions might experience similar business cycle phases for two different reasons.

Depending on the pattern of the state level real estate cycles formation, we sort states into four categories. The first group is the leading group, where the real estate cycle begins. In other words, this is the group of states where the real estate cycles start before those states' own business cycles, as well as the national real estate and business cycles. In total eighteen U.S. states¹⁶ fall into the first category of states, where the state level real estate cycle started before the state level business cycles during the two national real estate fluctuations. Figure 4.2: California represents one of the eighteen leading states. In Figure 4.2, we observe both state level real estate fluctuations (1981 and 1990), started right before the national real estate fluctuations, which were later followed by the state level business cycle fluctuations. We observe a similar pattern at the beginning of 2006 and 2007 in California when the state entered into economic recession in 2007:IIQ following its real estate recession of 2006:IIIQ. This result of leading states' real estate fluctuation may indicate that the probability that the nation will enter into economic fluctuation in 2008 is very high. The second group contains states where the real estate cycles follow those states' state level business cycles. In other words, for this group of states, state level business cycles were formed first and then followed by the state level real estate cycles. Thus, the second group of states is the lagging states. For this group of states, some state level

¹⁶ CA, CO, CT, IL, MA, MI, MN, MT, NV, NH, NJ, NY, NC, OH, OR, PA, TN, and VA.

Figure 4.2: California's Real Estate Cycle Analysis



variables, other than real estates, are more responsible for the formation of the state level business cycle, which might eventually affect those states' real estate sectors. In total, six states - Alabama, Delaware, Maryland, New Mexico, Texas, and Washington - fall into this category of states. In Figure 4.3: Maryland, we observe how the 1981s, the 1990s and the 2007s Maryland's real estate cycles not only followed the state's state level business cycle patterns with lags, but it also followed the pattern of the national real estate cycle with lags. In Figure 4.3 the state level business cycle is marked by the solid red line¹⁷ (curve). In all three cases, the solid red line is followed by the national and state level real estate cycles which are marked by the dotted green and blue lines¹⁸ respectively.

The third group is a mixture of the leading and the lagging states. This set of states sometimes faces the leading real estate cycles, and sometimes faces the lagging real estate cycle compared to these states business cycles. Nine U.S. states¹⁹ fall into this category. In Figure 4.4: Maine, we observe that during the 1980s' and the 2000s', economic and real estate fluctuations, the real estate cycle followed the state level business cycle with four and twenty quarters lags respectively. The 1980s the real estate recession in Maine persisted for maximum six quarters where the state level economic recession persisted for twenty quarters. In other words in Maine

¹⁷ The red line is only visible in the colored version. In the black and white version it is just a solid line.

¹⁸ Blue and green color is only visible in colored version of the paper. In black and white version of the paper, blue color is represented by the darker dotted lines and green color is represented by the lighter dotted lines.

¹⁹ AK, FL, HI, ME, NE, RD, SC, UT, and VT.

Figure 4.3: Maryland's Real Estate Cycle Analysis

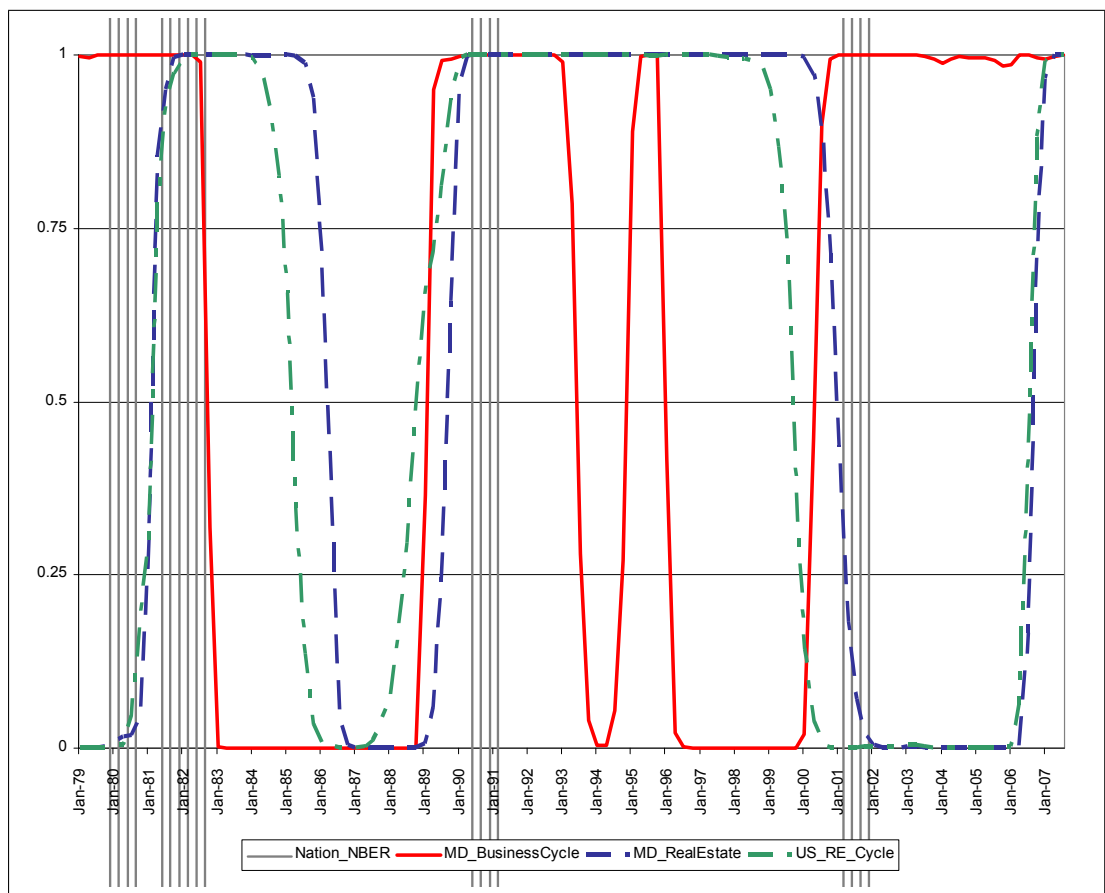
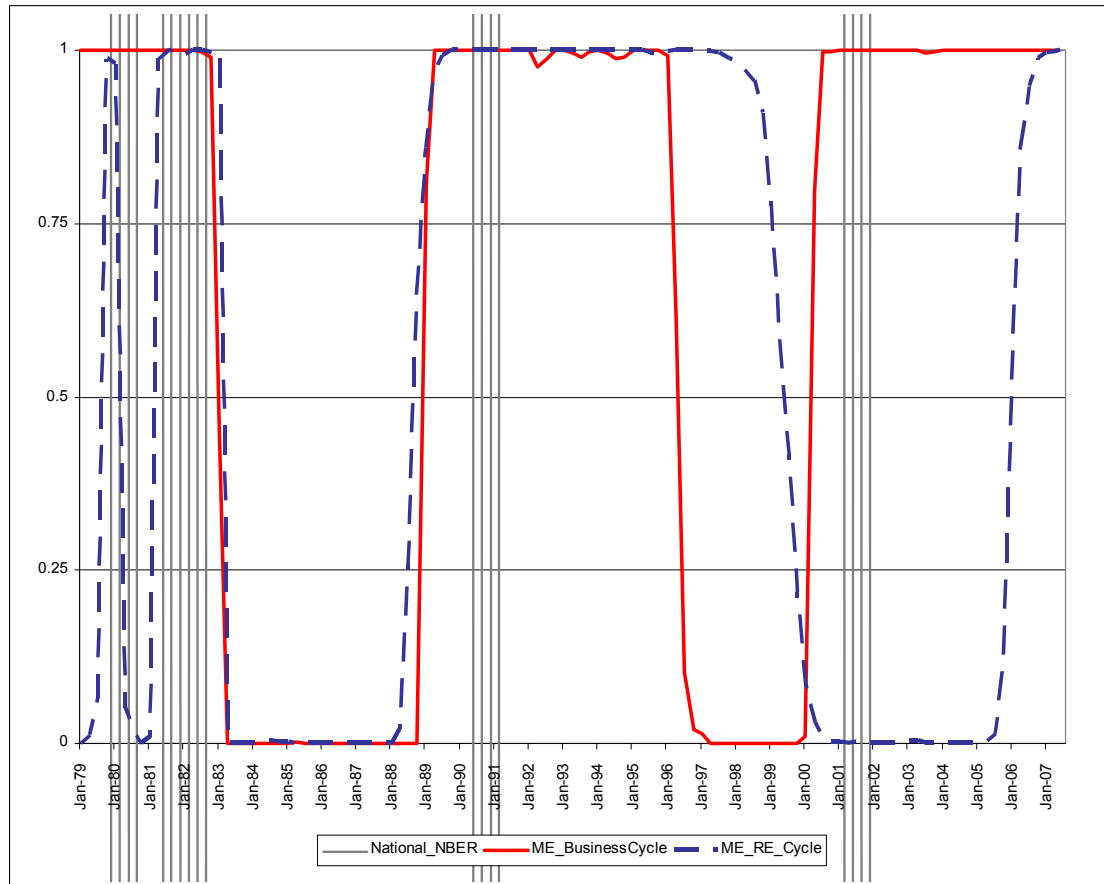


Figure 4.4: Maine's Real Estate Cycle Analysis



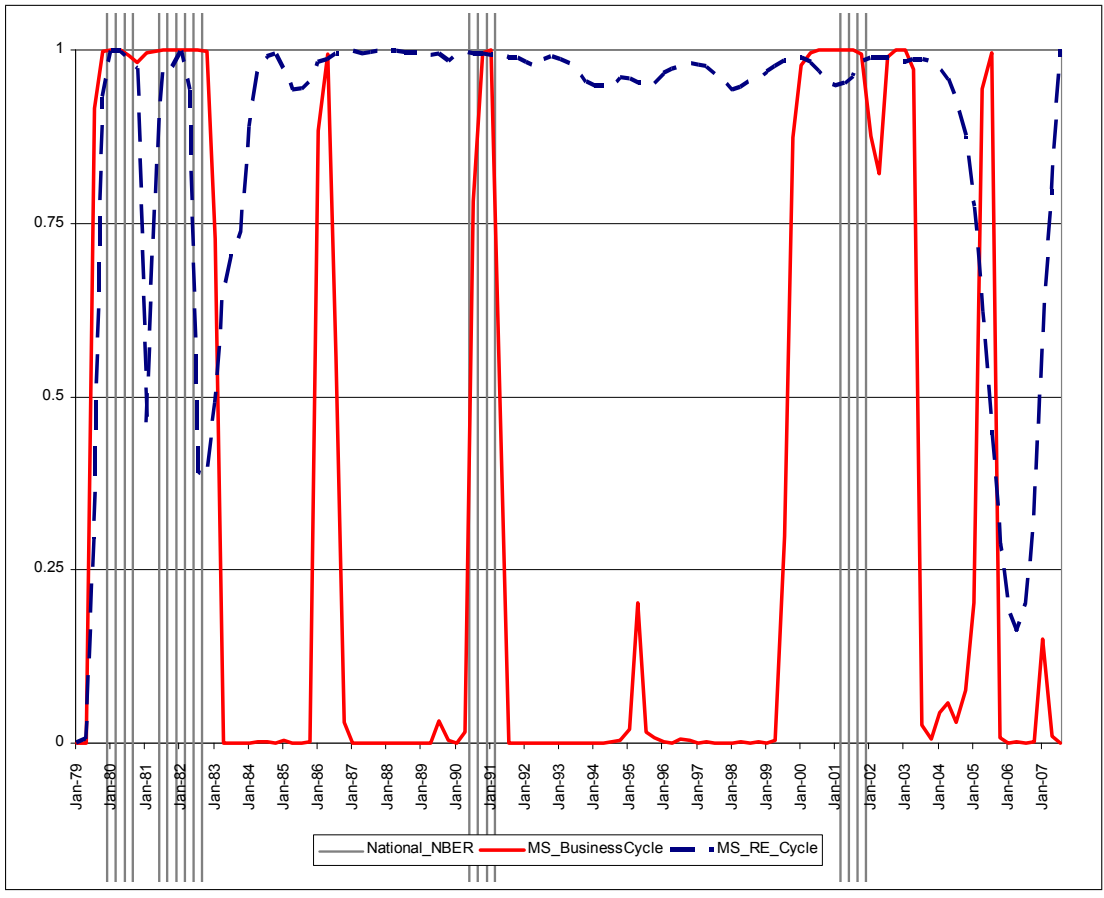
during the 1980s the state level economic recession continued longer than the state level real estate recession. During the 2000s recession we observe that Maine first entered into economic recession in 2000:IIQ, and then went into real estate recession around 2005:IIIQ, which still persists to this date. Similar pattern we observe for other eight states in this group where the states' economic cycles acted as a leading indicator of the real estate recession of the 1980s and of the 2000s.

On the other hand, the order of the economic and the real estate cycles were reversed during the 1990s for this third group of states, where the state level business cycles followed the real estate cycles. In Figure 4.4: Maine, we observe that the real estate recession started at 1988:IVQ, and followed by the economic recession after a quarter in 1989:IQ. Thus, we can assume that in these nine states the 1990s recession was mostly due to the real estate recession.

The fourth category contains states where the state level business cycles are not related to the state level real estate cycles. In this category of states, the real estate cycles have comparatively insignificant effect on the state level economic conditions. However, most of these states' state level business cycles are related to the national business cycles. The sixteen U.S. states²⁰ fall into this category of states. It might be possible that this category of states economic and real estate sectors are affected by some out-of-state variables. Our analysis shows that most of the states in this category faced the real estate recession eighty percent of time during 1979:IQ to 2007:IIIQ time period. While the state economies experience various phases of the business cycles during the same time period. In Figure 4.5: Mississippi represents this group of states where we observe quite persistent and erratic real estate recession compare to its economic recession.

²⁰ AZ, AR, GA, ID, IN, KS, KY, LA, MO, MS, ND, OK, SD, WV, WI, and WY.

Figure 4.5: Mississippi's Real Estate Cycle Analysis



4.6 Convergence Analysis

Convergence analysis measures the convergence and divergence in the state level growth rate of the real estate sector during the various phases of a business cycle in the United States. “Beta 0” and “Beta 1” in Figure 4.6: Convergence Analysis, represent the average real estate growth during the state level recession and expansion respectively. Where “max” represents the average maximum state level real estate growth rate and “min” represents the average minimum state level real estate growth rate during the two phases of a business cycle. Our analysis shows that the median growth rate during the recession is (-15.7868) percent and during the expansion is about three percent. According to the Figure 4.6, the statewide average real estate growth rate diverges more during the recession compared to the expansionary period average growth rate. Thus, the convergence analysis shows that the gap in real estate growth rate decreases or converges during the boom and diverges during the recession across the states. The second part of the convergence analysis is used to calculate the severity of state level real estate recessions. In the Figure 4.7: Severity Analysis, the x – axis represents “Beta 0”, the growth rate of the real estate market during recessions, and the y – axis represents “Beta 1”, the growth rate of the real estate market during expansion. The upward sloping trend line reconfirms that the gap between average growth rates of the real estate market throughout the United States increase during the real estate recession. In other words, the average states level real estate growth rate diverges more during the period of real estate recessions.

Figure 4.6: Convergence Analysis

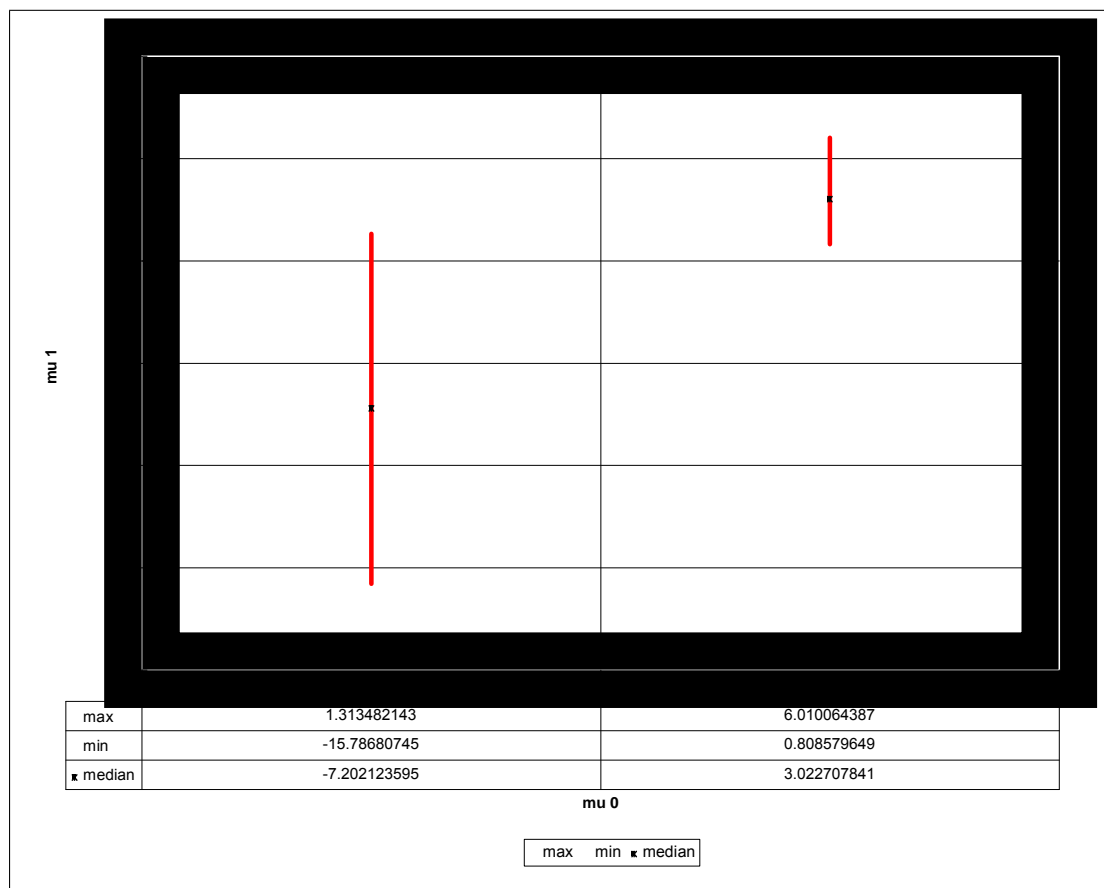
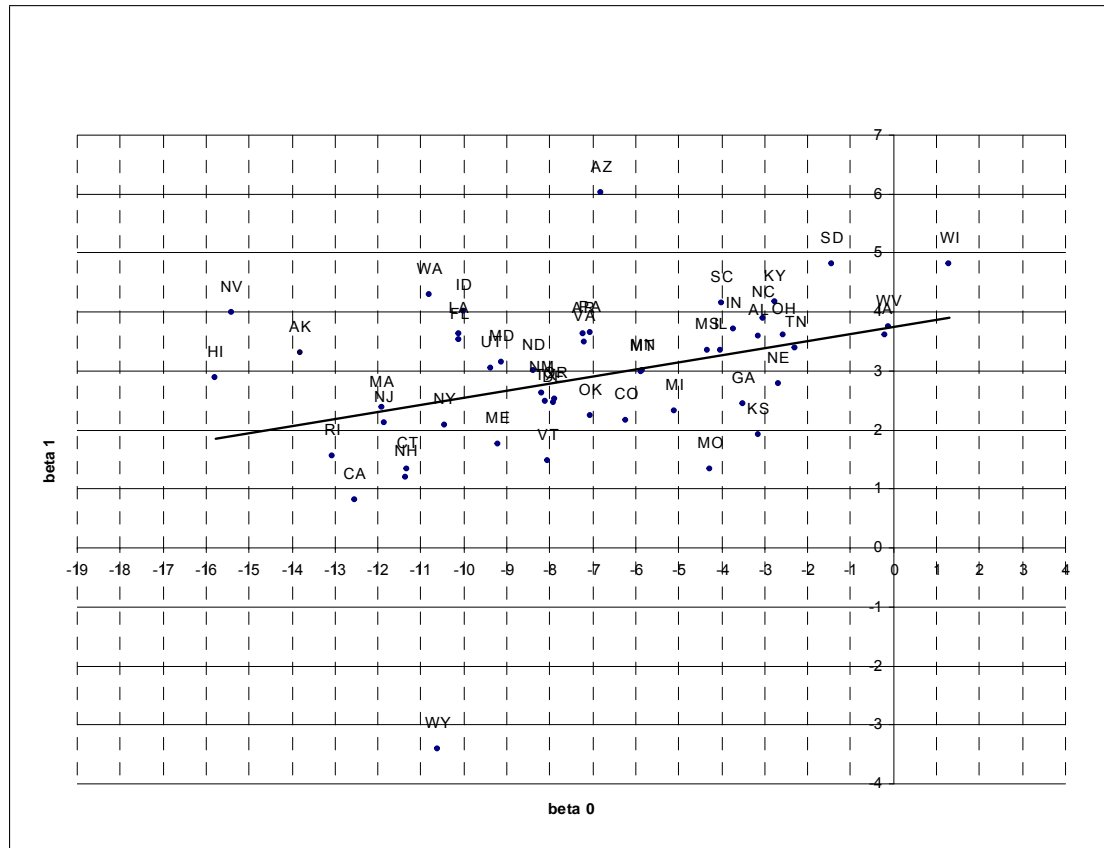


Figure 4.7: Real Estate Fluctuations and Severity Analysis



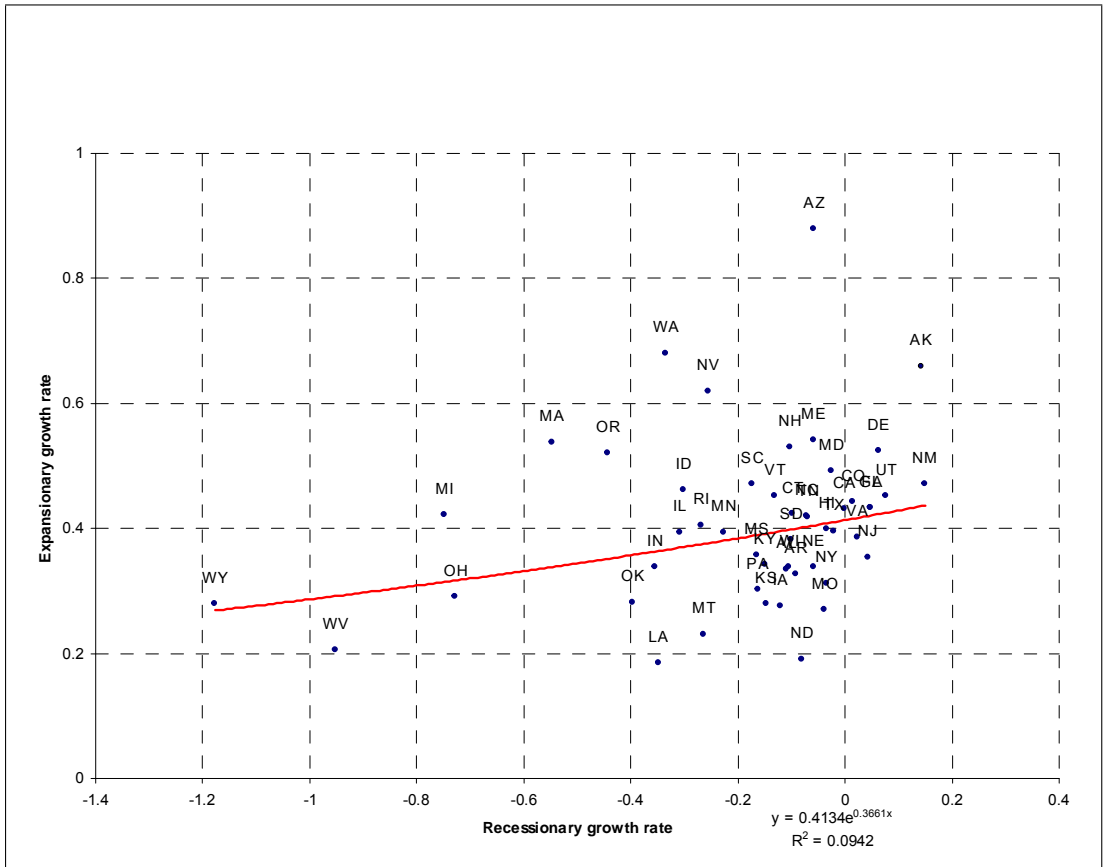
In the Figure 4.7: Severity Analysis, we observe that the severity of the real estate recessions vary across the states. Where beta 0 (β_0) is the recessionary growth rate and beta 1 (β_1) is the expansionary growth rate. On the one hand, the severity of the real estate recession in some states, e.g., West Virginia, Iowa, and South Dakota, is less than some other states. In these states, the average real estate sector growth rate during expansion is higher than the negative growth rate during recession. On the other hand, there are states where the negative recessionary growth rate exceeds

the positive expansionary growth rate. For example, Rhode Island, California, New Hampshire, and Connecticut represent states, where the average recessionary growth rate is negative twelve percent while the average expansionary growth rate is less than positive two percent. There are two anomalies in our study: 1) Wisconsin, in Figure 4.7: we observe Wisconsin faces positive real estate growth rate during both expansionary and recessionary states; 2) Wyoming, where the state, faces negative growth rate throughout the business cycle.

We present Figure 4.8: Economic Fluctuation and Severity Analysis, to compare the state level economic severity²¹ with the state level real estate severity in Figure 4.7. We observe that the magnitude and depth of the real estate fluctuation is greater than the magnitude of the state level economic fluctuation. Additionally, on average the severity of the state level real estate recession is much higher than the severity of the economic recession. For some state results are relatively consistent. For example, the average expansionary growth rate is the highest in Arizona during the economic and real estate expansionary phases. While the state of Wyoming faces the worst outcomes for both fluctuations. However, for other states the severity of the state level economic recession differs from the severity of the state level real estate recession. For example, in Figure 4.7, West Virginia, and Ohio faced comparatively moderate real estate recession during 1979:IQ – 2007:IIIQ period. When we compare Figure 4.7 with Figure 4.8, we observe that both West Virginia and Ohio faced

²¹ For the elaborate computation see Giannikos and Mona (2005).

Figure 4.8: Economic Fluctuation and Severity Analysis



very severe economic recession during the same period. The opposite result we observe for New York, New Jersey, and California: these states experienced extreme real estate recession and comparatively reasonable economic recession.

4.7 Conclusion

Using Markov Switching estimation technique, this paper estimates the turning points of the national and the state level business cycles as well as the real estate cycles. We show that the national business cycle is different from the national real estate cycle. Among four national recessions between 1979:IQ and 2006:IQ, only two were followed by the real estate recessions. This suggests that not all national recessions are due to the real estate fluctuation. However, the persistence of the real estate recession is longer compare to the persistence of the economic recession for both national and state level. We also found that the state level real estate cycles are different from the state level business cycles. Despite the dissimilarity of the state level real estate and business cycles, depending on the formation of the state level real e

state cycles, we divided U.S. states into four categories: e.g., 1) Leading states, where the real estate cycles develop first and followed by those states business cycles; 2) lagging states where the real estate cycles follow the state level business cycles; 3) mixtures of leading and lagging states; and 4) where state level business cycles do not coincide with those states real estate cycles. This result and the division of the

states based on the formation of the state level real estate and the business cycles are important for both state and national policy makers.

Further our analysis show that between 2006:IIQ and 2007:IIIQ the probability of the nation and the forty five U.S. states entering into real estate recession (Appendix 4.A.2) is very high. However, so far only nineteen states tend to have high probability of entering into economic recession, but there is no indication of national economic recession.

The convergence analysis of this paper suggests that the average growth rate of the state level real estate market diverges during the recession across the United States. A similar result we observed for the state level economic growth rate by Mona and Giannikos (2005). The second part of the convergence analysis shows that the magnitude, depth, and severity of the real estate recessions are higher than the economic recession.

4.A Appendix

4.A.1 A Derivation Of Steady-State Probabilities:

The transition probabilities for a first order²², M-state Markov-switching process S_t in (2.7-2.10 and 4.6-4.9) can be expressed in the following matrix notation:

$$P^* = \begin{bmatrix} P_{11} & P_{21} & \cdots & P_{M1} \\ P_{21} & P_{22} & \cdots & P_{M2} \\ \vdots & \vdots & \ddots & \vdots \\ P_{1M} & P_{2M} & \cdots & P_{MM} \end{bmatrix} \quad (4.10)$$

Where $P_{ji} = \Pr[S_t = i \mid S_{t-1} = j]$. The following condition must hold:

$$i_M' P^* = i_M' \quad (4.11)$$

where, $i_M = [1 \ 1 \ \cdots \ 1]$.

If we let π_t be a vector of $M \times 1$ steady state probabilities, then

$$\pi_t = \begin{bmatrix} \Pr[S_t = 1] \\ \Pr[S_t = 2] \\ \cdots \\ \Pr[S_t = M] \end{bmatrix} = \begin{bmatrix} \pi_{1t} \\ \pi_{2t} \\ \vdots \\ \pi_{Mt} \end{bmatrix} \quad (4.12)$$

$$i_M' \pi_t = 1 \quad (4.13)$$

According to the definition of steady state probabilities, $\pi_{t+1} = P^* \pi_t$, and

$\pi_{t+1} = \pi_t$, hence

²² Even though Hamilton's (1989) model is not first but a fourth order, two-state Markov chain, it can simply be considered as a first-order, 32-state (24+1) Markov chain.

$$\pi_t = P^* \pi_t \implies (I_M - P^*) \pi_t = 0_M \quad (4.14)$$

where 0_M is an $M \times 1$ matrix of zeros. Combining equation 4.13 and 4.14 we will get:

$$\begin{bmatrix} I_M - P^* \\ \mathbf{1}_M \end{bmatrix} \pi_t = \begin{bmatrix} 0_M \\ 1 \end{bmatrix}$$

or

$$A \pi_t = \begin{bmatrix} 0_M \\ 1 \end{bmatrix} \quad (4.15)$$

The matrix of the steady state probabilities can be obtained by pre-multiplying 4.15 by $(A' A)^{-1} A'$, hence the matrix of steady state probabilities is:

$$\pi_t = (A' A)^{-1} A' \begin{bmatrix} 0_M \\ 1 \end{bmatrix} \quad (4.16)$$

(10) Missouri to Wyoming and the U.S.: 2003:I - 2007:III

		03				04				05				06				07		
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III
Missouri	State	■	■	■																
	RS																			■
Montana	State																			
	RS																			■
Nebraska	State	■	■						■											■
	RS	■	■	■	■															■
Nevada	State																			■
	RS	■	■											■	■	■	■	■	■	■
New Hampshire	State																			
	RS													■	■	■	■	■	■	■
New Jersey	State	■																		
	RS															■	■	■	■	■
New Mexico	State	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	RS	■	■	■	■															■
New York	State	■	■																	
	RS	■	■	■	■												■	■	■	■
North Carolina	State	■	■																	
	RS	■	■	■	■	■	■	■	■											■
North Dakota	State																			
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Ohio	State																			
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Oklahoma	State	■	■																	
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Oregon	State	■	■																	
	RS	■	■	■	■															■
Pennsylvania	State	■																		
	RS	■	■	■	■												■	■	■	■
Rhode Island	State																			
	RS													■	■	■	■	■	■	■
South Carolina	State	■	■																	
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
South Dakota	State	■	■																	
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Tennessee	State	■	■																	■
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Texas	State	■	■	■																
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Utah	State	■	■	■																
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Vermont	State	■																		■
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Virginia	State	■	■																	■
	RS	■	■	■	■											■	■			■
Washington	State																			
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
West Virginia	State																			
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Wisconsin	State	■	■																	
	RS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Wyoming	State																			
	RS																			■
US	RS																	■	■	■

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