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## REGIONAL BUSINESS CYCLES AND INCOME CONVERGENCE IN US

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# Short run dynamics of income disparities across U.S. States

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**Abstract:**

Since 90s, the issue of regional income convergence and its long term tendencies has been discussed in a number of papers. Much less attention has instead been devoted to the short-run dynamics of regional convergence. Two important aspects have not yet been adequately studied in this area. First, do regional disparities move along the national cycle, if yes, in which fashion does this happen; pro or anti-cyclically? Second, what are the mechanisms and economic reasons behind the cyclical evolution of regional income disparities? More specifically, is the cyclical evolution a consequence of differences in the timing with which the business cycle is felt in regional economies or is it mainly motivated by the amplitude differences, rather than timing, across local cyclical swings. In this paper, we try to investigate these issues using various business cycle analysis tools applied to the states of US between 1969 and 2008.

**Keywords:**

cyclical income disparities, regional business cycles, cyclical synchronization

**JEL Codes:**

R11, E32, O18

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# 1 Introduction

During recent decades, there has been a long tradition among regional economists of evaluating the long run tendency of income disparities among regions (Barro and Sala-i Martin, 1992; Magrini 1999; 2009). Despite there is an extensive empirical literature on the reduction or persistence of regional disparities over the long-run, a very limited number of studies deal with the short run behaviour of regional disparities. Those of few papers, which try to understand such short run disparities relate this behaviour to the changes in national business cycle. They find that, in a country, inequalities among regions follow a cyclical pattern and enlarge or diminish according to whether the aggregate economy is in an expansion or in a recession phase.

However, we think that there some important gaps in this field which need to be filled by the reaserchers. First, the analysis implemented in the literature includes controversial results, some important technical problems and, therefore, is far from being satisfactory. Second, although some economists studied the cyclical disparities, so far none of them dealt with the economic reasons and mechanisms behind such cyclical behaviour. This gap might be due to the fact that such an investigation requires large regional data sets with long time series dimension and, more importantly, advanced business cycle analysis tools. These requirements are relatively new to the regional convergence literature. However, we find it crucial to study such mechanisms which might substantially help us in understanding the short run behaviour of regional income disparities.

In this paper, we aim at adressing some open questions and the shortcomings of the existing literature explained above. Therefore we propose to analyze, first, whether or not the regional disparities follow a cyclical pattern and change according to whether the aggregate economy is in expansion or in recession phase, second, the possible mechanisms behind the cyclical evolution of regional disparities. We consider two possible mechanisms and try to answer if the evolution of short run regional disparities mostly created by the “timing” or “amplitude” differences across regional business cycles. In order to answer these questions, we apply some modern econometric techniques and statistical tools including business cycle analysis to the personal income series of US States between 1969 and 2008.

As a consequence of our analysis, we obtained a set of results which has some important indications. We find that income disparities across US states follow an anti cyclical pattern and, therefore, move in the opposite direction of US national cycle. Thus, disparities tend to increase during the national recessions and diminish during the national expansion times. Furthermore, using information about the state specific cycles that we obtained from a turning points detection analysis, we found that there are important differences in the timing and amplitudes of the state business cycles. Moreover, we found an unnegligibile role of timing differences across states on the creation of short run income disparities, especially during national recessions.

The organization the paper is as follows; in part (2), we review the existing literature, explain the drawbacks of the recent studies and our marginal contribution. In part (3), we study the time series aspects of income disparities. In particular, we test the stationarity of the disparities which is an essential step in any time series analysis. In part (4), to test if there exist cyclical disparities, we perform a regression analysis by regressing the income disparities among US states on a national business cycle measure. In part (5), we try to study the possible mechanisms giving rise to the cyclical disparities. We perform such an analysis in three subparts. In (5.1), we detect the turning points of US states and US national economy. In (5.2) using the information that we obtain in (5.1), we explore the timing and amplitude differences across state business cycles and in (5.3) we analyze the role of timing differences

across US states on the creation of short run of income disparities and finally in part (6) we finish our study with concluding remarks.<sup>1</sup>

## 2 Literature Review

Although there is very limited number of studies which aim at understanding the short run regional inequalities, the debate on the link between national cycle and regional disparities is far from reaching a consensus and results found in the literature are controversial.

Most of the European studies found evidence in favour of pro-cyclical income convergence where regional disparities move in the same direction as the aggregate economic cycle and tend to increase during the expansion times when the aggregate economy is booming and diminish in the times of recessions when the aggregate economy is performing poorly. For example, Dewhurst (1998) analyzed 63 UK counties between 1984 and 1993, Petrakos and Saratsis (1999) studied the inequalities among Greek prefectures between 1970 and 1995 and Petrakos, Pose and Rovolis (2005) focused on inequalities across EU countries between 1960 and 2000. The studies cited above follow, in general, a time series regression approach. They regress a measure of regional disparities (i.e. coefficient of variation) on the growth rate of aggregate economy. At some stage, they prefer to use only graphical tools to explore the relationship between business cycle and regional disparities.

From theoretical point of view, most of the studies try to explain the pro-cyclical regional disparities by referring to Berry (1988). Berry's explanations are consistent with Cumulative Causation Theory (Mrydal, 1957). Berry (1988) claims that expansion phases begin in well developed metropolitan areas in which agglomeration and market size create an advantage for these areas. Expansions, which start from the metropolitan areas, increases the regional inequalities since it spreads to the rest of the country not automatically (Berry, 1988). By contrast, metropolitan areas suffer more than other areas during the national recessions and therefore income inequalities decrease in these periods (Petrakos and Saratsis, 2000). Recently, Fratesi and Pose (2007) showed that most of the European countries show a pro-cyclical regional disparities between 1980 and 2005 and have sheltered regions in their rural areas. These areas are not tied to the market forces, heavily dependent on government transfers and public employment (Fratesi and Pose, 2007). Therefore, they are not well prepared to compete with the rest of the economy and can not use their potential for convergence which is mostly available during the expansion periods (Fratesi and Pose, 2007). Similarly, they remain unaffected from the national recessions since they are not tied to market forces to a large extend, consequently, regional disparities increase during booms and decrease during the times of recessions (Fratesi and Pose, 2007).

Apart from the pro cyclical findings, there are some other studies in the literature which find evidence in favor of anti cyclical regional disparities. Pekkala (2000) investigated the disparities across 88 Finnish regions between 1988 and 1995. She used a distribution approach with discrete time markov chains and she related the upward or downward income mobility to the national periods of expansions or recessions. She found evidence for the anti cyclical regional disparities where the direction of mobility is linked to the aggregate performance of the economy (Pekkala, 2000). Intra-distribution mobility is high during the boom times and regional disparities tend to decrease and, by contrast, increase during the

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<sup>1</sup> In this paper, there regression analysis is performed using EVIEWS 4.0 program. For the business cycle analysis, we used BUSY 4.1 program.

times of recessions (Pekkala, 2000). Finally, Quah (1996) finds no evidence for the impact of business cycle on the distribution dynamics of US economy.

However, in these studies there are some important shortcomings with which the researchers need to deal in order to understand well the short run behaviour of regional inequalities. For instance, since there is very limited time series data at the regional level which is available only for recent years, the results obtained from regression analysis which is implemented by using only low number of observations may be unreliable and far from being general which is the case in most of the cited studies above.<sup>2</sup> Furthermore, in some of the studies (i.e. Petrakos and Saratsis, 1999; Petrakos, Pose and Rovolis, 2005) there is an important technical issue that they ignore the stationarity test for regional disparities. However, one must implement such a test when using a variable in a time series regression model. Moreover, in those papers which do not take into account the stationarity aspect of the regional disparities, the graphical view of regional disparities suggests a non-stationary process. Using a non-stationary variable and stationary variables in the same regression model creates misleading results.

One of the most important shortcoming of the existing literature is that the mechanisms and their importance for the short-run evolution of regional disparities are not yet analyzed. This is largely due to the fact that analyzing the mechanisms, requires, first, large data sets with long time series data at the regional level, second, and more importantly, it is necessary to adopt advance techniques to analyze the regional business cycles, i.e. detecting the turning points of regional business cycles. There is neither large regional data sets for this scope nor analyzing the business cycles at the regional level is common among researchers. Consequently, most of the studies are far from being deep enough to analyze the mechanisms behind the cyclical evolution of disparities. In general, they prefer to explain briefly the possible reasons for the cyclical income disparities by referring to some well known theories (i.e. cumulative causation) and do not analyze quantitatively the reasons and mechanisms behind such cyclical evolution. However, understanding well the mechanisms might help us much in understanding the nature of short run disparities.

In this paper, we try to fill these shortcomings by using necessary tools. Below, we briefly summarize our set of research questions:

(i) *Do regional disparities move along the national cycle? If yes, in which fashion do they move :pro or anti cyclically?* We propose to analyze whether or not regional disparities change during different stages of national cycle. For this purpose, we, first, explore the stationarity feature of regional disparities by implementing an ADF test and, second, perform a regression analysis by using more number of observations than used in the existing literature.<sup>3</sup>

(ii) *What are the real mechanisms behind cyclical disparities? Are there important timing or amplitude differences across regional business cycles? Do cyclical evolution of regional disparities come, more importantly, from timing or amplitude differences across regional business cycles?*

We consider two possible mechanisms by which the evolution of short run disparities might be motivated during the national expansions and recessions; (i) amplitude differences across regional business cycles (ii) timing differences regional business cycles. We illustrate these mechanisms with an example: In figure 1, we observe an expansion phase between  $t$  and  $t+1$  for Region A and B, where the economic growth rate is positive, and a recession phase between  $t+1$  and  $t+2$ , where economic growth is negative. In both phases, the business cycle of Region A and Region B are fully synchronized and there exists no timing differences between these economies. However, there exist some important amplitude

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<sup>2</sup> Petrakos and Saratsis (1999) use 21 observations in their regression analysis.

<sup>3</sup> ADF: Augmented Dickey Fuller

(size) differences between regional cycles.<sup>4</sup> As a consequence of these differences, any increase or decrease in regional disparities during the expansion or recession periods is totally motivated by the amplitude differences across regions. For example, assuming that Region A is richer than Region B in all instants between  $t$  and  $t+2$ , income difference between Region A and Region B increase during the expansion period and decrease during the recession period. Therefore, in this case, regional inequalities follow a pro-cyclical pattern and this behaviour is completely explained by the amplitude differences across regional cycles.

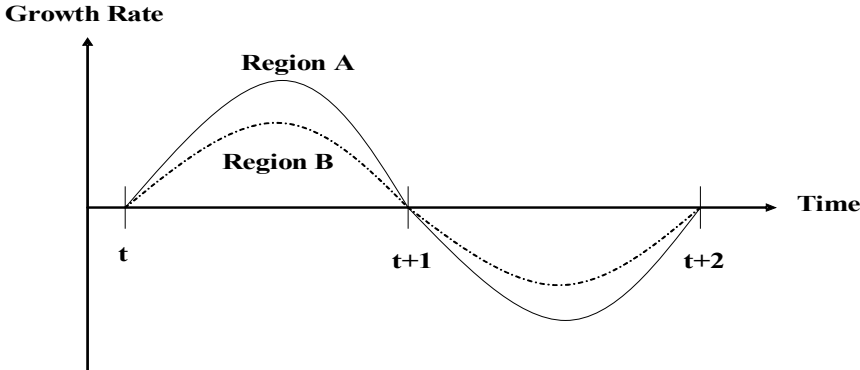


Figure 1. Cyclical income disparities and amplitude differences across regional cycles (Mechanism 1)

On the other hand, in Figure 2, Region A is in expansion between  $t$  and  $t+2$  and in recession between  $t+2$  and  $t+4$  and Region B is in expansion between  $t+1$  and  $t+3$  and in recession between  $t+2$  and  $t+4$ . The cycle amplitudes of Region A and B is identical during the recessions and expansions. However, there are considerable timing differences across these economies. Region B follows Region A always with a time lag. In this case, during the national expansions or recessions, any increase or decrease in income inequalities is completely explained by the timing differences across regional cycles.

In the later parts of the paper (part 5), we will proceed to analyze the relative importance of these mechanisms for the evolution of regional inequalities in the short run.

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<sup>4</sup> Amplitude of a phase can be defined as the cumulative growth rate of an economy during that phase.

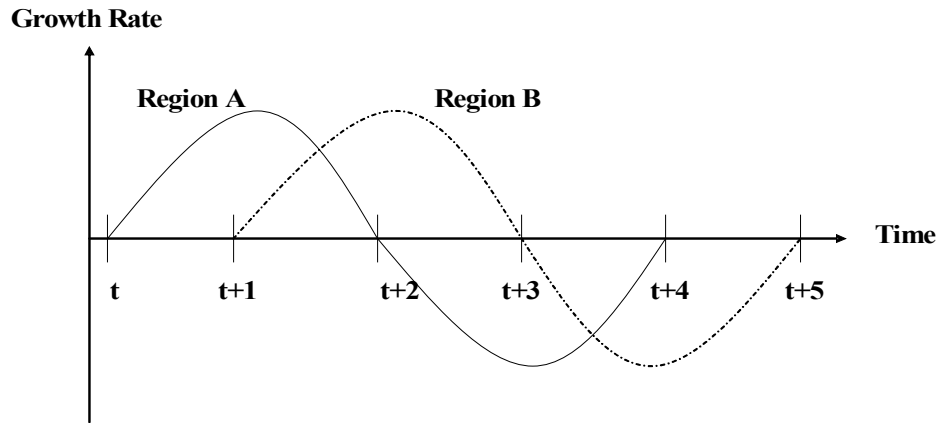


Figure 2. cyclical income disparities and timing differences across regional cycles (Mechanism 2)

### 3 Time series features of income disparities

It is a fundamental concern in any time series analysis that the stationary and non-stationary variables must not be considered in the same regression model, otherwise, some misleading and unreliable results might be obtained. Since one of the frameworks that we consider in this paper is a time series regression analysis, we must carefully understand whether our variables follow stationary or non stationary processes. In our regression analysis, we consider two types of variables. First, is a measure of national business cycle and second, is a measure of regional disparities. Business cycle measures clearly follow stationary processes since they fluctuate around the zero line and therefore, we find it sufficient to test only the stationarity of regional disparities. However, before that, we should clearly define the measure for the regional disparities that we use in our study.

As a regional disparities measure, we use the coefficient of variation (CoV) calculated using per capita Real Personal Income minus current transfer receipts series for 51 US states and the period between 1969:2 and 2008:4. The whole data set used in this study consists of the series including 51 US States and US national data. These series are in quarterly data form and in logged terms. They are deflated using 1982-1984 prices, city average national consumer price index, and seasonally adjusted using multiplicative ratio to moving average technique.

$$CoV_t = \frac{\sqrt{\frac{\sum_{i=1}^n (X_{it} - \bar{X}_t)^2}{n-1}}}{\bar{X}_t} \quad (1)$$

In equation (1),  $X_{it}$  is the personal income of state  $i$  and at time  $t$ .  $\bar{X}_t$  is the average of personal incomes of  $n$  states at time  $t$ .  $n$  is the number of states in the economy and 51 in our case. Equation (1) measures the standard deviation of state-level personal incomes divided by the average of the personal incomes at time  $t$ . In other words, it measures how dispersed the personal income across states in the economy. Figure 3 shows the evolution of coefficient of variation in US over time. It seems that the disparities across US states follow a stationary process which do not diminish or increase over the 40 years, rather, it appears to be fluctuating around 0.018 level. However, to make sure that it follows a stationary process, we implement some unit root tests. Therefore, we prefer to implement Augmented Dickey Fuller (ADF) test. This test is well known in the time series literature and used by many economists due to its accurate outcomes and simplicity for understanding.

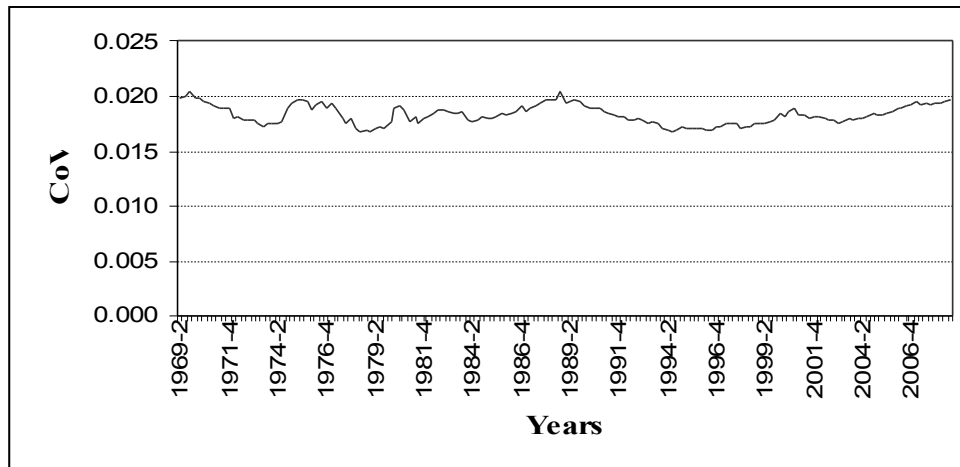


Figure 3. Coefficient of Variation (in logs) for per capita real personal income minus current transfer receipts for US states and 1969:2-2008:4

As seen in Table 1, ADF test results show that regardless 2,3 or 4 order of lags we add to the ADF test regression where the constant is also included, regional disparities follow  $I(0)$  stationary process, which is evident at 5 % significance level.

The results of the ADF test have two important implications for our study. First, stationary income disparities found in the ADF test provide a technical possibility for using this variable as a dependent variable in our regression analysis when regressing it on another stationary variable. Second, stationary income disparities imply that inequalities across states tend to persist and do not diminish over the 40 years



| # of lags of $\Delta\text{CoV}$ in ADF Equation | ADF statistics | 1 % Critical Value | 5 % Critical Value | 10 % Critical Value |
|---|----------------|--------------------|--------------------|---------------------|
| 1   | -2.672586*     | -3.473000          | -2.879900          | -2.576400           |
| 2   | -3.109553**    | -3.473300          | -2.880000          | -2.576500           |
| 3   | -3.129138**    | -3.473500          | -2.880100          | -2.576600           |
| 4   | -3.416023**    | -3.473800          | -2.880200          | -2.576600           |

“\*” implies significance at 10%, \*\* at 5 %, \*\*\* at 1%.

Table 1. ADF Test Results

#### 4 Do income disparities move along the national cycle?

One of the main objectives of this paper is to understand whether or not the income disparities across US states change in response to the aggregate fluctuations of the US economy. Therefore, in this section, we would like to relate the income disparities across US states to the national cycle of US by regressing the coefficient of variation (CoV) on an appropriate measure for the aggregate cycle of US.

$$\text{CoV}_t = \alpha_0 + \beta_1 \Delta RPI + \varepsilon_t. \quad (2)$$

$$\text{CoV}_t = \alpha_0 + \beta_2 \Delta GDP + \varepsilon_t. \quad (3)$$

$$\text{CoV}_t = \alpha_0 + \beta_3 RPIHP + \varepsilon_t. \quad (4)$$

$$\text{CoV}_t = \alpha_0 + \beta_4 GDPHP + \varepsilon_t. \quad (5)$$

*CoV*: Coefficient of Variation (in logs) for per capita real personal income minus current transfer receipts for US states.

$\Delta RPI$ : First Difference of logged US per capita real personal income minus current transfer receipts.

$\Delta GDP$ : First Difference of logged US per capita Real GDP.

*RPIHP*: Hodrick-Prescott (1997) detrended per capita US real personal income excluding current transfer receipts.<sup>5</sup>

*GDPHP*: Hodrick-Prescott (HP) detrended per capita US Real GDP.

In the regression specifications, our independent variable is US business cycle. We define two types of business cycles. First, is the national growth rate of an aggregate economy (i.e. per capita real personal income, GDP etc.). This definition is in line with the business cycle definition in “classical

<sup>5</sup> Hodrick-Prescott detrending is implemented using smoothing parameter,  $1600=\lambda$

cycle” sense where absolute declines or increases in aggregate output are required in order for the economy to be in recession or in expansion. Figure 4 illustrates classical cycle of US. In this figure we visually observe several recessions where aggregate levels of personal income declined in absolute terms.



Figure 4. US Classical Cycle: per capita real personal income excluding current transfer receipts, 1969:2-2008:4

Second, we use the HP detrended aggregate economic activity as a business cycle measure. This measure corresponds to a deviation cycle definition and it is constructed by subtracting the HP trend values of the personal income (or GDP) from its original values. It basically demonstrates the economic fluctuations around a deterministic trend. In such a cycle definition, in order for an economy to be in recession, there may not, necessarily, be absolute declines in output but it is sufficient that economy is growing below its trend growth rate (Figure 5).

Our dependent variable is Coefficient of Variation across state personal incomes as explained before.

The regression results are summarized in Table 2. In all regressions, we face an autocorrelation problem. In order to fix this problem, we allow up to a certain order of autoregressive errors. We follow a rule that we allow up to high order of autoregressive errors until we eliminate 8<sup>th</sup> order of autocorrelation. As a consequence, in all regressions where some order of autoregressive errors are allowed, Breusch Godfrey LM test gives no serial correlation even we test for up to 2 years (8 quarters) serial correlation.

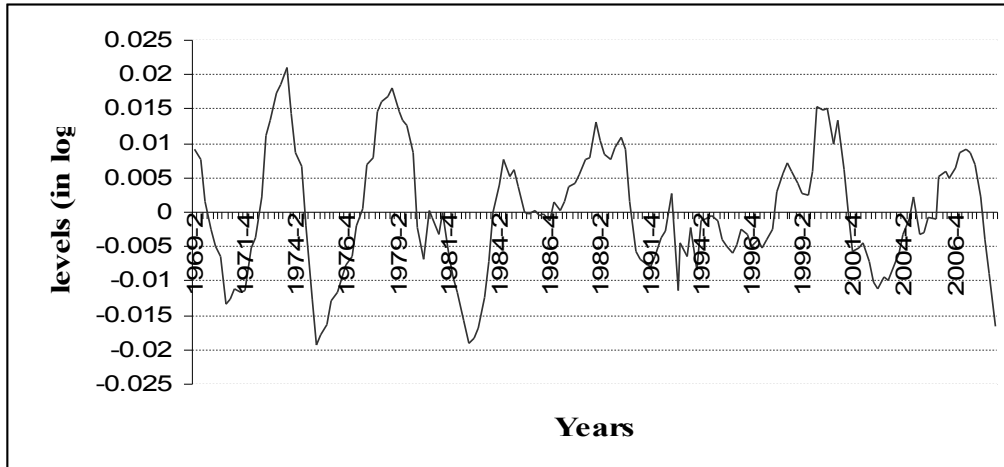


Figure 5. US Deviation Cycle: Hodrick-Prescott filtered per capita Real Personal Income excluding current transfer receipts, 1969:2-2008:4

|   | Classical Cycles        |                        | Deviation Cycles        |                         |
|---|-------------------------|------------------------|-------------------------|-------------------------|
| Period: 1969:2 2008:4                     | Equation (2)            | Equation (3)           | Equation (4)            | Equation (5)            |
| $\alpha_0$                                | 0.018374***<br>(0.000)  | 0.018383**<br>(0.000)  | 0.018301***<br>(0.000)  | 0.018314***<br>(0.000)  |
| $\beta_1$ (p-value)                       | -0.006937**<br>(0.0371) |                        |                         |                         |
| $\beta_2$ (p-value)                       |                         | -0.006412*<br>(0.0848) |                         |                         |
| $\beta_3$ (p-value)                       |                         |                        | -0.031054***<br>(0.000) |                         |
| $\beta_4$ (p-value)                       |                         |                        |                         | -0.042931***<br>(0.000) |
| R-Square                                  | 0.849506                | 0.847539               | 0.861389                | 0.86355                 |
| White-Heteroscedasticity<br>(obs*Rsquare) | 17.21481***             | 16.2568***             | 1.258183                | 1.740053                |
| Durbin-Watson                             | 1.991728                | 1.975798               | 2.110825                | 1.989637                |

“ \* ” implies significance at 10%, \*\* at 5 %, \*\*\* at 1%.

Table 2. Regression results: income disparities across states vs. US national cycle

$$Y_t = \alpha + \beta Z_t' + \varepsilon_t. \quad (6)$$

$$\varepsilon_t = \rho \varepsilon_{t-1} + u_t. \quad (7)$$

$$Y_t = \rho Y_{t-1} + \beta (Z_t - \rho Z_{t-1})' + \varepsilon_t. \quad (8)$$

The example above shows a regression model with first order autoregressive errors where  $Z'$  is the set of independent variables. Equation (6) and (7) is combined to each other and became a transformed model (equation (8)).  $\rho$  (the serial correlation parameter) and  $\beta$  coefficient is simultaneously estimated by applying Marquardt Nonlinear Least Squares Algorithm on equation (8). We allow for first order autoregressive errors in equations (2), (3) and (4) and up to 5th order autoregressive errors in equation (5). Estimated  $\beta$  coefficient, t-statistics and standard errors can be interpreted in usual manner as in the original model (equation (6)).

In the regressions where we find a significant heteroscedasticity in the error terms, we use White's heteroscedasticity consistent standard errors. White (1980) created a heteroskedasticity consistent covariance matrix estimator and this estimator provides correct measure for the coefficient covariances in the presence of heteroskedasticity in the residuals (Eviews, Guide 4.0).

From economic point of view, regression results show us some important indications about the short-run behaviour of income disparities across US States. In general, we find negative and significant  $\beta$  coefficients which mean that the relation between US national cycle and income disparities across the states is negative. In other words, short-run income disparities across states move in the opposite direction of national cycle. In particular, equations (2) and (3) show that as US economy performs higher growth rates during expansions, disparities across states tend to decrease where, by contrast, during the recessions as the economy performs poorly regional disparities tend to increase.

In equations (4) and (5), we consider the HP detrended national personal income and GDP as national business cycle measure. The results suggest much stronger evidence for the anti cyclical disparities where  $\beta$  is negative, much lower than in other equations and highly significant. In economic terms, we interpret it in a way that as US economy moves from the beginning to the end of expansion times (i.e. from trough to peak) income disparities tend to diminish where, by contrast, as US economy moves from the beginning to the end of recession times (i.e. from peak to trough) disparities across states tend to increase.

When interpreting the results, one should be aware of the fact that the results obtained by estimating the models which include the business cycles in classical and deviation cycle sense are not comparable with each other. This is because the two business cycle measures tell different stories. In equations (2) and (3), we measure the business cycle as the growth rates of the economy where in equations (4) and (5) we measure the business cycle as the output levels in terms of its deviation from a trend. We think that the indications of equations (2) and (3) and the equations (3) and (4) are not comparable but complimentary to each other.

Consequently, we think that using a parametric least squares model, we found an important set of evidences which is in favour of anti-cyclical disparities across US states, which in general, move in the opposite direction of aggregate performance of the US economy. However these findings can well be improved by studying different aspects of the short-run behaviour of income disparities.

First, the relation between income disparities and aggregate cycle may not necessarily be linear but may, rather, be nonlinear. This might be due to the asymmetric effects of business cycle on the income disparities. Indeed, it is plausible to believe that income convergence during national expansions might be stronger or weaker than the income divergence during recession times. From methodological point of view, one could study the nonlinearity by using nonparametric tools which do not require making structural assumptions as we do in parametric model. However, in such a possible study, one should carefully study how to perform a non parametric regression when the residuals are serially correlated (Gerolimetto and Magrini, 2009).

Second, the parametric model that we estimated does not provide us detailed information about the shape of the income distribution and its evolution over time. However, one might be interested in investigating the evolution of the shape of the income distribution during national expansion and recession times and therefore have more detailed information about the changes in income distribution. These two additional aspects can be studied in the future as an extension of this paper.

## **5 Mechanisms behind the anti-cyclical disparities: amplitude or timing differences matter?**

After having showed some evidence for the anti-cyclical income disparities across US states, we would like to start an investigation of the real mechanisms giving rise to the anti-cyclical evolution of income disparities. However, analyzing the mechanisms is not a simple task but requires some advanced tools for the business cycle analysis. Therefore, to analyze the mechanisms, we prefer to adopt a simple, transparent and reproducible methodology. We follow a three step approach for implementing such an investigation.

First, we detect the turning points of US aggregate economy and 51 states. When detecting the turning points, we refer to both classical cycles and deviation cycles and use a non parametric business cycle dating technique developed by Bry and Boschan (1971).

In the second step, we use the information that we obtain from turning points detection and show that there exist large timing and amplitude differences across state business cycles. We try to explore the timing and amplitude differences by referring to some newly developed measures in the literature, i.e. for timing differences; concordance rate and diffusion index.

In the third step, we implement a simple variance partitioning analysis and try to figure out if the income disparities are mostly created by those states which show good synchronization with the national cycle, or by those which differ largely from national cycle in timing of the phases. We are aware of the fact that this third step does not provide us a complete overview about the mechanisms behind the cyclical disparities. In other words, it does not totally describe if short run disparities are mostly motivated by the amplitude or timing differences across local cycles but it gives a well documented set of descriptive results which shows the importance of timing differences on the creation of income disparities. We think that this can be a good first step of a complex analysis of variance decomposition of income disparities in the short run.

## 5.1 Turning Points Detection

The graph of many economic series suggests the existence of cyclical patterns (Harding and Pagan, 2002). Dissecting the economic series into different segments is desirable and crucial for policy purposes. In the last decades, there has been a common practice across researchers of separating expansion times from the periods of recessions (Owyang, Piger and Wall, 2005). Burns and Mitchel (1946) established the methods which became main principles of the NBER and its business cycle dating procedure. Since 1980, the NBER is officially responsible for detecting and declaring the chronology of US turning points (Harding and Pagan, 2002). NBER's Business Cycle Dating Committee declares a turning point when its members reach a consensus (Chauvet and Piger, 2003). The decision is given using many variables and techniques. Usage of multiple series is largely due to the fact that there exists no single variable which represents perfectly the aggregate economic activity.

However, recently the NBER has been criticized by some economists. Since each committee member provides different techniques, the turning point detection seems subjective, neither transparent nor reproducible (Chauvet and Piger, 2003). Furthermore, the NBER discloses the turning points not timely but well after the fact (Chauvet and Piger, 2003). Therefore, the literature in this issue tried to develop and formalize the dating rules by using transparent and simple methodologies in order to reproduce NBER's chronology accurately and timely.

In early times, the literature focused on how one can replicate accurately the NBER's dates using single series. Bry and Boschan (1971) documented first the formal algorithm which aims at finding specific phases and cycles in the economic series. The basic principle of this non-parametric technique is to find the set of local maxima and minima in the economic series and ensure that any detected cycle shows persistence. Harding and Pagan (2002) re-organized this algorithm and modified it for the quarterly data.

On the other hand, a parametric autoregressive Markov-Switching (MSVAR) model was developed by Hamilton (1989) to find the regime shifts in the economic activity and this technique became a commonly used tool in the business cycle literature (Owyang, Piger and Wall, 2005). This model defines the shifts in the business cycle phases as the shifts in the mean growth rate of the economy which follows an autoregressive process and switch between two regimes; expansion and recession (Hamilton, 1989; Owyang, Piger and Hall, 2005). By applying this model, researchers can find the recession probabilities given at a time and convert these probabilities into turning points. The two techniques, Bry-Boschan algorithm and MSVAR model are able to replicate accurately the NBER's dates. Bry-Boschan (1971) algorithm is known to be simple, transparent and reproducible method. Differently, MSVAR is neither simple nor transparent but well connected to the data generating process (Harding and Pagan, 2002). The comparison of these techniques has recently been studied in the literature. (Harding and Pagan, 2002; Chauvet and Piger 2003; Billio, Caporin and Cazzavillan, 2007). Generally, it is found that the two techniques produce similar and robust results and therefore they are accepted as default methods in the business cycle literature. That is the most important reason that we consider employing some of these models in our turning points detection analysis.

As the methodological improvements increased over time, the business cycle literature started dealing with more complicated issues. First, how can one detect the turning points quicker? Second, knowing that a single variable can hardly represent the aggregate economic activity, with which techniques multiple series can be used in dating exercises? Chauvet and Piger (2003) show that using the real time data available at the end of each sub-period, turning points can be detected timelier.

Although the main goal of NBER is to find the turning points correctly rather than faster, the policy makers emphasize the necessity of quicker announcements (Chauvet and Piger, 2003). However, since it fits our purposes well, we completely focus on detecting the turning points correctly rather than quicker.

In the business cycle literature, despite much effort has been put on the dating analysis at the national level, little work has been done at the regional or state level (i.e. Owyang, Piger and Wall, 2005; Hall and Dermott, 2047). Primarily, the researchers focused on looking for the co-movements in the regional/state level growth and tried to split growth rates into trend and cyclical components (Quah, 1996; Carlino and Sill, 2001). However, recently, Owyang, Piger and Wall (2005) have analyzed the turning points of US states. They used a simple Markov-Switching model and a coincident index developed by Crone (2002) and detected state specific cycles. As an outcome, they found that there exist great deal of variation in timing and amplitude of the business cycles across states.

In this paper, we use Bry Boschan Quarterly algorithm to detect the turning points of US aggregate cycle and 51 state business cycles. The main principles of this algorithm require that the selected cycles have clear and certain duration and amplitude (Bry and Boschan, 1971).

Practically, Bry and Boschan (1971) algorithm first detects the local minima and maxima in the economic series. A peak occurs at time  $t$  when  $y_t$  exceeds its values  $y_s$  for  $t > s$  (Harding and Pagan, 2002). However, we need to limit the window time and we set a domain  $\{t-k, t+k\}$  (Harding and Pagan, 2002). For quarterly data we set  $k=2$ . As seen in equation (9), we will be looking for a local maximum (or minimum) for every 5 quarters (15 months) in the economic series.<sup>6</sup>

$$\begin{aligned}
 \text{peak} &= \{(y_{t-2}, y_{t-1}) < y_t > (y_{t+1}, y_{t+2}) \\
 \text{trough} &= \{(y_{t-2}, y_{t-1}) > y_t < (y_{t+1}, y_{t+2})\}.
 \end{aligned}
 \tag{9}$$

Following this main step, the algorithm imposes some restrictive rules which ensures the minimum phase and cycle duration (Harding and Pagan, 2002). We set the minimum duration for a phase as 2 quarters and minimum cycle length as 5 quarters. Apart from these broad steps, the Bry Boschan program includes many other intermediate steps which help in handling not only the two issues above but ensuring that the peaks and troughs orderly alternate, the results are robust against outliers, i.e. values outside the range of  $\pm 3.5$  standard deviations are corrected. Furthermore, in this algorithm it is imposed that the potential turning points which are detected in the first and last 6 observations of the data sets should be eliminated

We apply the Bry Boschan Quarterly program for per capita real personal income minus current transfer receipts of US aggregate economy and 51 states. As an alternative, the same algorithm is applied to the HP cyclical components of the same economic series. To check if our turning points analysis gives accurate results, we compare the NBER's official chronology with the national turning points that we detected. Table 3 shows the results obtained from the dating analysis. According to these results, our dating algorithm is able to detect 10 out of 13 turning points announced by the NBER. This result is true for both classical cycles and deviation cycles. Furthermore, the dating algorithm is able to detect the NBER turning points on average with  $\pm 2$  quarters lead (lag) discrepancy. Considering that we use a single variable rather than many variables like the NBER and our variable is real personal

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<sup>6</sup> Harding and Pagan, 2003

income which is a coincident indicator of US economy but not as general as other indicators (i.e. GDP) which represent aggregate economic activity better than real personal income, our dating results are quite acceptable and reasonably match the NBER's chronology. Moreover, in deviation cycles, we obtain many extra turning points different than NBER's announcements.

| NBER Announcements:            | Classical Cycle  |             | Deviation Cycle (HP,1600) |             |
|--------------------------------|------------------|-------------|---------------------------|-------------|
|                                | Turning Points   | Discrepancy | Turning Points            | Discrepancy |
| Q4-1969 (Peak)                 | -                | -           |                           | -           |
| Q4-1970 (Trough)               | Q4-1970 (Trough) | 0           | Q4-1970 (Trough)          | 0           |
| Q4-1973 (Peak)                 | Q4-1973 (Peak)   | 0           | Q4-1973 (Peak)            | 0           |
| Q1-1975 (Trough)               | Q2-1975 (Trough) | 1           | Q2-1975 (Trough)          | 1           |
| Q1-1980 (Peak)                 | Q1-1979 (Peak)   | -4          | Q1-1979 (Peak)            | -4          |
| Q3-1980 (Trough)               | -                | -           |                           | -           |
| Q3-1981 (Peak)                 | -                | -           |                           | -           |
| Q4-1982 (Trough)               | Q4-1982 (Trough) | 0           | Q4-1982 (Trough)          | 0           |
| Q3-1990 (Peak)                 | Q1-1989 (Peak)   | -6          | Q1-1989 (Peak)            | -6          |
| Q1-1991(Trough)                | Q4-1991 (Trough) | 3           | Q4-1991 (Trough)          | 3           |
| Q1-2001(Peak)                  | Q1-2001 (Peak)   | 0           | Q1-2000 (Peak)            | 0           |
| Q4-2001(Trough)                | Q1-2003 (Trough) | 5           | Q1-2003 (Trough)          | 5           |
| Q4-2007(Peak)                  | Q3-2007 (Peak)   | -1          | Q2-2007 (Peak)            | -2          |
| Extra turning points detected: | -                |             | Q3-1984 (Peak)            |             |
|                                |                  |             | Q4-1986 (Trough)          |             |
|                                |                  |             | Q4-1994 (Peak)            |             |
|                                |                  |             | Q4-1995 (Trough)          |             |

Note : + (-) denotes a lag (lead) with respect to the reference series

Table 3: Turning points of US Cycle (real personal income per capita minus transfers) Bry-Boschan Quarterly Algorithm



## 5.2 Amplitude and timing differences across state business cycles

There is a growing body of literature which study the tendency of regional cycles to synchronize with each other and the economic determinants of such synchronization (i.e. Montoya and Haan, 2007; Carlino and Sill, 2001). However, among these studies, a very limited number of studies perform turning points detection and use this information when exploring the synchronization of cycles and amplitude differences across economies. In general, they try to look at commovements between regional economies and evaluate the tendency of cycles to synchronize with each other. (Carlino and Sill, 2001). Some of the studies, which detects the turning points at the regional level uses some descriptive statistics to show the timing and amplitude differences across regional cycles. In this section, referring to these statistics, we try to explore the timing and amplitude differences across US state cycles.

However, before proceeding, it worths mentioning that, in this study, during some of the analysis timing differences across states are explored using timing differences between states and US national economy. Since aggregate economy represents the weighted average of all states, higher timing differences between aggregate economy and states mean greater timing differences across states.

### 5.2.1 Timing differences across US states (or synchronization of state cycles)

Recently, two popular measures for synchronization of cycles are built by economists. These measures are “concordance rate” of a regional cycle with national cycle and “diffusion index” of expansions or recessions to the rest of the country. These measures tell similar stories.

Concordance rate measures the percentage of time in which two economies are in the same business cycle phase. This measure is used by some economists in the literature. Owyang, Piger and Hall (2005) calculated the concordance index for US states and US aggregate economy. Hall and Dermott (2007) used the concordance index to analyze the degree of synchronization among regions of New Zealand. Artis, Marcellino and Proietti (2003) studied the concordance index to evaluate the synchronization within the Euro area.

As seen in equation (10),  $I$  is the index of concordance where  $S$  is a binary variable and takes 1 when an economy is in recession and 0 when it is in an expansion phase.  $i$  and  $j$  represent two different economies.

$$I = \frac{1}{T} \sum_{t=1}^T [S_{it}S_{jt} + (1 - S_{it})(1 - S_{jt})]. \quad (10)$$

We summarize the concordance of US states with US national economy in the tables 4 and 5 which is based on the turning points information detected for classical and deviation cycles. For classical cycles, during the period of analysis, on average a state and US economy is in the same business cycle phase 82 % of the time where this index turns to be 77 % for the deviation cycles. Alaska and Hawai are the states which show least concordance with US economy. The concordance rate ranges

between 0.56 and 0.92 in classical, 0.53 and 0.92 in deviation cycles. The results show that although there exist a good synchronization between the states and US aggregate economy, there are still important timing differences. For example, 0.77 concordance rate indicates that during a 10 quarter national expansion, on average a state is not in expansion but in recession during 23 % of the time, which is equivalent to 2 quarters. Considering that there are 51 states and each state has some timing differences, in aggregate terms there might exist serious timing differences between states and national economy.

| States | Concordance | States | Concordance | States | Concordance | States  | Concordance |
|--------|-------------|--------|-------------|--------|-------------|---------|-------------|
| AL     | 0.90625     | IL     | 0.9125      | MT     | 0.76875     | RI      | 0.85        |
| AK     | 0.5625      | IN     | 0.88125     | NE     | 0.75        | SC      | 0.8875      |
| AZ     | 0.85625     | IA     | 0.75        | NV     | 0.825       | SD      | 0.68125     |
| AR     | 0.875       | KA     | 0.89375     | NH     | 0.85        | TN      | 0.925       |
| CA     | 0.90625     | KY     | 0.875       | NJ     | 0.91875     | TX      | 0.825       |
| CO     | 0.85625     | LA     | 0.7         | NM     | 0.84375     | UT      | 0.89375     |
| CT     | 0.90625     | ME     | 0.85625     | NY     | 0.825       | VT      | 0.88125     |
| DE     | 0.8375      | MD     | 0.875       | NC     | 0.91875     | VA      | 0.85        |
| DC     | 0.71875     | MA     | 0.9         | ND     | 0.5125      | WA      | 0.86875     |
| FL     | 0.8         | MI     | 0.8125      | OH     | 0.89375     | WV      | 0.79375     |
| GA     | 0.925       | MN     | 0.8375      | OK     | 0.73125     | WI      | 0.91875     |
| HI     | 0.61875     | MS     | 0.93125     | OR     | 0.8625      | WY      | 0.7         |
| ID     | 0.89375     | MO     | 0.93125     | PA     | 0.9         | average | 0.827       |

Table 4. Concordance of states with US national economy (Classical cycles)

Another popular measure for synchronization is diffusion index of expansions or recessions to the rest of the country. It is used by some economists to understand how well the recessions are spread to a country or an area (i.e. Artis, Marcellino and Proietti, 2003)

$$D_t = \frac{1}{N} \sum_{i=1}^N S_{it} . \tag{11}$$

As shown in equation (11), diffusion index basically tells, given at a time, how many percentage of the states are in recession and how many are in expansion. In other words, it measures how well the recessions are spread to the country. Using this simple measure, we can find out, given at a time, how

many states do not coincide with national economy and experience recessions when national economy is in expansion or vice versa.

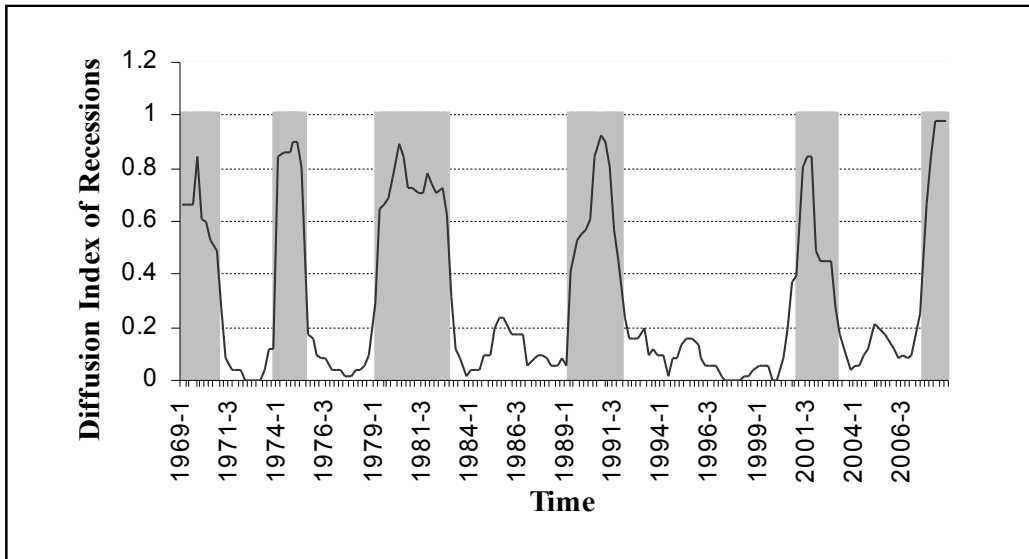
Figures 6 and 7 show the results from diffusion indexes. The gray shaded areas represent the national recession periods. In these figures, diffusion index shows the percentage of the states which are in recession given at a time. It is clearly observed that not all the states coincide with the aggregate economy. In classical cycles, during national expansions, states show a good synchronization. On average, given at a time only 10 % of states is in recession period and the 90 % is in expansion period. However, during the national recession times, on average and given at a time, 30 % of the states are in expansions and 70 % is in recessions. So, during national recessions, many states do not coincide with the national economy and show some important timing differences.

| States | Concordance | States | Concordance | States | Concordance | States  | Concordance |
|--------|-------------|--------|-------------|--------|-------------|---------|-------------|
| AL     | 0.8375      | IL     | 0.85625     | MT     | 0.575       | RI      | 0.80625     |
| AK     | 0.53125     | IN     | 0.825       | NE     | 0.73125     | SC      | 0.9125      |
| AZ     | 0.78125     | IA     | 0.6625      | NV     | 0.73125     | SD      | 0.6125      |
| AR     | 0.75625     | KA     | 0.69375     | NH     | 0.81875     | TN      | 0.88125     |
| CA     | 0.825       | KY     | 0.88125     | NJ     | 0.84375     | TX      | 0.775       |
| CO     | 0.8125      | LA     | 0.68125     | NM     | 0.74375     | UT      | 0.80625     |
| CT     | 0.1625      | ME     | 0.8125      | NY     | 0.83125     | VT      | 0.81875     |
| DE     | 0.74375     | MD     | 0.8875      | NC     | 0.9125      | VA      | 0.8625      |
| DC     | 0.74375     | MA     | 0.86875     | ND     | 0.5125      | WA      | 0.79375     |
| FL     | 0.825       | MI     | 0.80625     | OH     | 0.925       | WV      | 0.71875     |
| GA     | 0.9         | MN     | 0.7         | OK     | 0.5875      | WI      | 0.8125      |
| HI     | 0.65        | MS     | 0.84375     | OR     | 0.75625     | WY      | 0.74375     |
| ID     | 0.8375      | MO     | 0.86875     | PA     | 0.85        | Average | 0.767769608 |

Table 5. Concordance of states with US national economy (Deviation cycles)

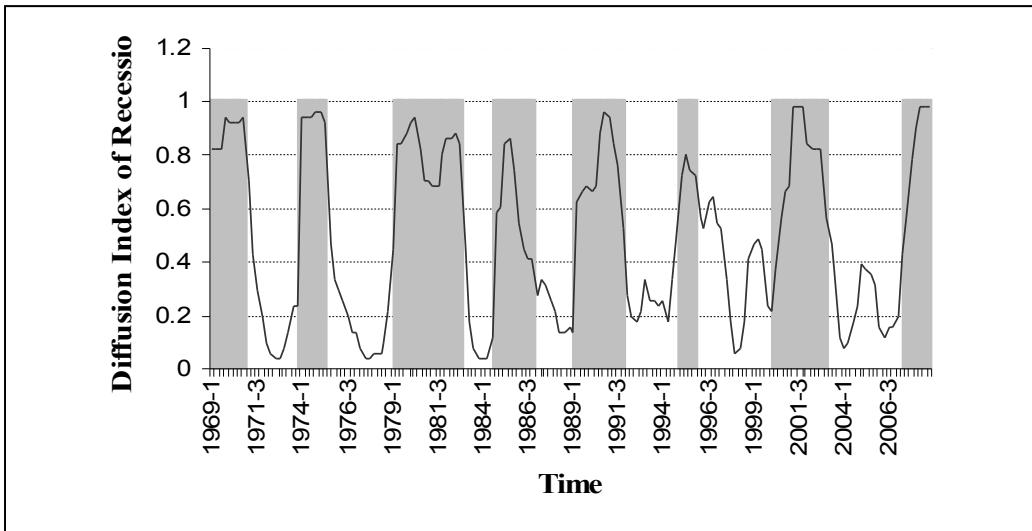
In deviation cycles, the timing differences are more evident. During national expansions, on average and given at a time, 31 % of the states are not in expansion but in recession and during national recessions, 21 % of the states are not in recession but in expansion. As a consequence, we conclude that there are important timing differences across states which might have some serious impact on the income disparities and its evolution in the short run. It is plausible to believe that when some states are in expansion, many other states might be in recession and, thus, income inequalities during the

corresponding national phase might increase or decrease due to the fact that the states grow in different regimes.



Note: Gray shaded areas represent the national recession periods

Figure 6. Classical cycles and diffusion index of recessions



Note: Gray shaded areas represent the national recession periods

Figure 7. Deviation cycles and diffusion index of recessions

### **5.2.2 Amplitude differences across state cycles.**

Another important mechanism behind the short run income disparities can be the amplitude differences across US states. Rather than timing, states may differ in the amplitudes of their cycles. In this study, we define the amplitude of a phase as the cumulative growth rate of a state/region during that cycle phase, say expansion. For example, 0.04 amplitude level of an expansion means that the economy grows cumulatively 4 % during such an expansion. In order to explore the amplitude differences across states, we calculate the average amplitudes of states during their expansion and recession periods. The results are summarized in the tables A.1 and A.2 in the appendix. The results suggest that there are large amplitude differences across states.

In classical cycles, among the US states, Mexico has the minimum level of expansion amplitude which is 4% and District of Columbia has the maximum level of expansion amplitude which is equal to 11%. For recessions, North Dakota has the maximum amplitude level which is -7 % and New Mexico has the minimum level of recession amplitude which is -1 %. In deviation cycles, West Virginia has the minimum level of expansion amplitude which is 3 % and the North Dakota has the maximum expansion amplitude which is 9 %. For recessions, District of Columbia has the maximum level of recession amplitude which is -0.4 % and North Dakota has the maximum recession amplitude which is -6%. If look at the aggregate statistics, the diversity of the amplitude levels across states is clearly observed. For recession amplitudes, standard deviation divided by the average amplitude is 0.34 in classical, 0.57 in deviation cycles. These statistics mean that if the average recession amplitude of US states was 1, then on average a state would deviate from this mean by 0.34 units in classical and 0.57 units in deviation cycles. The same statistics for expansion amplitudes is around 0.20 which means that if the average expansion amplitude of US states was 1 then on average a state would deviate from this mean by 0.20 units. These numbers indicate a great deal of variation in the amplitudes of states, especially for recession amplitudes which might play an important role on the evolution of income disparities in the short run.

### **5.3 Variance decomposition of disparities into amplitude and timing differences across the state cycles**

We have so far shown that there are important variation in the timing and amplitudes of the state cycles. However, in order to understand if the income disparities are motivated by timing or amplitude differences, one should decompose the variance of income disparities into timing and amplitude differences across states. Then, one can find how much percentage of variation in short run income disparities is explained by the changes in timing or amplitude differences. To have more clear idea, this variance decomposition should be done separately for national expansion and recession periods. However, implementing such a complex variance analysis is not easy and might require some sophisticated modeling tools.

Therefore, we would like to start tackling this issue by implementing a descriptive and simpler analysis which shows the importance of timing differences across states on the creation of income disparities during national expansion and recession times.

$$TSS_t = \sum_{i=1}^{51} \left( \frac{X_{i,t}}{\bar{X}} - 1 \right)^2 . \quad (12)$$

*TSS* (total sum of squares) is a measure of income disparities which is very close to the coefficient of variation and tells the same story in the context of income inequalities (equation 13). *TSS* is the total sum of squares of relative incomes of states at time *t*.  $X_{it}$  is the income of state *i* at time *t*. Relative incomes are in the form of proportional to average income,  $\bar{X} = 1$ .

We partition the *TSS* into the *TSS* created by the states which are and which are not in the same phase with the national economy given at a time.

$$CoV = \sqrt{TSS / (n - 1)} . \quad (13)$$

$$TSScoin_t = \sum_{i=1}^{51} C_{it} \left( \frac{X_{i,t}}{\bar{X}} - 1 \right)^2 . \quad (14)$$

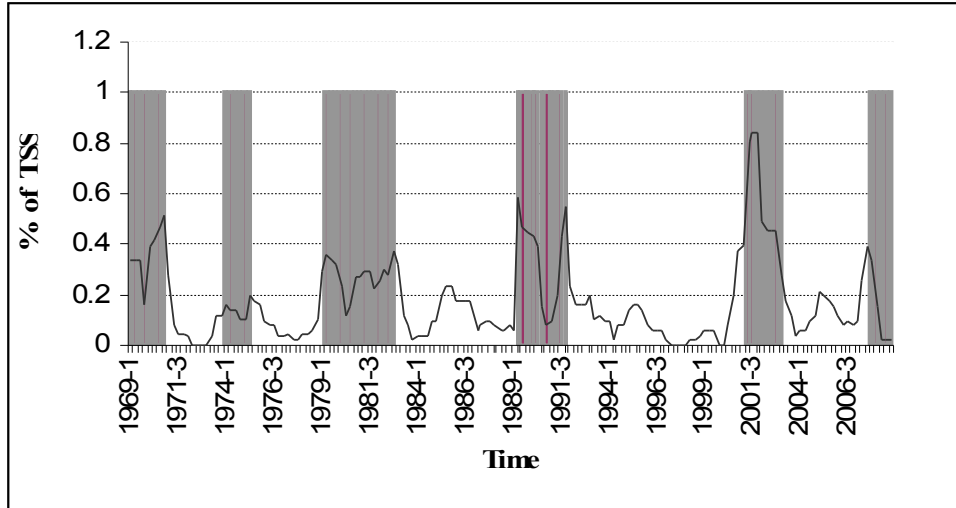
$$TSSuncoin_t = \sum_{i=1}^{51} U_{it} \left( \frac{X_{i,t}}{\bar{X}} - 1 \right)^2 . \quad (15)$$

$$TSS = TSScoin + TSSuncoin . \quad (16)$$

*TSScoin* is the total sum of squares created by the relative incomes of states which are in the same phase with US national economy. *C* is a binary variable and takes 1 if the state is a coincident state which is in the same phase with the aggregate economy and 0 otherwise. *TSSuncoin* is the total sum of squares created by the relative incomes of states which are not in the same phase with US national economy. *U* is a binary variable takes 1 if the state is not a coinciding state, 0 otherwise. From equation (16) we can understand that the total sum of squares is the sum of contributions of coincident and uncoincident states to *TSS*.

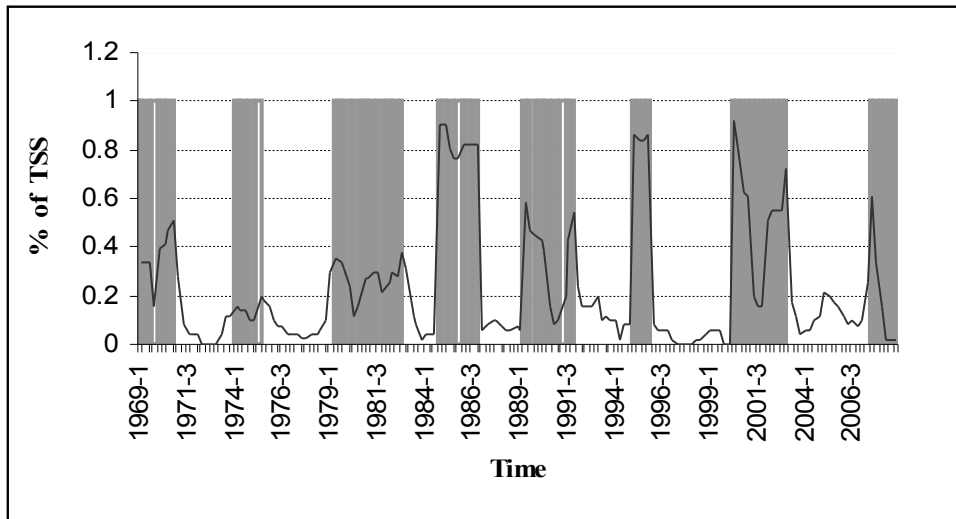
$$(TSScoin/TSS) + (TSSuncoin/TSS) = 1 . \quad (17)$$

In equation (17), the first component is the percentage of income disparities created by the states which are in the same regime with US national economy. The second component is the percentage of income disparities created by the states which are not in the same regime with US national economy. Figures 8 and 9 illustrate the second component and its evolution over time. In other words, they show the percentage of regional disparities created by uncoincident states with the US economy.



Note: Gray shaded areas represent the national recession periods

Figure 8. Percentage contribution of uncoincident states to the income disparities (in classical cycles)



Note: Gray shaded areas represent the national recession periods

Figure 9. Percentage contribution of uncoincident states to the income disparities (in deviation cycles)

In both figures (8) and (9), we clearly observe that role of the states, which do not coincide with aggregate economy, on the creation of income disparities is small during the national expansion times where but increases rapidly during the national recession periods. This pattern is true for both definitions of business cycle and gives us an initial idea about the mechanisms behind the income disparities. The findings are well supported by an aggregate statistics summary:

| Phases:             | Classical cycles | Deviation cycles |
|---------------------|------------------|------------------|
| national expansions | 10%              | 8%               |
| national recessions | 29%              | 42%              |

Table 6. Average (%) contribution of timing differences on the creation of income disparities

In above matrice,. it is clearly seen that during national expansions, most of the income disparities is created by the states which are also in expansion but only 9-10 % of the TSS is created by the states which are in recession. This finding means that during the national expansions there is a small fraction of TSS created by the states which do not coincide with aggregate economy and the TSS created by this small fraction is negligible. Therefore, during expansions, the driving force of the income disparities does not seem to be the timing differences between states. However, during recessions, 29 % (classical cycles) and 42 % (deviation cycles) of the TSS is created by the states which are in expansion while US economy and many other states are in recession. This finding well emphasizes the importance of timing differences on the creation of income disparities during the national recessions.

In the light of these findings, we can argue that the timing differences across states and its impact on the evolution of income disparities might be negligible during national expansions but should carefully be taken into consideration during the national recessions.

## 6 Conclusions

In this paper, we studied the short run dynamics of regional disparities. In particular, we aimed at understanding well the income disparities across US states and its evolution in the short run. For this purpose, we evaluated such a behaviour for the period between 1969 and 2008 using personal income series of US states.

In particular, having performed a regression analysis, we tried to find if the income disparities move along the national cycle and, if so, do they move in the same or opposite direction of the national cycle. Then, we tried to understand the possible mechanisms behind such cyclical behaviour of regional disparities and considered two important mechanisms; amplitude and timing differences across state cycles. In order to evaluate the mechanisms, we followed a three step approach and analyzed, respectively, the turning points of 51 states and US national economy, the possible timing and amplitude differences across state cycles and the role of timing differences on the creation of income disparities in the short run. Following these steps, we found a set of results which include some important indications. Our results are summarized in five groups;

First, income disparities across US states follow a stationary process between 1969 and 2008. This means that over the 40 years, income disparities do not show a tendency to diminish, rather, remain persistent.

Second, as an outcome of the regression analysis, we find a negative and significant relation between “income disparities across US states” and “US national business cycle.” This finding corresponds to an anti cyclical evolution of income disparities. According to this result, disparities



across states move in the opposite direction of aggregate cycle and tend to diminish during the expansion times when US economy is booming and decrease during the recession times when US economy is performing poorly.

Third, the results from turning points detection analysis show that our dating algorithm is able to detect 10 out of 13 turning points announced by the NBER. This is an acceptable and reasonable dating performance considering that we use single variable, which is real personal income, rather than many variables like the NBER.

Fourth, we find a great deal of variation in timing and amplitudes across state business cycles. For example, with regard to the timing differences, the diffusion index suggests that during national expansion times, on average, 17 out of 51 states are not in expansion but in recession, where, during national recessions, 10 out of 51 states are not in recession but rather in expansion. With regard to amplitude differences, we find that amplitudes of state cycles significantly differ from each other, especially for recessions.

Fifth, we find that the timing differences across state business cycles have important effects on the creation of income disparities. For example, a simple variance partitioning analysis shows that during national recession times, 42 % of the income disparities is created by those states which are not in recession but in expansion.

To sum up, we can conclude that the income disparities across US states move in the opposite direction of aggregate performance of the economy. Such an anti cyclical behavior might be motivated by the timing or amplitude differences across state cycles. There are important timing and amplitude differences across states and among these mechanisms the role of timing differences have unavoidable and serious effects on the evolution of income disparities, especially during the national recessions. Studying the mechanisms in more detailed and complex frameworks is of our special interest and included in our research agenda.

## References

Artis M., Marcellino M. and Proietti T. (2003) Dating the Euro area business cycle, *CEPR discussion papers 3696*

Barro R.J. and Sala-i Martin X. (1992) Convergence, *Journal of Political Economy*, 100(2) : 223-251

Berry B. (1988) Migration reversals in perspective: the long wave evidence, *International Regional Science Review*, volume 11, 245-251

Billio M., Caporin M. and Cazzavillan G. (2007), Dating EU15 monthly business cycle jointly using GDP and IPI, *Ca' Foscari University of Venice working papers*, no 19

Bry G. and Boschan C (1971) Cyclical analysis of time series: selected procedures and computer programs, *NBER technical paper*, no 20

Burns A.F. and Mitchel W.C (1946) Measuring business cycles, *NBER*

- Carlino G. and K. Sill (2001) Regional income fluctuations: common trends and common cycles, *The Review of Economics and Statistics*, volume 83, 446-456
- Chauvet M. and J.M Piger (2003) Identifying business cycle turning points in real time, *Federal Reserve Bank of St Louis Review*, volume 85, p. 47-61
- Crone T.M (2002) Consistent economic indexes for the 50 states, *Federal Reserve Bank of Philadelphia working paper*, no.02-7
- Cleveland (1979) Robust locally weighted regression and smoothing scatterplots, *Journal of the American Statistical Association*, volume 74, p. 829-836
- Dewhurst, J.H.L (1998) Convergence and divergence in regional household incomes per head in the United Kingdom, 1984-93, *Applied Economics*, volume 30, p. 31-35
- Dolores R.M. and Sancho I. (2003) On asymmetric business cycle effects on convergence rates:some EU evidence, *Working Paper University of Murcia*, p. 1-26
- Fingleton B. (2003) Models and simulations of GDP per inhabitant across Europe's regions: a preliminary view, *European Regional Growth*, p. 11-53
- Gerolimetto M. and Magrini S. (2009) Nonparametric regression with spatially dependent data, DSE Working Paper 20 , Ca' Foscari University of Venice
- Hall V. and McDermott J. (2004) Regional Business Cycles in New Zealand : Do they exist? What might drive them?, *Motu Working Paper* 04-10.
- Hamilton J.D. (1989) A new approach to the economic analysis of non stationary time series and the business cycle, *Econometrica*, volume 57, p. 357-84
- Harding D. And Pagan A. (2002) A comparison of two business cycle dating methods, *Journal of Economic Dynamics and Control*, volume 27, p. 1681-90
- Hodrick R. And Prescott E.C. (1997) Postwar U.S. Business Cycles: An empirical investigation, *Journal of Money, Credit and Banking*
- Magrini,S. (1999) The evolution of income disparities among the regions of the European Union, *Regional Science and Urban Economics*, Elsevier, vol. 29(2), pages 257-281
- Magrini S. (2009) Why Should We Analyze Convergence Using the Distribution Dynamics Approach?, *Scienze Regionali*, FrancoAngeli Editore, vol. 8(1), pages 5-34.
- Nadaraya E.A (1964) On estimating the regression, *The Theory of Probability and its Applications*, volume 9, p. 141-142
- Owyang M.T., Wall H.J and J.M. Piger (2005), Business cycle phases in US states, *The Review of Economics and Statistics*, volume 87, p. 604-616
- Pekkala S. (2000) Aggregate economic fluctuations and regional convergence: the Finnish case 1988-1995, *Applied Economics*, volume 32, p. 211-219
- Petrakos, G., Pose, A.R. and Rovolis A. (2005) Growth, Integration, and regional disparities in the European Union, *Environment and Planning*, volume 37, p. 1837-1855
- Petrakos, G. and Saratsis Y (1999) Regional inequalities in Greece, *Papers in Regional Science*, volume 79, p. 57-74

Pose A.R. and Fratesi U. (2007) Regional business cycles and the emergence of sheltered economies in the southern periphery of Europe, *Growth and Change*, volume 38, p. 621-648

Quah D.T. (1996) Aggregate and regional disaggregate fluctuations, *Center for Economic Performance Discussion Paper no. 275*

Wahba G. (1990) Spline models for observational data , Regional conference series in Applied Mathematics, volume 59

White H. (1980) A Heteroscedasticity Consistent Covariance Matrix Estimator and a direct test for the Heteroscedasticity, *Econometrica*, vol. 48, issue 4, p. 817-38

## Appendix

| States | Expansions | Recessions | States        | Expansions | Recessions |
|--------|------------|------------|---------------|------------|------------|
| AL     | 0.0750474  | -0.02131   | NE            | 0.0511022  | -0.0212911 |
| AK     | 0.0621237  | -0.043322  | NV            | 0.0606122  | -0.0328997 |
| AZ     | 0.0770786  | -0.042768  | NH            | 0.1079841  | -0.0412846 |
| AR     | 0.0776646  | -0.031574  | NJ            | 0.0734432  | -0.0240949 |
| CA     | 0.0705782  | -0.031971  | NM            | 0.0410369  | -0.0120402 |
| CO     | 0.0653864  | -0.019682  | NY            | 0.0771744  | -0.0361883 |
| CT     | 0.0832195  | -0.027114  | NC            | 0.0813853  | -0.0262971 |
| DE     | 0.0589429  | -0.028813  | ND            | 0.1105343  | -0.0729246 |
| DC     | 0.1175596  | -0.022847  | OH            | 0.054236   | -0.0313265 |
| FL     | 0.0725711  | -0.038289  | OK            | 0.0547398  | -0.0238769 |
| GA     | 0.0793795  | -0.02641   | OR            | 0.0599822  | -0.0309526 |
| HI     | 0.0609108  | -0.033287  | PA            | 0.0636866  | -0.0245562 |
| ID     | 0.064392   | -0.033979  | RI            | 0.0917767  | -0.0393687 |
| IL     | 0.0646944  | -0.028918  | SC            | 0.0735416  | -0.026555  |
| IN     | 0.0630678  | -0.037565  | SD            | 0.0755591  | -0.0571204 |
| IA     | 0.0653418  | -0.032644  | TN            | 0.0765795  | -0.0293935 |
| KA     | 0.0614567  | -0.026022  | TX            | 0.0612685  | -0.0226708 |
| KY     | 0.059567   | -0.027896  | UT            | 0.0583792  | -0.021979  |
| LA     | 0.065132   | -0.018182  | VT            | 0.0601068  | -0.0233093 |
| ME     | 0.0801952  | -0.038184  | VA            | 0.0652474  | -0.0162192 |
| MD     | 0.0575466  | -0.0162    | WA            | 0.0717492  | -0.0216973 |
| MA     | 0.0858723  | -0.031256  | WV            | 0.0683116  | -0.0281751 |
| MI     | 0.0679264  | -0.045454  | WI            | 0.0687555  | -0.0313672 |
| MN     | 0.0692979  | -0.026099  | WY            | 0.1013557  | -0.0405313 |
| MS     | 0.0644564  | -0.026287  | Average       | 0.0707809  | -0.0303867 |
| MO     | 0.0610874  | -0.02714   | stdev         | 0.0148669  | 0.0103542  |
| MT     | 0.060732   | -0.028655  | stdev/average | 0.2100414  | -0.3407467 |

Table A.1 Amplitudes of US states (Classical Cycles)

| States | Expansions | Recessions | States     | Expansions | Recessions |
|--------|------------|------------|------------|------------|------------|
| AL     | 0.0412933  | -0.007695  | NE         | 0.04832008 | -0.0222624 |
| AK     | 0.0395902  | -0.025489  | NV         | 0.03052358 | -0.0106593 |
| AZ     | 0.0539689  | -0.021467  | NH         | 0.05388386 | -0.0176896 |
| AR     | 0.0457531  | -0.016381  | NJ         | 0.04629891 | -0.0143882 |
| CA     | 0.0457626  | -0.016     | NM         | 0.03601644 | -0.0072297 |
| CO     | 0.0422719  | -0.007939  | NY         | 0.05685085 | -0.0211138 |
| CT     | 0.0560271  | -0.014826  | NC         | 0.05668371 | -0.0229395 |
| DE     | 0.0354734  | -0.015608  | ND         | 0.09160717 | -0.0688177 |
| DC     | 0.0502435  | -0.00494   | OH         | 0.03797634 | -0.0225045 |
| FL     | 0.0428595  | -0.009041  | OK         | 0.04285926 | -0.0168558 |
| GA     | 0.0441693  | -0.013524  | OR         | 0.03743719 | -0.0138337 |
| HI     | 0.0452414  | -0.022222  | PA         | 0.04793562 | -0.0146003 |
| ID     | 0.0516832  | -0.025079  | RI         | 0.05241615 | -0.0196521 |
| IL     | 0.0347431  | -0.013111  | SC         | 0.04281799 | -0.0145065 |
| IN     | 0.0482767  | -0.02596   | SD         | 0.06347448 | -0.0402491 |
| IA     | 0.0400957  | -0.022261  | TN         | 0.05127588 | -0.0165089 |
| KA     | 0.0339868  | -0.013191  | TX         | 0.04147844 | -0.0122473 |
| KY     | 0.0426107  | -0.018596  | UT         | 0.03954967 | -0.0125674 |
| LA     | 0.0417394  | -0.00667   | VT         | 0.04537972 | -0.0151937 |
| ME     | 0.0518801  | -0.019358  | VA         | 0.05489179 | -0.0115484 |
| MD     | 0.0415583  | -0.00497   | WA         | 0.04590161 | -0.0139165 |
| MA     | 0.0482871  | -0.012167  | WV         | 0.03003593 | -0.0124313 |
| MI     | 0.0483698  | -0.033239  | WI         | 0.03964245 | -0.0141187 |
| MN     | 0.0359596  | -0.010458  | WY         | 0.05596063 | -0.0210534 |
| MS     | 0.0467175  | -0.015058  | Average    | 0.04581493 | -0.0172923 |
| MO     | 0.0329666  | -0.012478  | stdev      | 0.00992526 | 0.00996993 |
| MT     | 0.0391559  | -0.015697  | stdev/mean | 0.21663801 | -0.5765523 |

### A.2 Amplitudes of US states (Deviation Cycles)

