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Conference Paper

Short run dynamics of income disparities and regional cycle synchronization

51st Congress of the European Regional Science Association: "New Challenges for European Regions and Urban Areas in a Globalised World", 30 August - 3 September 2011, Barcelona, Spain

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Duran, Hasan Engin (2011) : Short run dynamics of income disparities and regional cycle synchronization, 51st Congress of the European Regional Science Association: "New Challenges for European Regions and Urban Areas in a Globalised World", 30 August - 3 September 2011, Barcelona, Spain, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

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**51st Congress of the European Regional Science Association
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Short run dynamics of income disparities and regional cycle synchronization

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Abstract:

Since the 1990s, the issue of regional income convergence and its long term tendencies has been thoroughly and heatedly discussed. Much less attention, however, has been devoted to the short-run dynamics of regional convergence. In particular, three important aspects have not yet been adequately addressed. Firstly, it is indeed essential to understand whether regional disparities manifest a tendency to move systematically along the national cycle. Then, if this happens to be the case, it becomes crucial to know whether: i. these movements are pro- or counter-cyclical, ii. the cyclical evolution of the disparities is a consequence of differences in the timing with which the business cycle is felt in regions or it is motivated by the amplitude differences across local cyclical swings. In this paper, we shed light on these issues using data on personal income for the 48 coterminous U.S. states between 1969 and 2008.

Keywords:

cyclical income disparities, regional business cycles, synchronization

JEL Codes: R11, E32, O18

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1 Introduction

In the literature on economic convergence, much attention has been devoted to the analysis of the evolution of regional disparities. In almost all cases, these studies have implicitly adopted a long-run perspective. This is probably motivated by the fact that the most commonly adopted empirical tools are derived, more or less directly, from the traditional neoclassical model which, as is well known, describes a monotone path along which, under certain assumptions on production, technology and preferences, each economic system converges towards a stable long-run dynamic equilibrium. The short-term dynamics and, in particular, the interconnections between the disparities across economic systems (e.g. between regions) and the aggregate economic cycle have received very limited attention.

In spite of this, the few studies which have been confronted with this topic seem to suggest that regional disparities can vary significantly along the aggregate economic cycle. This result, if confirmed, has extremely important implications both for the empirical analysis of convergence and for regional economic policy. On the one hand, because at the regional level time series on income are usually quite short, if regional disparities are shown to move significantly over the business cycle, it follows that the period of analysis should be chosen with great care so to avoid to affect the results (Magrini, 1999; Pekkala, 2000). Indeed, it is clear that if, for instance, regional disparities move in an anti-cyclical fashion, increasing during the economic downturn and decreasing during the expansion phase, the choice of a period of analysis that does not contain entirely both phases of the cycle is likely to produce misleading results due to an overestimation of the tendency towards divergence (convergence) when the period of analysis excludes a part of the contraction (expansion) phase.

With regard to the implications for regional economic policy, it is important to emphasize that the recognition and quantification of a short-term component in the dynamics of regional disparities, as well as the causes of this component, would help understanding the extent to which policy interventions are needed in order to absorb structural and

long-run regional differences. In a European perspective, in particular, assuming that regional disparities move in an anti-cyclical fashion, if the widening of the disparities during a recession is such to undermine the overall objective of social and territorial cohesion within the Union, it may be appropriate to put in place additional resources explicitly targeted to the containment of these dynamics. Conversely, if regional disparities demonstrate a pro-cyclical component, the reduction of disparities that take place during an economic downturn can be considered rather positively as it eases the pressure on resources to be devoted to the objective of territorial cohesion during the contraction phases.

Most of the papers dealing with the short-term regional disparities report evidence in favour of a pro-cyclical behaviour. This finding implies that regional disparities move in the same direction as the national economic cycle and, therefore, tend to increase during expansion periods and diminish in times of recession. Some examples are Dewhurst (1998) who analyzes income disparities among 63 UK counties between 1984 and 1993, Petrakos and Saratsis (2000) who study inequalities among Greek prefectures between 1970 and 1995 and Petrakos, Rodriquez-Pose and Rovolis (2005) who focus on the disparities across EU countries between 1960 and 2000. In terms of methodology, most of the studies adopt a time series regression approach and regress a measure of regional disparities (i.e. the coefficient of variation) on the growth rate of the aggregate economy.

From a theoretical point of view, the studies try to interpret the pro-cyclical disparities by referring to Berry's (1988) explanations which are in line with the spatially cumulative nature of growth (Myrdal, 1957). According to this view, expansion phases begin in more developed regions where agglomeration and market size create a lead over other regions. As a consequence regional inequalities increase during the expansions the since economic growth does not spread to the rest of the country automatically (Petrakos, Rodriquez-Pose and Rovolis, 2005). By contrast, the developed areas suffer more than other regions during recessions and therefore income inequalities decrease. (Petrakos and Saratsis, 2000).

An alternative explanation is provided by Rodriguez-Pose and Fratesi (2007). They show that most European countries exhibit pro-cyclical regional disparities between 1980 and 2005. These countries leave sheltered regions in their rural areas. Sheltered regions are isolated economies which are mostly dependent on the agriculture sector, government transfers and public employment. Therefore, they are not well prepared to compete with the rest of the economy and cannot use their potential for convergence which is generally available during the expansion periods. By contrast, they do not suffer in recessions as much as other regions and, therefore, tend to converge to richer regions. Consequently, in these countries, regional disparities follow a pro-cyclical pattern and increase during the national booms and decrease in the times of recession.

Apart from these pro-cyclical findings, there are some other studies which find evidence for anti-cyclical regional disparities. Pekkala (2000) investigates inequalities across 88 Finnish regions between 1988 and 1995 by using distribution dynamics approach. She finds evidence for anti-cyclical regional disparities and mentions that mobility of regions within the cross sectional distribution is high during boom times and regional disparities tend to decrease and, by contrast, increase during the times of recessions. Finally, Quah (1996) finds no evidence for the impact of business cycles on the income distribution of the US economy between 1948 and 1990.

The present paper extends the literature in several directions. First, the relationship between regional disparities and business cycle might not be constant over time. Despite this, with the only exception of Rodriguez-Pose and Fratesi (2007), none of the studies have attempted to analyze the change in this relationship over time. Here, we try to fill the gap and investigate the evolution of this relationship.¹

Second, in all existing studies, the national business cycle is defined referring directly to the growth rate of the aggregate economy. Therefore, positive growth years are interpreted as expansion periods and negative growth years are interpreted as recession

¹ For instance, Pose and Fratesi (2007) found that European countries exhibit increasingly pro-cyclical regional disparities over time.

periods. However, we prefer to define the business cycle in a wider sense, and, therefore, use deviation cycles. The deviation cycle represents the fluctuations of the aggregate economy around its deterministic trend. So that in order for the economy to experience a recession, it is not necessary to observe an absolute decline in output, but, it is adequate that the actual growth is smaller than the trend growth.

Third, none of the studies on the short run behaviour of regional disparities have attempted to investigate the dynamics behind it. However, understanding these dynamics might help us in discovering the short run behaviour of disparities. In particular, we consider two short run mechanisms behind the evolution of the disparities: the evolution of the disparities might be a consequence of differences in the timing with which the business cycle is felt in regional economies or it might be motivated by the amplitude differences, rather than timing, across local cyclical swings.

In this paper, we try to implement the extensions above by characterising the short run behaviour of income disparities across U.S. states in relation to the national business cycle. Below, we briefly summarize our set of research questions:

- i) Is there a relationship between the U.S. business cycle and income disparities across states? If so: do income disparities move pro-cyclically or anti-cyclically? Does this relationship change over time?
- ii) Are there meaningful state specific cycles? Are there important differences in the timing and amplitudes of the cycles of the states? How do the differences in timing and amplitudes change over time?
- iii) What are the short-run driving forces behind the evolution of income disparities? Do the differences in amplitudes or timing across state cycles drive the evolution of income disparities? Which mechanism is more important?

The organisation of the paper is as follows. In part 2, we implement the regression analysis in order to characterise the short-term behaviour of income disparities. In part 3, we show the sizable differences in amplitudes and timing across state cycles by using

information obtained from the turning points of state cycles. In part 4, using Cholesky variance decompositions, we analyze whether amplitude or timing differences across states tend to be the major short-run driver of income disparities. Finally, part 5 covers the conclusion of the paper.

2 Characterizing the short-run behaviour of regional disparities

One of the main objectives of this study is to characterise the short-run behaviour of income disparities among states. Therefore, in this part, we try to understand whether income disparities change in response to aggregate fluctuations of the economy. To do so, we regress the measure of income disparities (*CVHP*) on a measure of the aggregate business cycle (*CYC*):

$$CVHP_t = \alpha + \beta CYC_t + \varepsilon_t \quad (1)$$

In equation (1), β coefficient explains the relationship between the business cycle and income disparities. A positive and significant β coefficient would indicate that income disparities move in the same direction as the aggregate cycle, i.e., pro-cyclically. By contrast, a negative and significant β implies that income inequalities move in the opposite direction to the aggregate cycle, i.e., anti-cyclically, or counter-cyclically.

As an income disparity measure, we use the de-trended coefficient of variation which is *CVHP*. The reasons why we de-trend will be explained in the later parts. Coefficient of variation (*CV*) is calculated using per capita real personal income net of current transfer receipts (quarterly) series for U.S. states over the period between 1969:1 and 2008:4. As commonly done in the literature, we exclude Alaska, Hawaii and the District of Columbia and focus on the 48 contiguous states. All the series used in this study are deflated using the 1982-1984 US city average national consumer price index. The seasonality is adjusted using a multiplicative ratio to moving average technique. Equation (2) explains the

calculation of the coefficient of variation:

$$CV_t = \frac{\sum_{i=1}^n [(RPI_{i,t} - R\bar{P}I_t)^2 / (n - 1)]}{R\bar{P}I_t} \quad (2)$$

In equation (2), RPI is the per capita real personal income excluding transfers of state i at time t . n is the number of states. Equation (2) measures the standard deviation of state-level personal incomes divided by the average personal incomes at time t . In other words; it measures how the income is unequally distributed across states. Figure (1) shows the evolution of the coefficient of variation over time. It is easily seen that income disparities across US states have a clear upward trend after the mid 70s.

(Figure 1 About Here)

As a national business cycle variable (CYC), we use Hodrick-Prescott (HP) de-trended U.S. per capita real personal income net of current transfer receipts between 1969:1 and 2008:4.² CYC variable without sub-script i denotes the national business cycle where i denotes the cycle of state i

In deviation cycle estimation, HP filtering is a widely used technique. Although there exists an extensive literature on estimating the deviation cycles, there is no clear-cut view on the ideal technique. Besides the HP cycle, Christiano Fitzgerald (CF) (2003), Baxter-King (1999) or two stage HP cycles have been discussed in a number of papers. We compare the CF and HP cycles for the aggregate economy and check their ability to match the NBER's turning point announcements.³ We observe that both cycles give similar results. For example, each cycle can detect 11 out of 13 NBER turning points. As a result, we prefer to focus on HP cycles due to their simplicity and acceptance by the literature. Equation (3) explains the HP filtering procedure where y represents income, λ is a parameter which captures the smoothness of the trend. Given an adequately chosen

² Hodrick and Prescott (1997)

³ NBER: National Bureau of Economic Research

λ , there is a trend that will minimise

$$\min \sum_{t=1}^T (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \quad (3)$$

The first term of equation (3) represents the deviations of income from trend. The second term is the product of λ and the sum of the squares of the second differences of the trend component which penalises variations in the growth rate of the trend. There will be a greater penalty as the λ increases in value. We set $\lambda=1600$ as it is recommended by Hodrick and Prescott (1997) for quarterly data. We present the evolution of US personal income and the deviation cycle in Figures 2 and 3:

(Figure 2 and 3 About Here)

Before running our regression, we find it crucial to investigate the stationary properties of the variables. It is a technical issue in time series analysis that stationary and non-stationary variables should not be considered in the same regression model. In such case, it is unlikely that residuals of the regression model have desired properties; white noise process. Therefore, we must clearly understand whether our variables follow a stationary process. In order to do so, we implement ADF (Augmented Dickey Fuller) tests for each variable. We determine the optimal lag length for the ADF regressions by choosing the number of lags which minimises the Akaike information criterion (AIC). The maximum number of lags has been determined by using the rule of thumb provided by Schwert (1989):

$$p \max = [12 \times [\frac{T}{100}]^{1/4}] \quad (4)$$

where T is the number of observations and $p \max$ is the maximum number of lags. Table

(1) summarises the results from the ADF tests. We observe that income disparities (CV) follow a non stationary, I(1), process. In order to be able to use this variable in a time series regression analysis, we de-trend it using an HP filter. De-trending the disparities enables us to observe the increase/decrease in disparities, not in absolute terms, but relative to its trend. De-trended disparities (*CVHP*) follow an I(0) process over the whole period and two sub periods (before and after 1990). In all cases, I(0) process is significant at least at the 10% level. Not surprisingly, the business cycle variable exhibits a mean reversion over the whole period and two sub periods and therefore follows an I(0) process.

(Table 1 About Here)

The results from the ADF tests provide some important implications for our study. For instance, non stationary income disparities imply that inequalities across states tend to increase over time and, therefore, characterising the behaviour of the income disparities both in the long run and in the short run has become more important in recent years. This, therefore, provides an additional motivation to the present study.

We run the regression in equation (1) for the whole period and two sub periods. In all regressions, we observe a serial correlation problem. In order to fix this problem, we allow for first order autoregressive errors and, in this way, get rid of the serial correlation. After allowing for the autoregressive errors, we test the autocorrelation using the Breusch Godfrey Lagrange Multiplier test using up to 8 quarters lag length and find no more evidence of serial correlation.

Equation (1) and autoregressive errors in equation (5) are combined and together yield a transformed model in equation (6). The serial correlation parameter ρ and the β coefficient are simultaneously estimated using the Marquardt Nonlinear Least Squares algorithm.

$$\varepsilon_t = \rho\varepsilon_{t-1} + u_t \quad (5)$$

$$CVHP_t = \alpha(1 - \rho) + \rho CVHP_{t-1} + (CYC_t - \rho CYC_{t-1})\beta + u_t \quad (6)$$

(Table 2 About Here)

The regression results are summarised in Table (2). It provides some important indications about the short-run behaviour of income disparities. In the first column, we present the results from the estimation for the whole period. We observe that β_1 is not statistically significant. However, we think that there might be some changes in the relationship between the business cycle and income disparities over time, especially before and after 1990.

There exist a number of political and socio-economic circumstances within and outside the US, which have rapidly changed after the 1990. 1990s are known to be the initial period of "new economy" which is a term to describe the transition from a industrial/manufacturing to knowledge/technology based economy in U.S. This change in the economic structure created permanent growth, low unemployment and immunity to boom-bust economic cycles during 1990s. Beginning of 1990s is a transition phase also for the economic conditions outside the U.S. For instance, most of the countries have accelerated the trade and financial liberalisation by signing international agreements including NAFTA, GATT and Multilateral Agreement on Investment.

Given these developments in the economic environment, we find it useful to investigate the change in the relationship between income disparities and business cycle in U.S. Therefore we run our regression for two sub-periods; before and after the end of 80s (1989:4).

In the regression for the first sub-period, the β_2 coefficient is negative and significant at the 5% level with a p-value of 0.02, suggesting the existence of an anti-cyclical behaviour for income disparities. In other words, before the 1990, income inequalities among states

tend to diminish relative to the trend during the national periods of expansion as the aggregate economy moves from the trough to peak, and increase during the times of recession, as the economy moves from peak to trough. By contrast, there exists strong evidence for pro-cyclical disparities after 1990 since the β_3 coefficient is positive and significant at 1%. In other words, it appears that income disparities have turned from anti-cyclical to pro-cyclical behaviour in last two decades and tend to comove with the aggregate cycle.

Concerning the size of the estimated coefficients, it should be noted that although estimated β coefficients look small in size, considering that business cycle variable moves in a very large scale between, about -400 and 400, business cycle has sizable impact on the income disparities.

Finally, we carry out a Chow breakpoint test to check whether there exists a significant break in the relationship between the business cycle and income disparities. According to F-statistics and the log-likelihood ratio, we found a significant break at the end of the 1980s (1989:4) in the relationship between the business cycle and income disparities. The break is significant at the 1% level.

Additional to the Marquardt Non-linear Least Squares algorithm, we estimated the model also using Prais-Winston regression. The results are very similar. Therefore, we do not report them here but they are included in Appendix-1, Table 11.

In addition to the previous regression model, we develop an alternative regression specification to check the sensitivity of our results previously found in Table 2. We regress the first differences of the income disparities (ΔCV) on the growth rate of the aggregate economy. Both variables clearly follow a stationary process.

(Table 3 About Here)

Table 3 summarises the results. For the whole period, we do not find any significant relationship between the growth rate of the economy and income disparities. However, in

the regression before 1990, we find a negative relationship between the growth rate of the economy and the change in income disparities. This relationship is significant at the 5% level. Consistent with the previous regression analysis, after 1990, the relationship between the business cycle and income disparities becomes positive and significant at the 1% level. The change in the relationship between the cycle and disparities has been tested by the Chow breakpoint test and the break is significant at 1%.

These results have an important implication for our study. The switch from anti-cyclical disparities to the pro-cyclical disparities after 1990 has been confirmed by an alternative regression specification in which the business cycle is defined using the growth rate of US personal income.

Consequently, we can conclude that income disparities in the U.S. follow an anti-cyclical pattern until the 1990s. The disparities tend to decline during times of national expansion and increase during the recessions. After the 1990, there exists a significant change in the short-run behaviour of the disparities such that the disparities tend to move pro-cyclically; hence, increasing during the expansions and declining during the recessions.

3 Are there meaningful state-level cycles?

After having characterised the short-run behaviour of income disparities, we would like to start an investigation into the short-run dynamics behind the evolution of the disparities. However, before investigating these dynamics, it is useful to understand whether there exist meaningful state-level cycles with different characteristics in timing and amplitudes. It is logical to argue that if there are no sizable differences in timing or amplitudes across state cycles, it is unlikely that the two mechanisms could actually play an important role in the evolution of the disparities.

In order to show the differences in timing and amplitudes, we first focus on detecting the turning points in state-level cycles and, afterwards, evaluate the size of such differences using several measures commonly adopted in the literature.

3.1 Turning points detection

Detecting the turning points for each state is an essential step in our study. There are several methodologies developed in the literature for this purpose. Before going a step further, we need to explain briefly the recent methodological advancements in the literature on turning points detection.

Burns and Mitchel (1946) established the methods which became the main principles of the NBER and its business cycle dating procedure. Since 1980, the NBER has been officially responsible for detecting and declaring the chronology of US turning points. NBER's Business Cycle Dating Committee declares a turning point when its members reach a consensus. The decision is taken using many variables and methodologies. The usage of multiple series is largely due to the fact that there exists no single variable which perfectly represents the aggregate economic activity.

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

The early literature focused on how one can accurately replicate the NBER's dates using single series. Bry and Boschan (1971) first documented the formal algorithm which aims to find 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-organised this algorithm and modified it for quarterly data.

On the other hand, a parametric autoregressive Markov-Switching (MSVAR) model was developed by Hamilton (1989) to find regime shifts in the economic activity. It became a

commonly used tool in the business cycle literature. 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 switches between two regimes; expansion and recession (Hamilton, 1989; Owyang, Piger and Wall, 2005).

In the business cycle literature, despite the fact that much effort has been put on 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, 2004)

In this paper, we use the Bry-Boschan Quarterly algorithm to detect the turning points of the U.S. aggregate cycle and 48 state-level cycles. We use HP de-trended log of per capita real personal income excluding transfers between 1969 and 2008.

The main principles of the Bry-Boschan algorithm require that any selected expansion, or recession shows persistence with a certain duration and amplitude. The algorithm is designed to detect, first, the local minima and maxima in the series and then impose several restrictions to ensure the persistence of the phases.

For instance, equation (7) shows an example of local minimum and maximum given a 5 year window length:

$$\begin{aligned} peak &= \{(y_{t-2}, y_{t-1}) < y_t > (y_{t+2}, y_{t+1})\} \\ trough &= \{(y_{t-2}, y_{t-1}) > y_t < (y_{t+2}, y_{t+1})\} \end{aligned} \quad (7)$$

Let y be a measure of an income, there exists a local maximum at time t if the value of y at time t is the highest among these five observations. By contrast, there is a local minimum at time t if the value of y at time t is the lowest among these 5 observations.

Having detected the local minima and maxima in the series, minimum duration restrictions are imposed that, any cycle, from peak (trough) to peak (trough), should have at least 5 quarters length and any phase, from peak (trough) to trough (peak) should have

at least 2 quarters length. Besides these main principles, the Bry-Boschan program includes several intermediate steps. The detailed program is included in the Appendix-2.

The results from turning points detection are presented in Table 4. At a first glance, it is observed that while until 1990s, state-level turning points are concentrated around the national turning points, after 1990, these turning points are rather dispersed. This implies the tendency of states to asynchronize with the U.S. Cycle. However, one needs to quantify this tendency by referring to commonly adopted measures of synchronization in the literature. In the next sub-section, we intend to implement this.

3.2 Cycle synchronization among states

There is a growing body of literature which studies the tendency of regional or national cycles to synchronize with each other and the economic factors behind such synchronization. These studies, primarily, looked at the comovement of the cycles of regions or countries. For instance, Fatas (1997) studied the comovement among European countries, Artis and Zhang (1999) among OECD countries, Montoya and Haan (2007) among European regions and Carlino and Sill (2001) among US regions. However, only a small proportion of the papers detected the turning points and used this information when assessing the synchronization of cycles (Owyang, Piger and Wall, 2005; Hall and Dermott, 2004). In line with these latter works, we think that the similarities or differences in the timing of the turning points may provide useful information about the synchronization of the cycles. In this section, therefore, we employ several descriptive statistics to explore the variation in timing across the cycles of US states.

Recently, two popular measures of synchronization have been developed. These are “concordance” and “diffusion” indexes. Owyang, Piger and Wall (2005) calculated the concordance index to evaluate the synchronization between U.S. states and the aggregate economy. Hall and Dermott (2004) used the concordance index to analyze the degree of synchronization among regions of New Zealand. Artis, Marcellino and Proietti (2003) used both the concordance index and the diffusion index to evaluate the synchronization within the Euro area. Specifically, the concordance index measures the percentage of time

in which two economies are in the same business cycle phase. In equation (8), I measures the concordance of economy i with economy j . S is a binary variable which takes the value 1 when an economy is in recession and 0 when it is in expansion. I ranges between 1 and 0: 1 indicates a perfect synchronization between economies in which i and j are in the same cycle phase 100% of the time, by contrast, 0 indicates no synchronization between economies.

$$I_t = \frac{1}{T} \sum_{t=1}^T [S_{i,t}S_{j,t} + (1 - S_{i,t})(1 - S_{j,t})] \quad (8)$$

The diffusion index (equation 9) instead measures the percentage of states which are in recession (or expansion) at a given time. The diffusion index of recessions is close to 1 if nearly all of the states are in recession and, by contrast, it is 0 if all states are in expansion.

$$D_t = \frac{1}{n} \sum_{i=1}^n S_{i,t} \quad (9)$$

We summarize the concordance of states with US national economy in Table 5, for the period 1969-1989, and in Table 6, for the period 1990-2008.

Before the 1990, the state that shows the highest level of synchronization with the national economy is Ohio as they are in the same phase of the cycle 96% of the time, followed by South Carolina and Georgia with concordance indexes at 95% and 94% respectively. The least synchronized states are North Dakota, Oklahoma and Kansas; their concordance indexes are 52%, 54% and 61% respectively.

On average, the concordance of states with national economy is 82%. This value is

consistent with Owyang, Piger and Wall (2005) 's findings. In their paper, they found that between 1979 and 2002 average concordance of states with the national economy is around 80%.

(Table 5 and 6 About Here)

After 1990 (Table 6), we observe a lower degree of synchronization, as the average concordance index decreases to 0.74. The most synchronized states remain the same but with lower rates of concordance (Ohio, South Carolina and Georgia with 88%, 87% and 86% respective concordance rates) while the least synchronized states are North Dakota, South Dakota and Montana whose concordance indexes are 50%, 55% and 55% respectively.

This change basically shows the increase in timing differences across states and it is consistent with the findings and theoretical arguments in the literature. Krugman (1991) argues that economic and financial integration of the states should increase the concentration of industries and specialization and therefore lead to asymmetric shocks and time-diverging business cycles.

A decreasing level of synchronization in the U.S. has also been found by Partridge and Rickman (2005) while analyzing regional cycle asymmetries between 1971 and 1998. Their conclusion is that synchronization declines after the late 1980s. Quite interestingly, they argue that while the US is commonly considered as a benchmark for the feasibility of the optimal common currency area (OCCA), the time-diverging pattern of regional cycles in the US does not support this idea. A similar result has been found by Artis, Dreger and Kholodilin (2009). They found no evidence for the convergence of cycles across US states.

(Figure 4 and 5 About Here)

Figure 4 and 5 illustrate the diffusion index of expansions and recessions. At a glance, we observe that the recessions are more homogeneously diffused across states than the expansions. During national expansions, on average, 75 % of the states (38 states) are in

expansion while during national recessions, 80 % of the states (40 states) are in recession. Moreover, the diffusion index shows that after the late 1980s, both expansions and recessions are weakly diffused in comparison to the 1970s and early 1980s. Weaker diffusion of economic phases implies declining synchronization and increasing timing differences across states over time which is a result that is clearly in line with the findings from the concordance index analysis.

3.3 Amplitude differences across state cycles

An important feature of the state cycles that might play a critical role in the evolution of the income disparities among states is represented by the differences in the amplitude of the cycles. For this reason, we find it crucial to demonstrate how much states differ from each other in the amplitudes of their cycles. Following Harding and Pagan (2002), the amplitude of a phase is measured by the cumulative growth rate of a state, excluding trend growth, during that specific phase. Tables 7 and 8 summarize, for each state, the average amplitude of recessions and of expansions.

We observe that before 1990, there is a wide variation of the amplitudes across the states. The state with the most volatile business cycle is North Dakota characterized by an amplitude equal to 0.11 both for expansions and recessions. The mean amplitude across all states is 0.036 for the expansions and 0.035 for the recessions. This means that, on average, a state grows by 3.5-3.6% during an expansion, and declines by similar percentage during a recession, net of the effect of the trend growth.

In order to provide a measure of the differences in amplitude across states, we consider the coefficient of variation of the amplitudes separately for expansions and recessions. The dispersion of amplitudes across states is 0.41 for expansions and -0.42 for recessions for the 1969-1989. These numbers indicate the existence of great differences in amplitudes across states. High dispersion of the amplitudes is consistent with the literature as well. Carlino and Sill (2001) found considerable differences in the amplitudes of U.S. regions in their study.

(Table 7 and 8 About Here)

However, after 1990, the picture changes as the coefficient of variation becomes 0.28 for expansions and -0.32 for recessions. In comparison with the previous period, differences in the amplitude across states appeared to have considerably declined both during expansions and recessions.

Overall, a very interesting feature appears to emerge from the analysis of timing and amplitude characteristics of the state cycles: after 1990, the states became less similar with respect to the timing of their cycles and more similar with respect to the amplitudes. This tendency implies some important facts about the short-run mechanisms of income disparities. Before the 1990s, while the large variations in cycle amplitudes might be an important driver of the disparities in the short-run, this importance tends to decline as the variation in amplitudes declines. Indeed, from 1990 onwards, it seems that an important factor behind the short-run disparities is now represented by the differences in the timing of the cycles. In the next section, we deal with this issue and try to disentangle more formally the importance of amplitude and timing differences across states on the short-run evolution of the disparities.

4 Short-run dynamics of income disparities: Does timing or amplitude matter?

As anticipated, we consider two possible short-run mechanisms which might drive the evolution of income disparities across states. The first mechanism is the differences in amplitudes; the second is the differences in the timing of the cycles across states.

As a first mechanism, amplitude differences across state cycles might play an important role in the evolution of the disparities if the cycle sizes of the states considerably differ from each other. The differences in the amplitudes across US regional cycles have been documented by some authors in the literature (i.e. Carlino and Sill, 2001). There exist a number of economic factors which might play a critical role in this cross sectional variation. For instance, many authors focus on the industry mix of the regions as a source of different cyclical responses. Carlino and Sill (2001) and Owyang, Piger and Wall

(2005) argue that the cyclical response of a region depends on its industrial structure and, in particular, on the share of employment in the manufacturing sector. Other sources, including regional differences in responsiveness to the changes in monetary policy, oil price or different demographical structure have also been suggested by these authors as a cause of different amplitudes

Specifically, the impact of amplitude differences on the evolution of the disparities works in the following way: suppose the cycles of two states are perfectly synchronized with each other, while they differ in terms of amplitude. In such case, any increase or decrease in differences in de-trended income is exclusively due to the differences in amplitudes of the cycles. Since the incomes are de-trended, the differences in trend growth across states cannot play a role. This is desirable since we focus only on the short-run dynamics where the trend concerns the long-run. The differences in the timing and frequency of the cycles will not have any influence on the evolution of the disparities since the regions are perfectly synchronized. Therefore, in such a situation, one can observe the pure effect of amplitude differences on the short-run evolution of the disparities.

On the other hand, differences in the timing of the cycles across states can also be an important short-run factor behind the evolution of the disparities. Similar to what we have seen above, supposing that the cycles of two regions have identical amplitudes, but they differ in terms of timing, then any increase or decrease in disparities between two regions must be attributed exclusively to the differences in timing since the amplitudes are identical and differences in trend growth are removed by using de-trended income series.

Although a number of papers studied the tendency of amplitudes and timing of cycles to converge (or diverge), none of them, to date, has considered these factors as important dynamics behind the short-run evolution of regional income disparities. In order to assess the relative importance of these short-run forces we, first, create a Vector Autoregression (VAR) system and then focus on the share of shocks to disparities explained by the timing differences across state cycles using Cholesky variance decomposition of the disparities. The VAR system is as follows:

$$DIS_t = \delta + \vartheta_1 DIS_{t-1} + \vartheta_2 DIS_{t-2} + \theta_1 NDIS_{t-1} + \theta_2 NDIS_{t-2} + \dots + \vartheta_p DIS_{t-p} + \theta_p NDIS_{t-p} + e_t \quad (10)$$

$$NDIS_t = c + \gamma_1 DIS_{t-1} + \gamma_2 DIS_{t-2} + \phi_1 NDIS_{t-1} + \phi_2 NDIS_{t-2} + \dots + \gamma_p DIS_{t-p} + \phi_p NDIS_{t-p} + \eta_t \quad (11)$$

DIS represents the cross-sectional income disparities. In order to calculate these disparities, we de-trend the personal income series of the 48 states and calculate the cross sectional variance of income over time. By de-trending the income, we remove the effect of the differences in trend growth across states on the evolution of the disparities. Thus, we focus exclusively on the effect of short-run forces; differences in the amplitude and timing of the cycles. The calculation of the disparities is as follows:

$$DIS_t = \frac{\sum_{i=1}^n (CYC_{i,t} - \bar{CYC}_t)^2}{n-1} \quad (12)$$

$CYC_{i,t}$ is the HP de-trended income (cycle) of state i at time t . DIS_t is the disparities across states in de-trended income at time t . In Figure 6, we present the evolution of the disparities. We clearly observe that there is a different pattern in the evolution of the disparities after 1990. While before this date, the disparities fluctuate greatly, after then the evolution of the disparities becomes smoother. As anticipated in the previous sections, this change of behaviour might be due to a wide range of reasons.

(Figure 6 About Here)

NDIS in equations 10 and 11 represents the disparities in de-trended income which are created by exclusively the timing differences across the cycles of the states. In order to isolate the effects of the differences in amplitude and timing of the regional cycles on the evolution of the cross sectional disparities, we first draw on the work by Carlino and Sill

(2001) and on the OECD's procedure for amplitude standardization of the cycles. For two sub-periods, we therefore divide the de-trended income series of the states by their standard deviation and in this way, homogenize the amplitudes of the cycles. As a consequence, most of the differences in amplitudes across states are removed and, therefore, the amplitudes of the states are approximately equalized.

Before standardization, as measured by the cross-sectional coefficient of variation, the amplitude differences were approximately around 0.41 before 1990 and 0.30 after the 1990 (as reported in section 3). Once standardization is carried out, the cross-sectional coefficient of variation becomes 0.10 before the 1990s and 0.17 afterwards. Having standardized the cycles with respect their amplitudes, then we re-calculate the cross-sectional variance at any given time using only the standardized series. It represents the disparities created mostly by the timing differences across states since amplitude and trend growth differences have been removed. Equation (13) and (14) explains the calculation of this variable:

$$NCYC_{i,t} = CYC_{i,t} / \sigma_i \quad (13)$$

$$NDIS_t = \frac{\sum_{i=1}^n (NCYC_{i,t} - N\bar{CYC}_t)^2}{n - 1} \quad (14)$$

$NCYC_{i,t}$ is the amplitude standardized de-trended income of state i and time t , σ_i is the standard deviation of de-trended income series of state i , finally, $NDIS_t$ represents the cross-sectional variance of de-trended and amplitude standardized income. The evolution DIS and $NDIS$ variables are presented in Figures 6,7 and 8.

(Figures 7 and 8 About Here)

We run the VAR system in equations 10 and 11 for two sub-periods. We use lag length of

1 for the first period and 5 for the second period determined using Akaike information criterion.

In order to evaluate the importance of timing differences on the evolution of disparities, we focus on the Cholesky variance decomposition of the disparities. It is a widely used tool which searches the proportion of variation in one variable due to shocks to another variable. In other words, It tells how much of a change in one variable is due to shocks to another variable. Many authors use this tool when evaluating the interactions among macroeconomic variables. For instance, Carlino and Sill (2001) estimates the percentage of variation in income of a region explained by the changes in cycle and trend using variance decompositions. In our case, we look for the percentage of variation in disparities (*DIS*) due to variation in the disparities created exclusively by the timing differences across state cycles (*NDIS*).

We present the variance decomposition results in Tables and Figures 9 and 10. The variance decomposition is implemented for 10 period time horizon which means that we evaluate not only simultaneous impact of timing differences on the disparities, but also the impact of up to 10 quarter lagged shocks to timing differences on the evolution of disparities.⁴ It is evident that before the 1990, only about 40% of the total variability in disparities is due to the timing differences across states while, by contrast, more than 80% of the total variability in disparities is due to timing differences across states after this date. Therefore, we can argue that the differences in timing across states become an increasingly important factor in the evolution of regional disparities in the U.S. after 1990. This is consistent with the main message given in section 3 that the amplitude differences across states tend to disappear and timing differences tend to increase since the 1990s.

(Tables 9 and 10 About Here)

(Figures 9 and 10 About Here)

⁴ In Cholesky variance decomposition, one needs to assume which variable propagates the other. So that in Cholesky ordering we assume that timing differences propagates the interactions among two variables.

5 Conclusions

In this paper, we tried to explicitly model the short-run nature of income disparities across 48 conterminous States between 1969 and 2008. First, we analyzed the stationarity of income disparities. We found that disparities follow a non stationary process with an upward trend which implies that the income inequalities across states became recently a more important problem. Second, we characterised the short-run behaviour of the disparities across states. We found that in the short-run, disparities move counter-cyclically before 1990 but tend to move pro-cyclically afterwards. The change in the relationship between the business cycle and disparities has been confirmed by a Chow structural break test. Third, we demonstrated that there exist sizeable differences in the timing and amplitudes of the cycles of the states. Furthermore, we noted that differences in timing were particularly evident after 1990, parallel to a decline in amplitude differences. Finally, through bi-variate VARs and Cholesky variance decomposition, we confirmed that, as a mechanism, differences in the timing of the cycles across states tend to be the major driving mechanism behind the disparities after 1990 while the impact of amplitude differences tends to fade away.

To sum up, income disparities do not move randomly in the short-run but tend to have a distinct pattern. Inequalities follow a cyclical pattern in the short-run, moving either anti-cyclically or pro-cyclically depending on the period. Furthermore, the differences in timing across states tend to be the main short-run mechanism behind the evolution of the disparities in recent decades.

These findings on short-run regional disparities have important implications for the researchers and regional policy makers. Income disparities which follow distinct cyclical pattern in the short-run implies that the choice of period of regional convergence analysis is crucial for the studies which have a long-run perspective. A similar implication exists for the regional policies that in the short-term a great attention is needed when devoting the resources to promote regional convergence since disparities tend to increase in one cycle phase but decrease in other.

Increasing importance of timing differences across the cycles of the states on the evolution of regional disparities increases the necessity of understanding the economic reasons behind these timing differences. We intend to investigate this topic in the future.

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APPENDIX.1: TABLES AND FIGURES

Table 1
ADF Test Results

Variables	McKinnon ADF Statistics	Optimal lag length	Stationary
CV	-1.09	1	I(1)
CVHP	-4.13***	1	I(0)
CVHP (1969-1989)	-2.72*	1	I(0)
CVHP (1990-2008)	-2.57*	1	I(0)
CYC	-5.00***	4	I(0)
CYC (1969-1989)	-4.16***	3	I(0)
CYC (1990-2008)	-2.73*	2	I(0)

* indicates significance at 10 %. ** at 5 %. *** at 1%

Note: optimal lag length is chosen using Akaike information criterion.

Table 2

Regression results: autocorrelation corrected parameter estimates, Marquardt NLS

Parameters	1969-2008	1969-1989	1990-2008	Chow Breakpoint test
α	-1.36E-05 (0.99)	0.000919 (0.62)	-0.00043 (0.48)	
β_1	9.11E-07 (0.70)	-	-	
β_2	-	-8.00E-06** (0.02)	-	
β_3	-	-	6.75E-06*** (0.00)	
Autoregressive error parameter	0.73*** (0.00)	0.81*** (0.00)	0.63*** (0.00)	
R-square	0.55	0.55	0.66	
White Het. (Obs-R)	7.36** (0.03)	4.42 (0.11)	11.72*** (0.00)	
Breuch-Godfrey LM (Obs- R)	0.12 (0.73)	0.54 (0.46)	1.07 (0.30)	
F-stat				4.60*** (0.00)
Log-likelihood				13.74*** (0.00)

Significance level: * 10 %. ** at 5 %. *** at 1% , p-values are in paranthesis.

Table 3

Alternative regression results: ΔCV regressed on the growth rate of economy

Parameters	1969-2008	1969-1989	1990-2008	Chow Breakpoint test
α	4.81E-05 (0.86)	0.000432 (0.62)	-0.000224 (0.41)	
β_4	-0.004567 (0.95)	-	-	
β_5	-	-0.21** (0.02)	-	
β_6	-	-	0.22*** (0.00)	
R-square	0.000039	0.06	0.14	
White Het. (Obs-R)	14.00*** (0.00)	0.79 (0.67)	1.40 (0.50)	
Breuch-Godfrey LM (Obs-R)	0.08 (0.77)	0.04 (0.85)	0.001 (0.97)	
F-stat				7.64*** (0.00)
Log-likelihood				14.95*** (0.00)

Significance level: * 10 %. ** at 5 %. *** at 1% , p-values are in paranthesis.

Table 5

Concordance of states with US cycle, 1969-1989

States	Concordance	States	Concordance
Alabama	0.93	Nebraska	0.77
Arizona	0.87	Nevada	0.80
Arkansas	0.79	New Hampshire	0.88
California	0.88	New Jersey	0.88
Colorado	0.80	New Mexico	0.81
Connecticut	0.82	New York	0.83
Delaware	0.88	North Carolina	0.92
Florida	0.92	North Dakota	0.52
Georgia	0.94	Ohio	0.96
Idaho	0.87	Oklahoma	0.54
Illinois	0.88	Oregon	0.87
Indiana	0.93	Pennsylvania	0.87
Iowa	0.64	Rhode Island	0.86
Kansas	0.61	South Carolina	0.95
Kentucky	0.89	South Dakota	0.63
Louisiana	0.77	Tennessee	0.89
Maine	0.81	Texas	0.77
Maryland	0.88	Utah	0.80
Massachusetts	0.87	Vermont	0.88
Michigan	0.88	Virginia	0.89
Minnesota	0.71	Washington	0.74
Mississippi	0.86	West Virginia	0.73
Missouri	0.87	Wisconsin	0.92
Montana	0.63	Wyoming	0.69
		Mean	0.82

Table 6
 Concordance of states with US cycle, 1990-2008

States	Concordance	States	Concordance
Alabama	0.75	Nebraska	0.71
Arizona	0.71	Nevada	0.71
Arkansas	0.74	New Hampshire	0.76
California	0.79	New Jersey	0.79
Colorado	0.79	New Mexico	0.64
Connecticut	0.82	New York	0.82
Delaware	0.57	North Carolina	0.91
Florida	0.75	North Dakota	0.50
Georgia	0.86	Ohio	0.88
Idaho	0.75	Oklahoma	0.64
Illinois	0.76	Oregon	0.62
Indiana	0.64	Pennsylvania	0.83
Iowa	0.66	Rhode Island	0.66
Kansas	0.75	South Carolina	0.87
Kentucky	0.83	South Dakota	0.55
Louisiana	0.58	Tennessee	0.83
Maine	0.80	Texas	0.78
Maryland	0.83	Utah	0.70
Massachusetts	0.83	Vermont	0.74
Michigan	0.70	Virginia	0.88
Minnesota	0.67	Washington	0.82
Mississippi	0.79	West Virginia	0.70
Missouri	0.82	Wisconsin	0.70
Montana	0.55	Wyoming	0.76
		Mean	0.74

Table 7
Amplitude of the cycle phases, 1969-1989

States	Expansions	Recessions	States	Expansions	Recessions
Alabama	0.0320	-0.0300	Nebraska	0.0370	-0.0380
Arizona	0.0450	-0.0430	Nevada	0.0350	-0.0340
Arkansas	0.0370	-0.0410	New Hampshire	0.0430	-0.0400
California	0.0310	-0.0260	New Jersey	0.0270	-0.0240
Colorado	0.0210	-0.0220	New Mexico	0.0220	-0.0230
Connecticut	0.0320	-0.0290	New York	0.0260	-0.0210
Delaware	0.0300	-0.0290	North Carolina	0.0370	-0.0350
Florida	0.0370	-0.0310	North Dakota	0.1160	-0.1110
Georgia	0.0330	-0.0320	Ohio	0.0360	-0.0340
Idaho	0.0390	-0.0400	Oklahoma	0.0370	-0.0320
Illinois	0.0290	-0.0290	Oregon	0.0320	-0.0310
Indiana	0.0430	-0.0440	Pennsylvania	0.0280	-0.0250
Iowa	0.0460	-0.0470	Rhode Island	0.0340	-0.0290
Kansas	0.0290	-0.0290	South Carolina	0.0340	-0.0320
Kentucky	0.0390	-0.0420	South Dakota	0.0770	-0.0680
Louisiana	0.0250	-0.0260	Tennessee	0.0350	-0.0370
Maine	0.0370	-0.0310	Texas	0.0270	-0.0250
Maryland	0.0220	-0.0200	Utah	0.0300	-0.0250
Massachusetts	0.0290	-0.0250	Vermont	0.0330	-0.0290
Michigan	0.0520	-0.0510	Virginia	0.0260	-0.0250
Minnesota	0.0380	-0.0330	Washington	0.0260	-0.0220
Mississippi	0.0340	-0.0350	West Virginia	0.0370	-0.0310
Missouri	0.0230	-0.0220	Wisconsin	0.0340	-0.0310
Montana	0.0470	-0.0470	Wyoming	0.049	-0.05
Mean	0.036	0.035			
Std. Dev	0.015	0.015			
Std. Dev/Mean	0.041	-0.042			

Table 8
Amplitude of the cycle phases, 1990-2008

States	Expansions	Recessions	States	Expansions	Recessions
Alabama	0.0150	-0.0100	Nebraska	0.0170	-0.0190
Arizona	0.0210	-0.0210	Nevada	0.0210	-0.0200
Arkansas	0.0160	-0.0120	New Hampshire	0.0200	-0.0180
California	0.0240	-0.0220	New Jersey	0.0230	-0.0220
Colorado	0.0230	-0.0260	New Mexico	0.0200	-0.0230
Connecticut	0.0290	-0.0260	New York	0.0360	-0.0360
Delaware	0.0160	-0.0140	North Carolina	0.0240	-0.0230
Florida	0.0200	-0.0160	North Dakota	0.0370	-0.0370
Georgia	0.0160	-0.0130	Ohio	0.0170	-0.0190
Idaho	0.0260	-0.0270	Oklahoma	0.0200	-0.0200
Illinois	0.0130	-0.0110	Oregon	0.0120	-0.0110
Indiana	0.0160	-0.0150	Pennsylvania	0.0180	-0.0210
Iowa	0.0180	-0.0170	Rhode Island	0.0150	-0.0090
Kansas	0.0160	-0.0150	South Carolina	0.0160	-0.0140
Kentucky	0.0130	-0.0140	South Dakota	0.0290	-0.0280
Louisiana	0.0230	-0.0200	Tennessee	0.0170	-0.0150
Maine	0.0160	-0.0150	Texas	0.0220	-0.0230
Maryland	0.0150	-0.0170	Utah	0.0170	-0.0160
Massachusetts	0.0190	-0.0160	Vermont	0.0190	-0.0190
Michigan	0.0220	-0.0200	Virginia	0.0170	-0.0170
Minnesota	0.0150	-0.0170	Washington	0.0270	-0.0270
Mississippi	0.0200	-0.0180	West Virginia	0.0120	-0.0140
Missouri	0.0140	-0.0130	Wisconsin	0.0150	-0.0140
Montana	0.0150	-0.0150	Wyoming	0.021	-0.019
Mean	0.019	-0.019			
Std. Dev	0.006	0.006			
Std. Dev/ Mean	0.283	-0.320			

Table 9 Cholesky Variance decomposition

Percentage of change in disparities due timing differences, 1969-1989

Period	S.E.	NDIS
1	6.97E-05	41.27
2	7.69E-05	37.99
3	7.87E-05	36.78
4	7.92E-05	36.36
5	7.94E-05	36.22
6	7.94E-05	36.18
7	7.94E-05	36.17
8	7.94E-05	36.16
9	7.94E-05	36.16
10	7.94E-05	36.16

Table 10 Cholesky variance decomposition

Percentage of change in disparities due timing differences, 1990-2008

Period	S.E.	NDIS
1	8.10E-06	81.34
2	1.03E-05	87.02
3	1.12E-05	85.56
4	1.15E-05	81.22
5	1.15E-05	81.47
6	1.16E-05	80.41
7	1.17E-05	80.33
8	1.17E-05	80.40
9	1.17E-05	80.35
10	1.17E-05	80.05

Table 11
 Regression results: Preis- Winston Regression

Parameters	1969-2008	1969-1989	1990-2008
α	-1.36E-05 (0.99)	0.000919*** (0.00)	-0.00029*** (0.00)
β_7	9.11E-07 (0.65)	-	-
β_8	-	-8.00E-06** (0.02)	-
β_9	-	-	6.92E-06*** (0.00)
Autoregressive error parameter	0.73	0.81	0.66

Significance level: * 10%. ** at 5%. *** at 1%, p-values are in paranthesis.

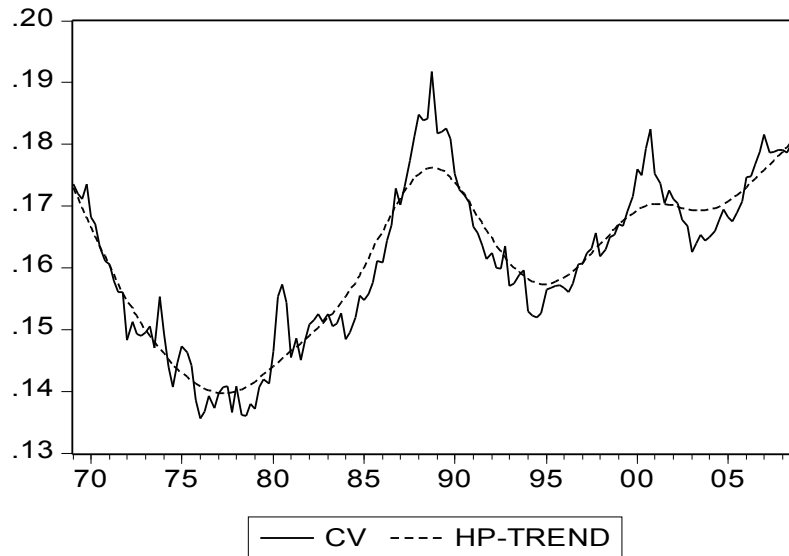


Fig. 1 Evolution of income disparities across states

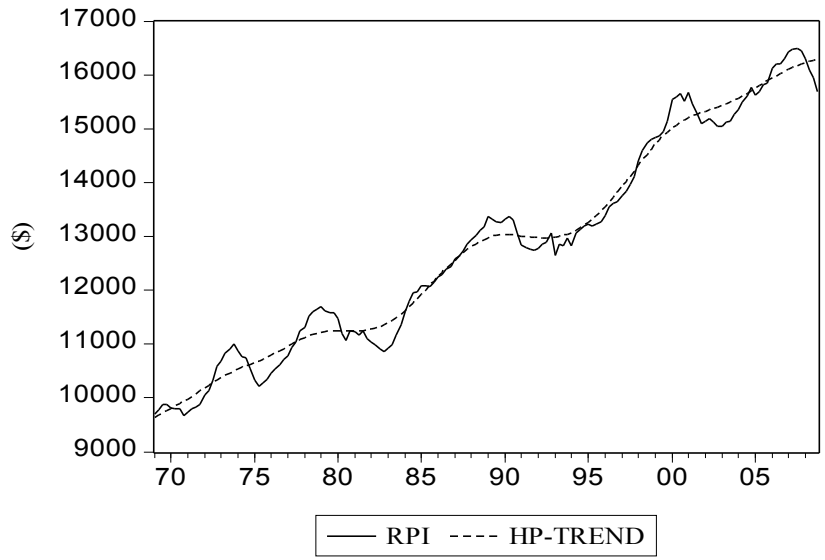


Fig.2 U.S. Personal Income

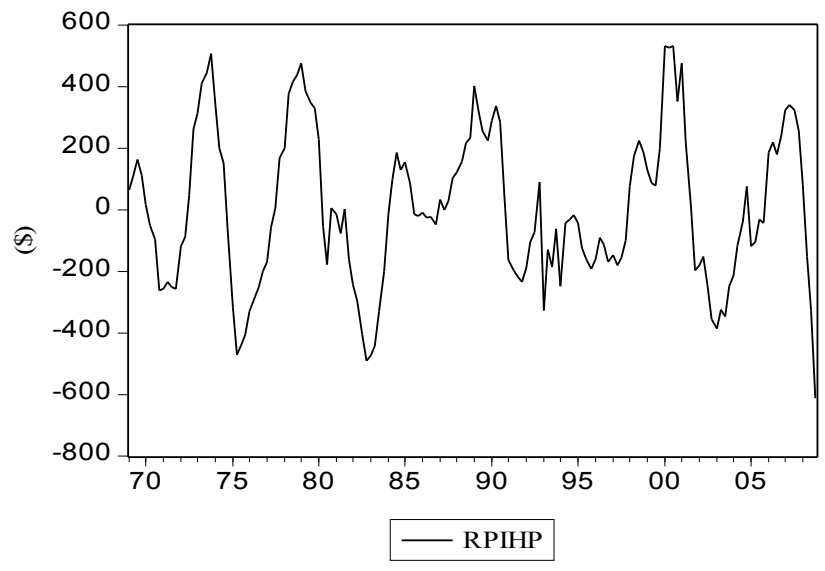
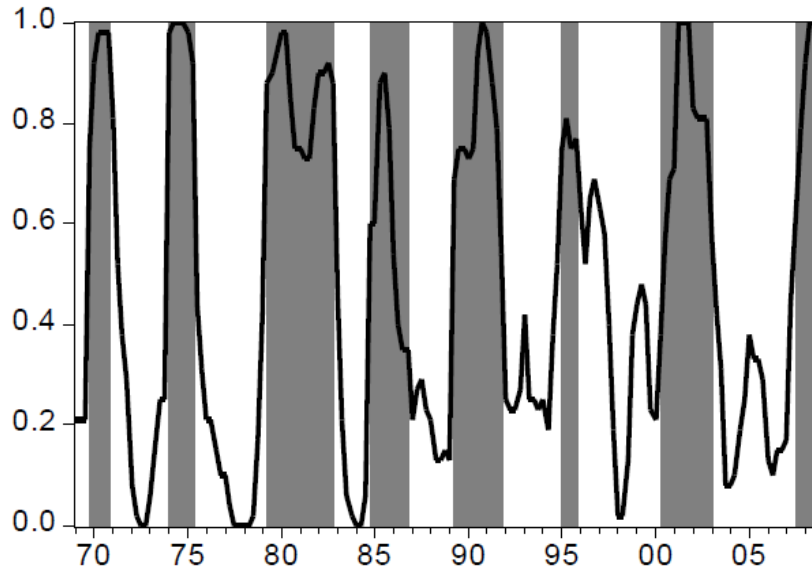
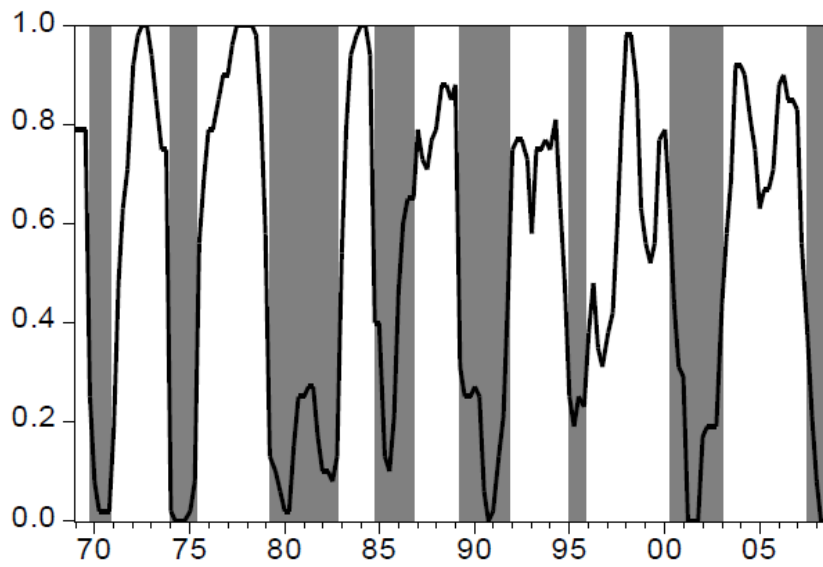


Fig. 3 US deviation cycle



Note: grey shaded areas represent the national recessions

Fig. 4 Diffusion of Recessions



Note: grey shaded areas represent the national recessions

Fig. 5 Diffusion of Expansions

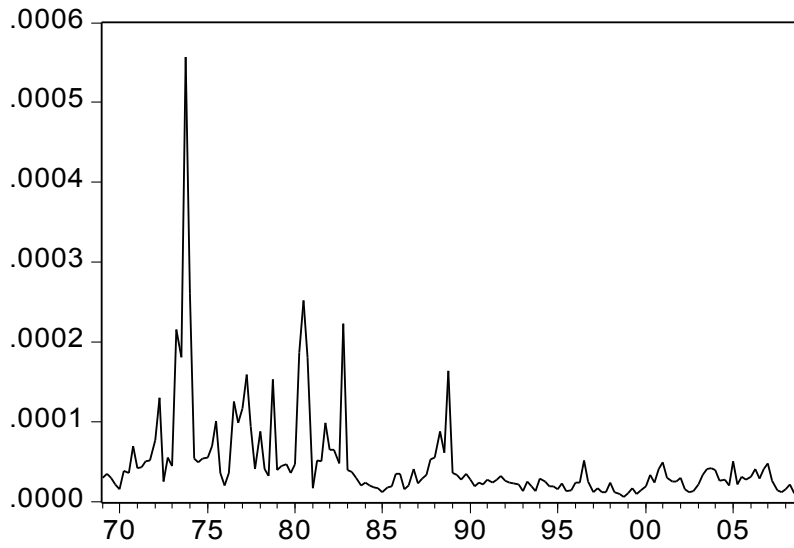


Fig. 6 Evolution of cross sectional disparities in de-trended personal incomes

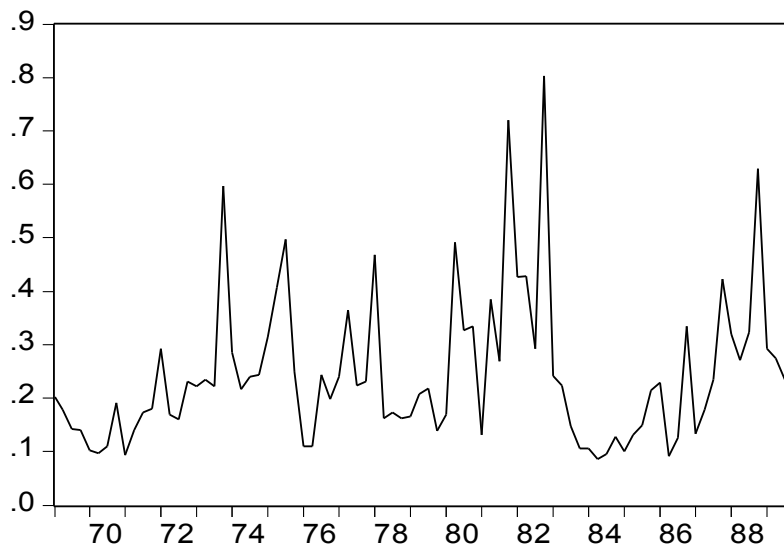


Fig. 7 Evolution of cross sectional disparities in de-trended and amplitudes adjusted incomes, 1969-1989

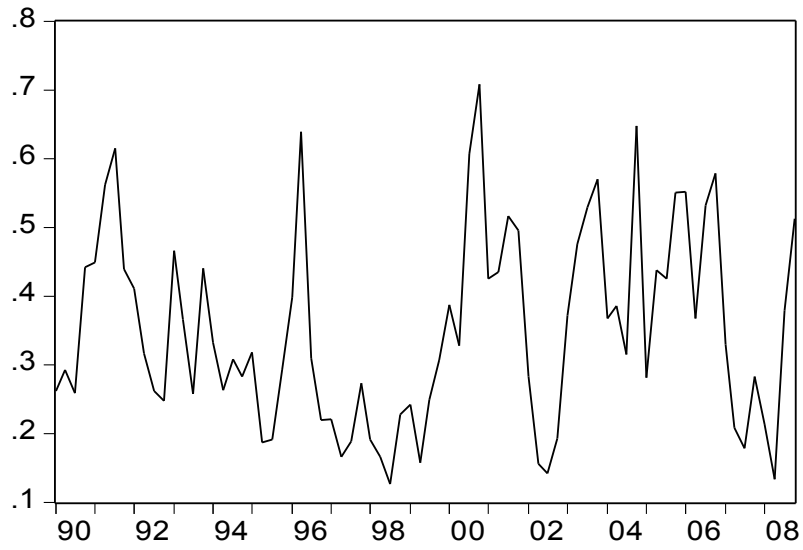


Fig. 8 Evolution of cross-sectional disparities in de-trended and amplitudes adjusted incomes, 1990-2008

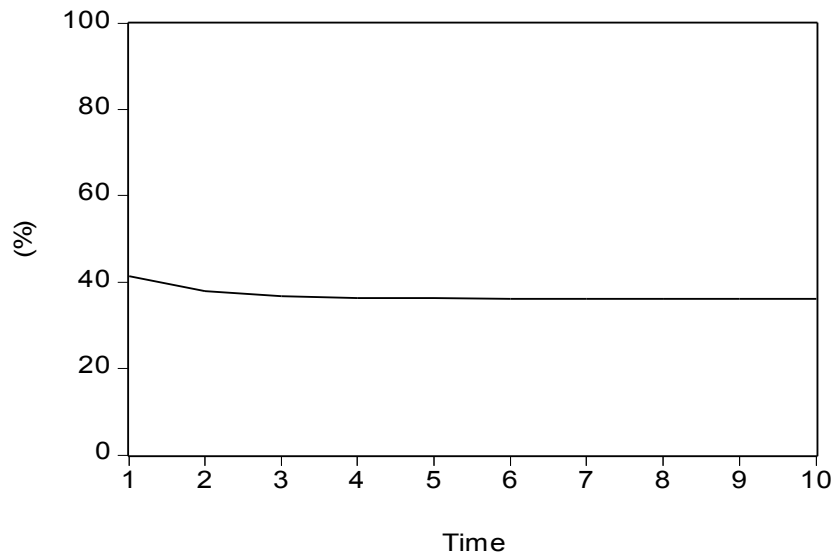


Fig. 9 VAR Cholesky decomposition: percentage of change in disparities due to timing differences, 1969-1989

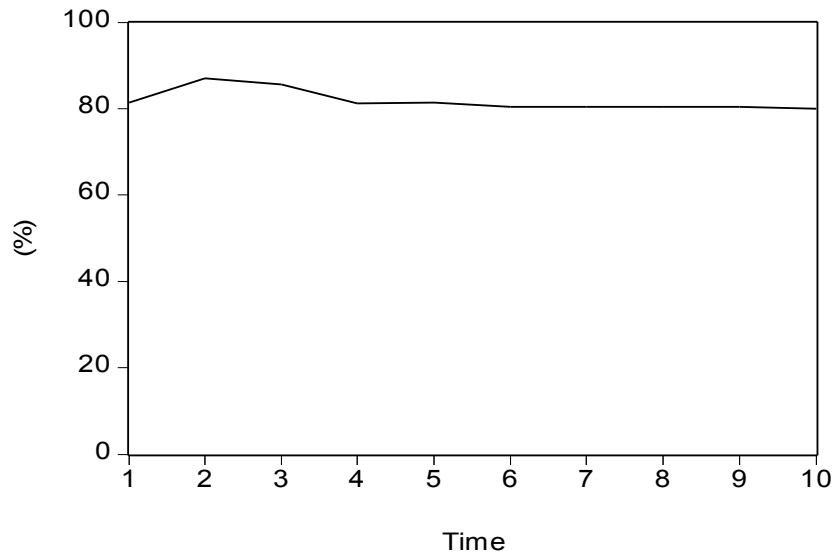


Fig. 10 VAR Cholesky decomposition: percentage of change in disparities due to timing differences, 1990-2008

APPENDIX.2: BRY BOSCHAN QUARTERLY PROGRAM

I. On the HP de-trended series, a Spencer moving average is applied in order to obtain the Spencer Curve.⁵

II. HP de-trended series are corrected for outliers. Outliers are the observations which are at least 3.5 standard deviations away from the mean. Outlying points are replaced by their equivalent value on the Spencer curve. Applying a Spencer moving average on the outlier corrected series creates an outlier-corrected Spencer curve.

III. A 2x4 centred Moving Average (MA) is applied on the outlier-corrected data to obtain the "first cycle" curve. 2X4 centred moving average means that, 4 term centred moving average is applied on the 2 term centred moving average cycle.

IV. A first set of turning points are searched within the first cycle curve and then the same turning points have been searched in Spencer curve. The local minima/maxima have been searched in every 5 quarters. Therefore, the window length is 5 quarters. Only the turning points detected in both first cycle and Spencer curve are maintained, and the others are discarded.

V. A minimum cycle length restriction is imposed. So that any cycle at least have 5 quarters duration.

VI. The Months for Cyclical Dominance (MCD), "the minimum month-delay for which the average of absolute deviations of growth in Spencer cycle is larger than that in the irregular component is computed. Then, a moving average of length MCD is applied on the previously outlier-corrected series." A new set of turning points is searched next to the complementary turning points that were found on the Spencer curve. Again a minimum cycle length restriction is imposed (5 quarters).

VII. These last set of turning points are cleaned by discarding the turning points found in the first and last six observations. A minimum phase length restriction (2 quarters) is

⁵ The details of the algorithm are obtained from manual of BUSY 4.1 program.

imposed. Thus, final set of turning points is obtained.

APPENDIX-3: VARIABLES AND DATA SOURCES

Variable	Definition
<i>RPI</i>	Per capita real personal income net of current transfers receipts. All income series are deflated using the 1982-1984 US city average national consumer price index.
<i>CYC</i>	Hodrick Prescott detrended per capita real personal income net of transfers series. It denotes national cycle unless sub-script <i>i</i> exists.
<i>CV</i>	Coefficient of variation as a measure of cross sectional dispersion of income across states calculated using per capita real personal income net of transfers.
<i>CVHP</i>	Hodrick Prescott detrended coefficient of variation.
<i>NCYC</i>	Hodrick Prescott detrended and amplitude adjusted per capita real personal income net of transfers series.
<i>DIS</i>	Cross sectional variance of income using de-trended personal income series of states.
<i>NDIS</i>	Cross sectional variance of income using de-trended and amplitude standardized personal income series of states.

Data Sources: Personal income and current transfer receipts series are obtained from U.S. Bureau of Economic Analysis (BEA). U.S. city average consumer price index is obtained from U.S. Bureau of Labor Statistics (BLS).

Software: The economic analysis in this paper has been implemented using EVIEWS 4.0, R 2.12 and BUSY 4.1 programs..