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Hysteresis vs. Natural Rate of US Unemployment

Ka Ming Cheng, Nazif Durmaz, Hyeongwoo Kim*, and Michael L. Stern

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Abstract: This paper investigates the stochastic nature of the unemployment rate allowing for cross-section dependence from a panel of US state-level data. We employ the PANIC method to test the null of nonstationarity for the common and idiosyncratic components separately. We find significant evidence of a nonstationary common component when the data from the most recent recession are included. Even when stationarity is empirically supported, the bias-corrected half-life of the common component appears very long.

Keywords: Unemployment Rate, Natural Rate Hypothesis, Hysteresis, PANIC, Cross-Section Dependence

JEL Classification: C23, J64

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I. Introduction

The severity of the most recent economic downturn in the US has caused many commentators to draw comparisons to the Great Depression. Some have even referred to this business cycle fluctuation as the 'Great Recession'. One feature of the Great Recession was sharp and widespread increase in unemployment across the US. Every US state experienced significant increases in unemployment and the average state saw their unemployment rate nearly double between 2007 and 2009. Furthermore, despite the National Bureau of Economic Research (NBER) declares an end to the recession in June 2009, unemployment rates have shown persistence near their peak levels deep into 2010 with numerous forecasts of continued persistence into 2011. If, as some have suggested, the recent turmoil in the labor markets represent a rare event that we have not witnessed since the Great Depression, then the most recent data may have important implications for the way we view unemployment rates.

In their early work, Phelps (1967) and Friedman (1968) claimed that unemployment should converge to a natural rate in the long-run, often referred to as the natural rate hypothesis. If this hypothesis correctly describes the time series properties of unemployment rates, deviations from the natural rate are short-lived and will die out eventually. Blanchard and Summers (1987), however, argue that the movement of unemployment has a characteristic of hysteresis, implying that economic shocks have permanent effects on unemployment rates.

These two competing hypotheses are empirically testable by employing conventional unit root tests on unemployment rates. Finding evidence of a unit root supports the hysteresis hypothesis, while rejecting a unit root serves as evidence for the natural rate hypothesis. Blanchard and Summers (1987), Brunello (1990), Mitchell (1993), Roed (1996), and León-Ledesma (2002) employ conventional univariate unit root tests to examine the unemployment rates in European Union (EU) countries and conclude that unemployment exhibits hysteresis. Empirical results on US unemployment rates are mixed. Mitchell (1993), Breitung (1994), and Hatanaka (1996) find US unemployment is nonstationary, while Nelson and Plosser (1982), Perron (1988), and Xiao and Phillips (1997) report evidence in favor of stationarity.

It is well-known that conventional unit root tests, such as the augmented Dickey-Fuller (ADF) test, exhibit very low power when the span of the data is not long enough. Later studies by Im, Pesaran, and Shin (2003), Harris and Tzavalis (1999), Maddala and Wu (1999), Levin, Lin, and Chu (2002), and Christopoulos and Tsionas (2004) applied panel unit root methods to help increase the power of the tests. Song and Wu (1997) use a panel unit test by Levin and Lin (1992) and reject unit root of unemployment rates in 48 US states while fail to reject it for most of the individual states. León-Ledesma (2002) confirm their findings by using the IPS panel unit root test by Im, Pesaran, and Shin (2003) for unemployment rates of 50 US states and the District of Columbia.

The aforementioned findings, however, may not serve as strong evidence for the natural rate hypothesis because they frequently make a restrictive assumption of cross-section independence. Phillips and Sul (2003) point out that panel unit root tests that do not allow for cross-section dependence are over-sized when the true data generating process contains substantial cross-section dependence. The recent, and virtually simultaneous, surge in state unemployment rates is highly suggestive of potentially strong cross-section dependence.

This paper empirically investigates the nature of the US unemployment rates incorporating the most recent data and allowing for cross-section dependence among the US states. Based on the test proposed by Pesaran (2007), we find strong evidence of cross-section dependence and motivation for the use of second generation panel unit root tests. We utilize the

PANIC method of Bai and Ng (2004) to extract the common component from the panel of US states and test the null of nonstationarity. The statistical conclusions regarding the common component of state unemployment rates appears to be heavily dependent on the inclusion of the most recent data. The null of nonstationarity (hysteresis) is easily rejected using data up through the end of last expansion; however, nonstationarity is easily accepted if the data from the Great Recession is included. Recent events may indeed be crucial to our understanding of unemployment.

The remainder of this paper is organized as follows. The next section discusses the econometric methodology and the unit root tests. The empirical results are presented in the third section, and the fourth section concludes.

II. The Econometric Model

1. Stochastic Representations of the Unemployment Rate

Let $u_{i,t}$ be the unemployment rate of state $i \in [1, N]$ at time $t \in [1, T]$. Under the hysteresis hypothesis, $u_{i,t}$ can be represented by the following unit root process.

$$\Delta u_{i,t} = \varepsilon_{i,t} \tag{1}$$

$$\varepsilon_{i,t} = \sum_{j=1}^{k} \alpha_{i,j} \, \varepsilon_{i,t-j} + e_{i,t}, \tag{2}$$

where Δ is the difference operator, $\left|\sum_{j=1}^{k} \alpha_{i,j}\right| < 1$, and $e_{i,t}$ is a zero-mean white noise process. Equations (1) and (2) can be jointly represented by,

$$\Delta u_{i,t} = \sum_{j=1}^{k} \alpha_{i,j} \, \Delta u_{i,t-j} + e_{i,t} \tag{3}$$

Note that (3) implies that the *level* of unemployment rate changes in the long-run by $\left(1 - \sum_{j=1}^{k} \alpha_{i,j}\right)^{-1} e_{i,t}$ when there is a shock $e_{i,t}$ at time t. Simply put, the shock has a permanent effect, which is consistent with the hysteresis hypothesis of the unemployment rate.

On the contrary, the natural rate hypothesis implies that deviations of $u_{i,t}$ from u_i^*, the natural rate of unemployment of state i, are short-lived and eventually die out. That is, under this hypothesis, the *level* unemployment ($u_{i,t}$) should be mean-reverting, which implies the following stationary stochastic process for $u_{i,t}$.

$$u_{i,t} = u_i^* + \varphi_{i,t} \tag{4}$$

$$\varphi_{i,t} = \sum_{j=1}^{k+1} \beta_{i,j} \varphi_{i,t-j} + e_{i,t}, \tag{5}$$

where $\left|\sum_{j=1}^{k+1} \beta_{i,j}\right| < 1$ and $e_{i,t}$ is a zero-mean white noise process as defined earlier. (4) and (5) jointly imply the following stationary autoregressive process.

$$u_{i,t} = c_i + \sum_{j=1}^{k+1} \beta_{i,j} u_{i,t-j} + e_{i,t}, \tag{6}$$

where $c_i = u_i^* \left(1 - \sum_{j=1}^{k+1} \beta_{i,j}\right)$. Or equivalently,

$$\Delta u_{i,t} = c_i - \lambda_i u_{i,t-1} + \sum_{j=1}^{k} \alpha_{i,j} \Delta u_{i,t-j} + e_{i,t}, \tag{7}$$

where $\lambda_i = 1 - \sum_{j=1}^{k+1} \beta_{i,j}$, $\beta_{i,1} = 1 - \lambda_i + \alpha_{i,1}$, $\beta_{i,j} = \alpha_{i,j} - \alpha_{i,j-1}$, for $j = 2, \cdots, k$, and $\beta_{i,j} = -\alpha_{i,k}$. Note that (7) is the conventional ADF regression equation.

Note that, abstracting from the intercept, (7) reduces to (3) when $\lambda_i = 0$. That is, one may statistically test the stochastic nature of unemployment rates by testing the null hypothesis, H_0: $\rho_i = 0$, by (panel) unit root tests.

2. Cross-Section Dependence

It is well-known that single-equation unit root tests often suffer from a low power problem in small samples. One may overcome this problem by employing panel unit root tests when $e_{i,t}$ is independent across i. Phillips and Sul (2003) showed, however, that conventional panel unit root tests such as the IPS test (Im, Pesaran, and Shin, 2003) and the LLC test (Levin, Lin, and Chu, 2002), which requires cross-section independence, tend to have a severe size distortion (rejects too often) problem when this assumption fails to hold. That is, in the presence of cross-section dependence, these tests tend to reject the null hypothesis of nonstationarity too often.

One may test cross-section dependence by the following statistic proposed by Pesaran (2007).

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{i,j}\right), \quad (8)$$

Where $\hat{\rho}_{i,j}$ is the pair-wise correlation coefficient from the residuals $(\hat{e}_{s,t}, s = i, j)$ of the ADF regressions (7).The *CD* statistic is asymptotically normally distributed and has good small sample properties. In what follows, we show that Pesaran’s test strongly rejects the null of cross-section independence in our data, which led us to use one of the so-called second generation panel unit root tests. Among others, we employ Bai and Ng’s (2004) PANIC method, which allows us to test the null of nonstationarity of the common and idiosyncratic components separately.

3. *PANIC Approach*

Consider the following stochastic process for the unemployment rate.

$$u_{i,t} = c_i + \gamma_i' f_t + \eta_{i,t}, \tag{9}$$

where $f_t' = [f_{1,t} \quad \cdots \quad f_{k,t}]$ is an $k \times 1$ vector of *latent* common factors at time t, $\gamma_i' = [\gamma_{i,1} \quad \cdots \quad \gamma_{i,k}]$ denotes an $k \times 1$ vector of corresponding factor loadings of i, and $\eta_{i,t}$ is the *idiosyncratic* component of i. Note that $e_{i,t}$ in previous specifications are decomposed to the common and idiosyncratic components, which are assumed to be mutually independent each other.

Estimations are carried out by the method of principal components. When $\eta_{i,t}$is stationary, $f_t$and $\gamma_i$can be consistently estimated irrespective of the order of f_t. If$\eta_{i,t}$isintegrated, however, the estimator is inconsistent because a regression of $u_{i,t}$ on f_t is spurious. PANIC avoids this problem by applying the method of principal components to the first-differenced data. That is,

$$\Delta u_{i,t} = \gamma_i' \Delta f_t + \Delta \eta_{i,t}, \tag{10}$$

for $t = 2, \cdots, T$. With a proper normalization, the method of principal components for $\Delta u_{i,t} \Delta u_{i,t}'$ yields the estimates, $\Delta \widehat{f_t}$ and $\hat{\gamma}_i$, thus $\Delta \hat{\eta}_{i,t} = \Delta u_{i,t} - \hat{\gamma}_i' \Delta \hat{f}_t$. Re-integrating these, we obtain the following.

$$\hat{f}_t = \sum_{s=2}^{t} \Delta \hat{f}_s \ , \ \hat{\eta}_{i,t} = \sum_{s=2}^{t} \Delta \hat{\eta}_{i,s} \tag{11}$$

Bai and Ng (2004) show that when $k = 1$, the ADF test with an intercept can be used to test the null of a unit root for the single common component $\hat{f}_t$.[1] For each idiosyncratic component $\hat{\eta}_{i,t}$, the ADF test with no deterministic terms can first be applied. Then, a panel unit root test statistic for these idiosyncratic terms can be constructed as follows.

$$P_{\hat{\eta}} = \frac{-2\sum_{i=1}^{N} ln p_{\hat{\eta}_i} - 2N}{2\sqrt{N}} \xrightarrow[d]{} \mathcal{N}(0,1), \qquad (12)$$

where $p_{\hat{\eta}_i}$ denotes the p-value from the ADF test for $\hat{\eta}_{i,t}$.

III. Empirical Results

We use state-level unemployment rates of 51 states, including the District of Columbia, of the US from 1976 Q1 to 2010Q2. We obtain the monthly data from the FRED and convert to quarterly data by taking the beginning of the period values.

We implement the IPS test (Im, Pesaran and Shin, 2003), one of the first-generation panel unit root tests, for comparison with some previous studies. The test rejects the null hypothesis of nonstationarity at the 5% significance level.[2] As we point out in previous sections, this evidence may not be reliable, because the first generation panel unit root tests are over-sized in the presence of cross-section dependence. With this concern, we test the null of cross-section independence by Pesaran's (2007) *CD* statistic (Table 1). The test strongly rejects the null hypothesis at any conventional significance level. This casts doubt on the statistical evidence in favor of stationarity by the IPS test. We, therefore, implement the PANIC method that does not

[1] When there are more than 2 nonstationary factors, cointegration-type tests can be used.
[2] The test statistic was -2.478.

require cross-section independence nor the stationarity of common components as other second generation panel unit root tests.

We implement PANIC test for the full sample as well as the sub-sample that ends right before the recent recession. Information criteria proposed by Bai and Ng (2002) suggest one common component.[3] Results are reported in Table 2.

(Insert Tables 1 and 2)

Panel unit root tests for the idiosyncratic components are consistent with stationarity for both the full and sub-sample at any significance level.[4] We note stronger evidence in favor of stationarity from the sub-sample than from the full sample data that includes the Great Recession. Since the ADF-type test tends to have higher power as the number of observation increase, this implies that the stochastic nature of the US unemployment rates (at least the common component) has been substantially affected by the recent episode.

To see this, we obtain the changes of the state unemployment rate for the Great Recession, 2007Q4 through 2010Q2. The minimum and maximum changes are 0.9% (North Dakota) and 8.4% (Nevada), respectively. The mean and the median are both about 4.4%, which is a substantial increase in a little over one year. As can be seen in the estimated density function (Figure 1), the Great Recession seems to be a truly national shock.

(Insert Figure 1)

[3] When multiple nonstationary common factors are chosen, one needs to implement a cointegration test.

[4] This does not imply that *all* idiosyncratic components are stationary. The rejection implies that there are a finite number of stationary components.

To further investigate this possibility, we employ an array of PANIC tests using 20-year moving window and the recursive approach. We first report ADF-based p-values of the unit root test for the common and idiosyncratic components in Figure 2. We note that the ADF test for the common factor often rejects the null of nonstationarity (hysteresis) even when we utilize only 20-year long data. Similar analysis with more powerful Recursive Mean Adjustment (RMA, So and Shin, 1999, Shin and So, 2001) based unit root tests (Figure 3) provides qualitatively same results. The bottom line is that the evidence of stationarity for the US state level unemployment rates is vulnerable to addition of new data that exhibits high persistence.

(Insert Figures 2 and 3)

We also plot persistence parameter estimates from the 20-year moving window and the recursive approach along with the 95% confidence bands in Figure 4. All estimates are corrected for the bias using RMA method. We note that the persistence parameter estimate is close to unity even when the confidence band falls below one. We then plot the corresponding half-life estimate for the point estimate in Figure 5, because when the confidence interval includes one, the half-life becomes infinity. We note that the half-life is about 6 years (from recursive approach) even when we have evidence for stationarity. By adding recent data, the half-life point estimate increases to about 14 years.

In a nutshell, we find evidence for stationarity when the recent Great Recession data is not included. Adding these data, we obtain much stronger evidence for the hysteresis for the US unemployment rates. Bias-corrected half-life point estimates are overall very long even when data exhibits evidence for the natural rate hypothesis.

(Insert Figures 4 and 5)

IV. Concluding Remarks

One of the notable features of the most recent economic downturn in the US is widespread increases in the unemployment rate across the US. Despite the NBER's announcement of an official end to the recession in June 2009, unemployment rates have shown persistence near their peak levels in 2010 with numerous forecasts of continued persistence into 2011, which may be consistent with the hysteresis hypothesis of unemployment rates.

We empirically investigate the nature of the US unemployment rates employing the PANIC method that allows for cross-section dependence among the US states. We find strong evidence of the hysteresis for the common components from the panel of 51 US state-level unemployment rates especially when new data from the recent recession is included. We also find that the persistence of the common component tends to be very high even when we have strong evidence for stationarity.

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Table 1. Cross-Section Independence Test Results

Average ($\rho_{i,j}$)	*CD*	*p*-value
0.381	155.89	0.000

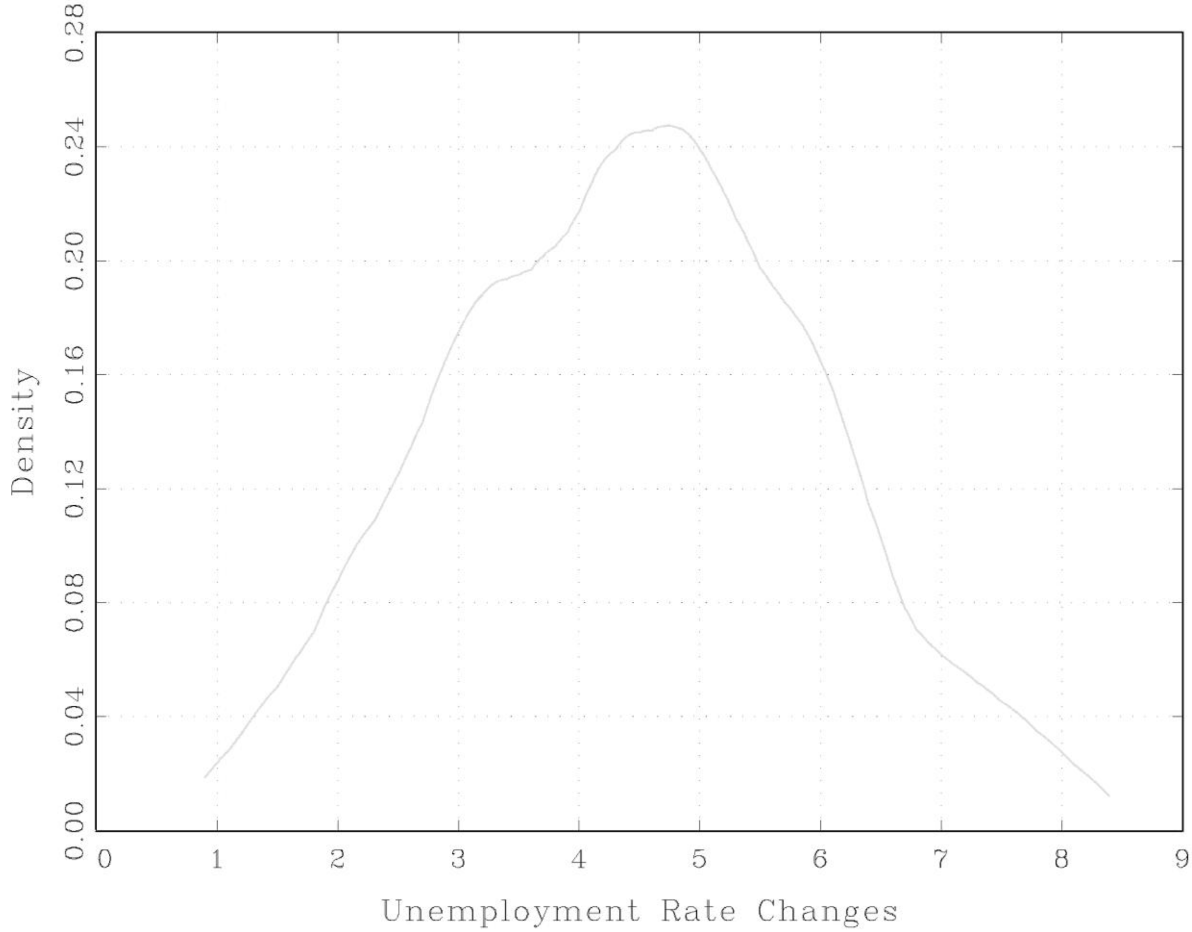
Note: *CD* denotes Pesaran's (2007) test statistic with the null hypothesis of cross-section independence given in (8).

Table 2. PANIC Test Result

	Full Sample (1976Q1-2010Q2)	
	Test Statistics	*p*-value
Idiosyncratic Components	8.058	0.000
Common Component	-1.906	0.318
	Sub-Sample (1976Q1-2007Q4)	
	Test Statistics	*p*-value
Idiosyncratic Components	8.272	0.000
Common Component	-2.829	0.051

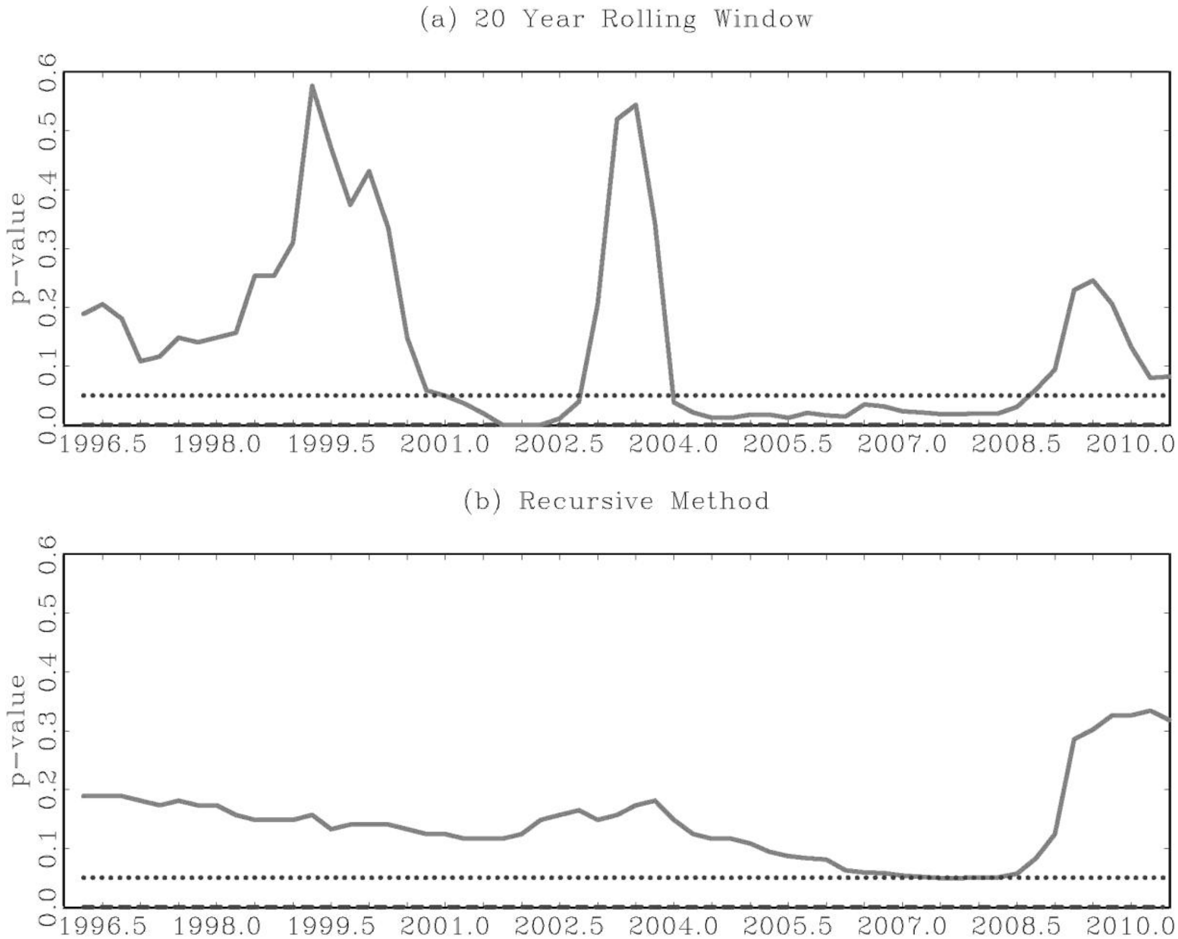
Note: The test statistic for the idiosyncratic components denotes the panel test statistic (12). The test statistic for the common component is the ADF statistic with an intercept. 2007Q4 corresponds to the beginning of the recent NBER recession date.

Figure 1. Changes in the US State Unemployment Rates



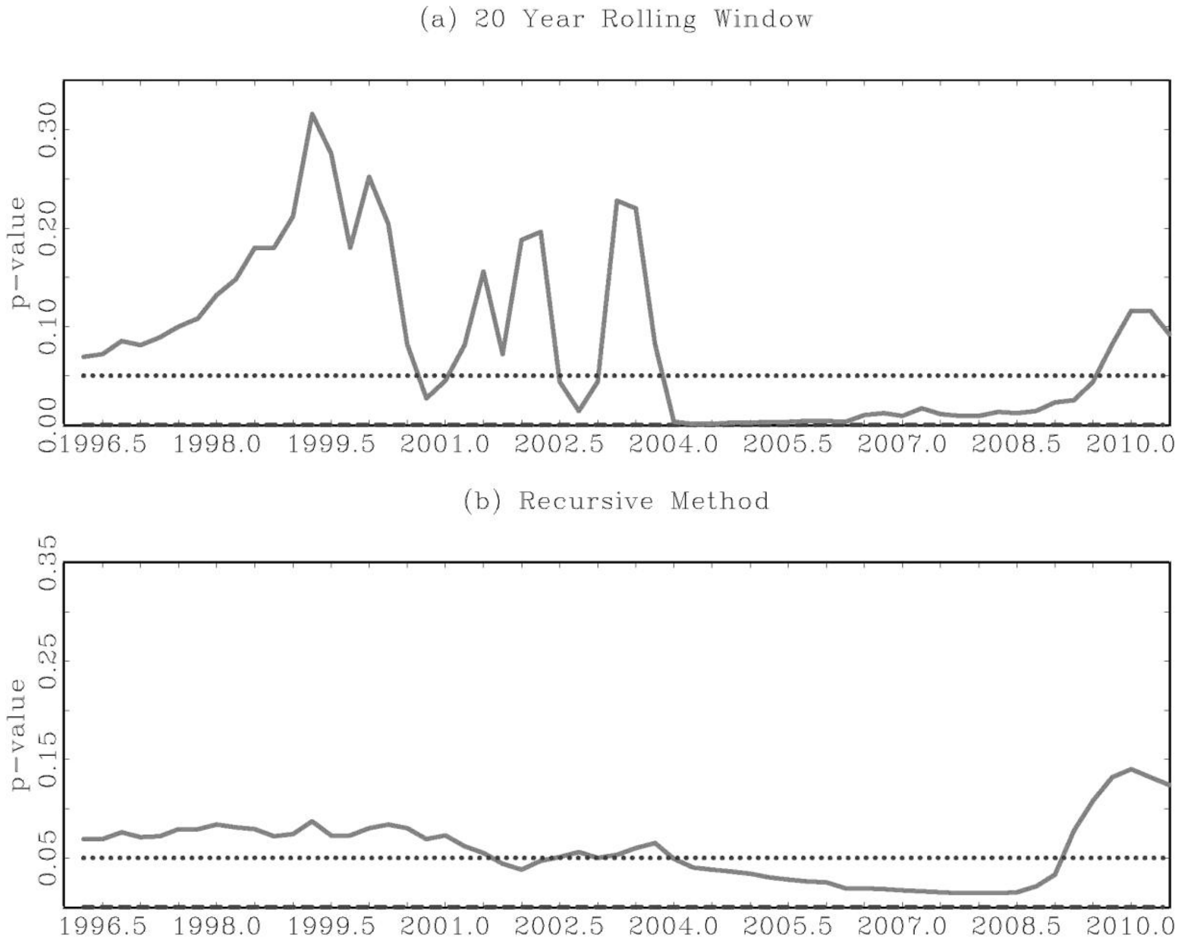
Note: We use the Epanechnikov kernel to estimate the density for the unemployment rate changes between 2008Q4 and 2010Q2.

Figure 2. PANIC Test Results



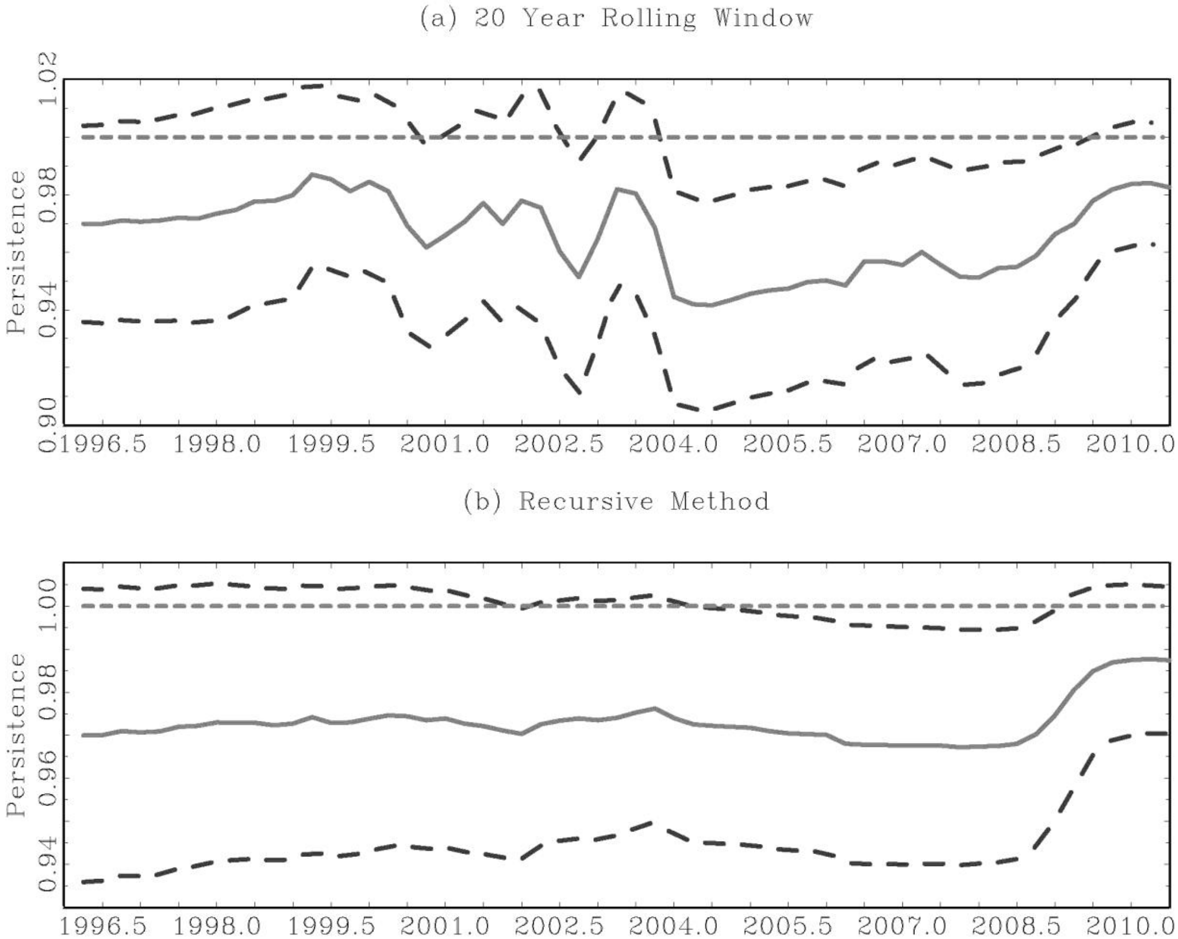
Note: The solid line is the p-value from the ADF statistics for the common component. The dashed line is the p-value of the panel test statistics for the idiosyncratic components. The dotted line is 5% as a benchmark significance level.

Figure 3. PANIC Test Results: RMA Method



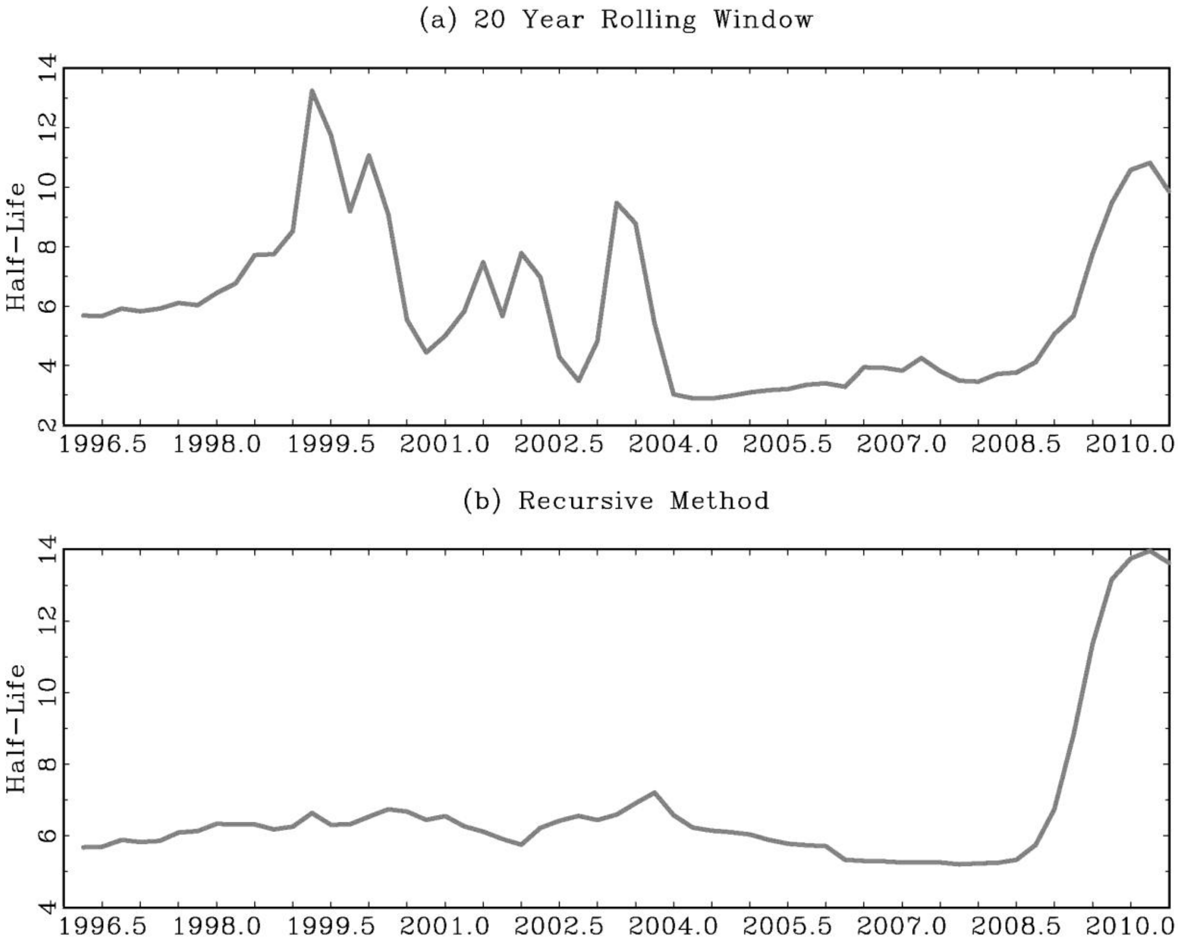
Note: The solid line is the p-value from the RMA-based ADF statistics for the common component. The dashed line is the p-value of the panel test statistics for the idiosyncratic components. The dotted line is 5% as a benchmark significance level. We obtained the asymptotic distribution of the test statistics under the null hypothesis by 100,000 Monte Carlo simulations with 1,000 observations.

Figure 4. Persistence Parameter Estimates



Note: We correct for the bias in the least squares estimate for the persistence parameter by recursive mean adjustment method proposed by So and Shin (1999). The 95% confidence band (dashed line) is the asymptotic band from the normal approximation. So and Shin (1999) and Kim and Moh (2010) demonstrate that, unlike the least squares method, the asymptotic confidence band works well with recursive mean adjustment.

Figure 5. Half-Life Estimates



Note: We correct for the bias in the least squares estimate for the persistence parameter by recursive mean adjustment method proposed by So and Shin (1999). The half-life is calculated by $\ln(0.5)/\ln(\alpha)$, where α is the persistence parameter estimate. The half-life is expressed in years by adjusting for data frequency. The 95% confidence band for the half-life is omitted because the upper limit often extends to a positive infinity.