Asymmetric behavior of unemployment rates: Evidence from the quantile covariate unit root test

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Mixed results for unemployment dynamics are reported in many studies using linear or non-linear unit root tests. A possible explanation is that the literature focuses on the average behavior of unemployment and assumes that the speed of adjustment towards its long-run equilibrium is constant, regardless of the magnitudes and signs of shocks. This paper seeks to re-examine the dynamics of the unemployment rates in terms of shocks for 12 OECD countries. A newly developed quantile unit root test by Galvao (2009) is applied to show potential asymmetric responses of unemployment to shocks over various quantiles, depending on the size and sign of the shocks that hit the unemployment rate. Our results suggest that generally, the unemployment rates are not only stationary but also exhibit obvious asymmetric behavior, in the sense that in the lower quantiles, negative shocks with large absolute value tend to induce faster speed of adjustment towards the long-run equilibrium, while in the upper quantiles, large positive shocks do not, and hysteresis exists. These findings can explain why unemployment rates display the behavior of fast rises and slow falls.

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1. Introduction

The behavior of unemployment crucially depends on the business cycle. According to Okun’s law, economic shocks first impact output asymmetrically, and then have a great influence on unemployment. Hence, understanding the influence of various sizes and signs of shocks on unemployment, and uncovering potential possible asymmetric adjustment of unemployment towards its long-run equilibrium have implications for both macroeconomic modelling and policy makers. If unemployment rates need longer time to recover from a contractionary shock, welfare costs are more likely to become larger due to a high level of unemployment. Also, if employment reacts only sluggishly to an expansionary shock, the effect of an unexpected money supply shock can be dampened since the resulting increase of price level is internalized in private expectations and nominal wage setting (see Kohns, 2001).

In the literature, two macroeconomic hypotheses underline different types of unemployment dynamics. One is the natural rate hypothesis of unemployment proposed by Phelps (1967) that shocks only have temporary effects on unemployment, and thus unemployment follows a stationary process. The other one is the hysteresis hypothesis that cyclical fluctuations can have permanent effects on the level of unemployment, implying that unemployment is a unit-root process. To assess the two competing hypotheses, we need a more general empirical framework to examine how the shocks impact the speed of adjustment in unemployment towards its long-run equilibrium.

The extant literature has examined the dynamics of unemployment with linear or non-linear unit root tests. These tests usually focus on the average behavior of unemployment without considering the influence of various sizes of shocks on unemployment. In other words, the speed of adjustment in unemployment towards its equilibrium is usually assumed to be constant, no matter how big or what sign the shock is. As a result, the commonly used unit root tests...
possibly lead to a widespread failure in the rejection of unit-root null hypothesis for international unemployment rates.

While investigating the dynamics of unemployment for the selected OECD countries, this paper intends to deal with the above deficiency by employing a newly developed quantile unit root test in Galvao (2009). The test basically is an extension to those in Koenker and Xiao (2004) by adding stationary covariates to enhance estimation accuracy. This is important for the estimation of conditional quantile functions since the quantile model generally involves many parameters to be estimated. Technically speaking, inclusion of covariates can lead to larger power gains while testing for a unit root (e.g., Hansen, 1995; Elliott and Jansson, 2003; Jansson, 2004).

The quantile approach has several advantages over the conventional counterparts. First, it can accommodate various adjustment speeds for unemployment in response to different sizes and signs of shocks, giving us a detailed picture on the role of shocks in the dynamics of unemployment. As a result, possible asymmetries in unemployment can be detected in this framework. As noted by Boldin (1999), taking into account possible asymmetric dynamics for unemployment can improve the performance of monetary policy.

Second, as argued in Koenker (2005), quantile regression is robust to outliers possibly resulting from nonlinear dynamics, which causes the violation of moment conditions in asymptotic theory for conventional unit-root tests.4 This implies that the quantile regression approach may be more appropriate for empirical studies than the usual unit root techniques. In addition, in a theoretic point of view, the limiting distribution of the quantile unit-root test is the same as that of the covariate ADF (CADF) test. Showed by Hansen (1995), the CADF test has large power gains over the conventional univariate unit-root tests. Therefore, the quantile unit-root test is more powerful than the commonly used unit-root tests even if it is based on the linear quantile regression.

Third, the quantile approach has the ability to uncover possibly different behavior in unemployment rates over various quantiles. Specifically, the unemployment rate may display unit-root dynamics in some quantiles, but fail to exhibit such behavior in the others. Such property can be easily discovered by the quantile technique.

Finally, the magnitudes of shocks are endogenous and can be estimated from the data under the quantile framework. As a result, we can assess how the magnitudes of shocks affect the dynamics of unemployment across various quantiles, and further uncover the potential asymmetries in unemployment.

Our empirical results suggest that at the 10% significance level, the unemployment rates for the 12 OECD countries are globally stationary by using the quantile technique with an exception in Australia, in sharp contrast to the results from the univariate unit root test where only two unit-root rejections are obtained. Moreover, estimated shocks are generally larger in the upper quantiles than in the lower quantiles, implying that the impact of economic recessions on unemployment is larger than economic booms. Most importantly, both the signs and sizes of shocks have various impacts on the speed of unemployment adjustment towards its long-run equilibrium, and asymmetric dynamics in unemployment are prevalent for most countries (7/12). To be precise, in the lower quantiles, negative shocks with big absolute value tend to induce faster speed of adjustment towards the long-run equilibrium, while hysteresis effect exists for positive shocks in higher quantiles. This finding is consistent with the observation that unemployment rises suddenly and falls gradually. Finally, we devise a method to separate periods of nonstationarity from stationary ones, based on the asymmetric results of unemployment from the quantile regression, and they show that negative shocks inducing stationarity seem to frequently occur during the periods when the unemployment rate is decreasing from a relatively higher level, while positive shocks mostly occur during the periods that the unemployment rate is increasing from the bottom. This might imply that the authorities in most countries cannot tolerate a high level of unemployment and may conduct continuously expansionary demand policies to curb unemployment when the level is relatively high.

The remainder of the paper is organized as follows. In Section 2, we review the literature on the unemployment rate. Section 3 discusses the quantile methodology used in this study. The empirical results are presented in Section 4. Section 5 concludes the paper.

2. Literature review

The extant studies examining the dynamics of unemployment often use traditional conditional mean approaches. Some of them tested for the presence of hysteresis effect in unemployment within a linear unit-root framework. However, it has been documented that the commonly used linear unit root tests, such as the augmented Dickey and Fuller (1979) (ADF) test and the Phillips and Perron (1988) (PP) test, may lack statistical power when the unemployment rate displays nonlinear behavior. Perhaps so, researches that used linear univariate unit root tests failed to overwhelmingly reject the null hypothesis of hysteresis (e.g., Blanchard and Summers, 1986; Alogoskoufis and Manning, 1988; Brunello, 1990; Reed, 2002; Gray, 2004).

Nonlinear behavior in unemployment has been documented in the literature. Unemployment often shows fast-up and slow-down dynamics over the business cycle. Based on the prediction from search and matching models, the literature has pointed out that shocks to the labor market will propagate asymmetrically in the unemployment. For example, Mortensen and Pissarides (1994) developed a model in which job creation takes longer time in a boom than job destruction in a recession because job creation requires firms to search for good matches. Hence, adjustment costs in the labor market will vary over the business cycle, implying that unemployment can show asymmetries in response to expansionary or contractionary shocks (e.g., Peel and Speight, 1998, 2000; Caporale and Gil-Alana, 2007; Cancelo, 2007). Such nonlinearities may have caused unemployment to exhibit highly persistent, leading to the failure of linear unit root tests to uncover mean reversion in unemployment.

Recently, researches in the literature used nonlinear unit root tests to determine whether or not unemployment is nonstationary or nonlinear. Gustavsson and Osterholm (2006) provided strong evidence of mean reversion in unemployment for Canada, Finland, Sweden and the US using the univariate test of Kapetanios et al. (KSS) (2003), Yilanci (2008) also applied the KSS test to unemployment rates in 17 OECD countries, and found mean reversion in only seven countries. Ghosh and Dutt (2008) adopted the test of Caner and Hansen (2001) to US unemployment and found that the series follows a stationary threshold autoregressive process. Recently, Lee (2010) tested for hysteresis of unemployment for OECD countries by combining the non-linear panel unit root test developed by Ucar and Omay (2009) with the sequential panel selection method of Chortareas and Kapetanios (2009), and gave strong evidence in favor of the natural rate hypothesis of unemployment for 23 of 29 OECD countries.

Another strand of literature has applied non-linear models to describe the disequilibrium adjustments of unemployment without considering the presence of unit-root behavior. Neftci

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4 We thank the referee for this comment.
(1984) pioneered this work by using the Markov chain model, and provided evidence in favor of asymmetries in the US unemployment rates. Other studies, such as Falk (1986), Rothman (1991), and Sichel (1993), have investigated the asymmetric unemployment behavior with the use of non-linear approaches. By using nonlinear models and Bayesian methods, Koop and Potter (1999) provided strong evidence supporting a two-regime threshold autoregressive model, indicating that negative shocks for unemployment tend to have a smaller effect than positive shocks. Brock and Sayers (1988) used the nonparametric BDS test to find non-linear dynamics in unemployment.

To the best of our knowledge, there has been no study applying the quantile approach with covariates to examine the dynamics of unemployment. The use of the quantile approach for unemployment in this study is appropriate to account for the asymmetric response of unemployment to shocks, as well as local unit root behavior around some quantiles. Recently, the quantile approach has been used in the empirical studies. Nikolaou (2008) conducted the quantile unit root test of Koenker and Xiao (2004) to the issue of real exchange rates. In addition, the behavior of nominal interest rates was investigated by Koenker and Xiao (2004) by using their test. Tsong and Lee (2011) also applied the same quantile unit root test to discuss the asymmetric dynamics of inflation in many OECD countries, and provided interesting results and important policy implications.

3. Econometric methodologies

3.1. The quantile covariate unit root tests

In this section we describe the new unit root tests developed by Galvo (2009), which is based on the quantile autoregression framework by adding stationary covariates. The tests basically are an extension to those introduced in Koenker and Xiao (2004), and are shown by simulation to have significant power gains. Within the quantile approach, the speed of adjustment in unemployment depends on both the sign and size of a shock, which allows us to explicitly test for a unit root over a range of quantiles. By contrast, the conventional unit root tests only limitedly analyze the average behavior of a tested series.

Suppose the demeaned unemployment rate \( y_t \) co-varies with an \( m \) vector of stationary variables \( x_t \) with zero mean in the following model:

\[
y_t = \alpha_1 y_{t-1} + \sum_{j=1}^{m} x_j \Delta y_{t-j} + \sum_{j=1}^{q_u} \gamma_j x_{t-j} + \nu_t, \quad t = 1, 2, \ldots, n, \tag{1}
\]

where \( y_t = \bar{y}_t - \mu \), with \( \bar{y}_t \) and \( \mu \) representing the unemployment rate and its long-run level, i.e., unconditional mean, and \( \nu_t \) is the uncorrelated regression error with zero mean. The unit-root null hypothesis of \( \alpha_1 = 1 \) is tested against the alternative hypothesis \( \alpha_1 < 1 \). According to Galvo (2009), the 95th conditional quantile of \( y_t \), conditional on the \( t – 1 \) information set \( \mathcal{S}_{t-1} \), can be expressed as a linear function of its lagged level \( y_{t-1} \), lagged values of \( \Delta y_t \) and the leads (\( q_1 \)) and lags (\( q_2 \)) of covariates in \( x_t \) as follows:

\[
Q_{\tau}(y_t|\mathcal{S}_{t-1}) = z'_t \hat{\beta}(\tau), \tag{2}
\]

where \( z'_t = (y_{t-1}, \Delta y_{t-1}, \ldots, \Delta y_{t-p}, x_{t-q_1}, \ldots, x_{t-q_2}) \) and \( \hat{\beta}(\tau) = (\hat{\alpha}_1(\tau), \hat{\alpha}_2(\tau), \kappa(\tau), \ldots, \kappa(\tau), \gamma_{q_2+1}, \ldots, \gamma_{q_2+q_2}) \) with \( \alpha(\tau) \) denoting the \( r \)th quantile of \( u_t \). Note that \( \alpha(\tau) \) is the autoregressive coefficient in each quantile and is dependent on \( \tau \) under investigation.

Estimation of \( \hat{\beta}(\tau) \) in Eq. (2) involves solving the problem

\[
\min_{u_t} \sum_{t=1}^{n} \rho_1(\hat{y}_{t} - z'_t \hat{\beta}(\tau)), \tag{3}
\]

where \( \rho_1(u) = u(\tau - l(u < 0)) \) as given in Koenker and Bassett (1978) with \( f \) denoting an indicator function. Given the estimator \( \hat{\beta}(\tau) \), Galvo (2009) tests for the unit-root null within the \( r \)th quantile by using the following t ratio statistic:

\[
t_{u}(\tau) = \frac{\hat{f}^{-1}(\tau)}{\sqrt{\tau(1-\tau)}} Y'_{-1} P_2 Y_{-1}^{-1/2}(\hat{\alpha}(\tau) - 1), \tag{4}
\]

where \( \hat{f}^{-1}(\tau) \) is a consistent estimator of \( f^{-1}(\tau) \), with \( f \) representing the density and distribution function of \( u_t \) in Eq. (1), \( Y_{-1} \) is the vector of lagged dependent variables \( y_{t-1} \), and \( P_2 \) is the projection matrix onto the space orthogonal to \( Z = (1, \Delta y_{t-p}, x_{t-q_1}, \ldots, x_{t-q_2}) \). The test statistic of \( t_{u}(\tau) \) allows us to examine the unit root properties of the series in each quantile. In other words, this not only enables us to take a closer look at the dynamics of the series, but also to investigate different behavior of conditional quantiles. By contrast, the conventional univariate and covariate unit root tests lack the ability to detect such behavior.

The asymptotic distribution of the \( t_{u}(\tau) \) test is the same as that of the quantile ADF (QADF) test proposed by Hansen (1995), which is a non-standard distribution dependent on a nuisance parameter \( \delta^2 \), representing the contribution of covariates to the power of the \( t_{u}(\tau) \) test. The smaller the value of \( \delta^2 \), the more powerful the \( t_{u}(\tau) \) test would be. To implement the \( t_{u}(\tau) \) test, one needs to consistently estimate the nuisance parameter and then to find suitable critical value from Table 1 in Hansen (1995) with interpolation if necessary. As recommended by Galvo (2009), \( \delta^2 \) is estimated in a nonparametric way given by

\[
\delta^2 = \frac{\sigma_{y u}^2(\tau)}{\sigma_{\hat{\epsilon} y u}^2(1-\tau)}, \tag{5}
\]

where

\[
\delta^2 = \sum_{k-M}^{M} \frac{(k/M)}{1/n} \sum \hat{\epsilon}_{i,k} \hat{\epsilon}_{i,k}, \quad \sigma_{y u}^2 = \sum_{k-M}^{M} \frac{(k/M)}{1/n} \sum \hat{\epsilon}^2_{i,k} \psi(\hat{u}_{i,k-1}), \tag{6}
\]

with \( \hat{\epsilon}_{i,k} = \sum_{l=q_2}^k \hat{y}_{i,l} + \hat{u}_i \), \( \hat{u}_i \) and \( \hat{y}_i \) are the LS estimates of \( y_i \) and the residual in Eq. (1), respectively; \( \hat{u}_{i,k} = y_{i,k} - \hat{\beta}(\tau) \) and \( \psi(u) = \tau - l(u < 0) \). The functions \( w \) and \( M \) in Eq. (6) are the kernel function and bandwidth, respectively. We used the Bartlett kernel and the automatic bandwidth selection method in Andrews (1991) to choose the bandwidth in the following empirical study. In addition, the optimal values of \( p, q_1 \) and \( q_2 \) in Eq. (1) are determined by minimizing the Bayesian information criterion (BIC) of Schwarz (1978) with a given maximum lag. The BIC and its robust versions are commonly used for the selection of lag length in the literature of quantile autoregression (e.g., Koenker and Xiao, 2004, 2006; Galvo, 2009). Based on the estimate \( \delta^2 \), the critical value can be easily obtained.

Instead of only focusing on a selected quantile, Galvo (2009) suggests the following quantile Kolmogorov–Smirnov (KS) test to test for the presence of a unit root over a range of quantiles:

\[
\text{QKS} = \sup_{\tau} t_{u}(\tau)|_{\gamma_{1}(\tau)}, \tag{7}
\]

where \( t_{u}(\tau) \) is defined in Eq. (4). In this study, we choose \( \Gamma = (\{30\})^{1/3} \) and thus the QKS test can be constructed by taking the maximum over \( \Gamma \).

\footnotetext[5]{To conserve space, the computation of \( f \) is omitted. Please refer to page 168 in Galvo (2009) for further information.}

\footnotetext[6]{For Bartlett kernel, \( M = 1.1447(d(1)n)^{1/3} \), with \( d(1) \) being defined in Eq. (6.4) on page 835 in Andrews (1991).}
The limiting distribution of the QKS test is also nonstandard and depends on nuisance parameters. To deal with such problem, Galvao (2009) devises a simulation procedure to compute the critical values for the QKS test under the null, which is described as follows:

1. For a given sample of observations, compute the estimates of \( \hat{\delta}(t_i) \) based on Eq. (5) for \( t_i \in \Gamma \) and the QKS test.
2. For each \( \hat{\delta}(t_i) \), simulate one realization from the Dickey–Fuller and standard normal distributions independently, and compute

\[
t(t_i) = \hat{\delta}(t_i) \left( \int_0^1 \mathcal{W}^2 \right)^{-1/2} \int_0^1 \mathcal{W} d\mathcal{W} + \sqrt{1 - \hat{\delta}^2(t_i)} N \times (0,1),
\]

where \( \mathcal{W} \) is standard Brownian motion, and \( \mathcal{W} \) is the de-mean counterpart. Maximize these absolute values over \( \Gamma \).
3. Repeat Step (2) several times (e.g., 3000), and obtain the critical value of interest from the empirical distribution. If the value of QKS test is larger than the critical value, one rejects the unit-root null hypothesis.

### 3.2. The choice of covariates

The choice of covariates plays an important role in the application of the covariate quantile unit root tests since it impacts their power and thus affects the empirical results. In this study, we follow the suggestion in the literature, using economic models as a guide to the choice of related covariates for the \( t_n(\tau) \) test (e.g., Amara and Papell, 2006; Elliott and Pesavento, 2006; Lee and Tsong, 2011). The potential covariates chosen here include inflation rate (inf), nominal interest rate (nir), GDP deflator and real GDP in each country. According to the Phillips Curve, there is a trade-off relationship between the unemployment rate and the inflation rate. In addition, the nominal interest rate is suited to the choice of covariates since it is associated with the monetary policy and the unemployment rate. The GDP deflator is also chosen since it is one of price indices, and its growth rate may be related to the unemployment rate to some extent. Finally, the unemployment rate is expected to be associated with the growth rate of GDP due to the business cycle.

Before used as potential covariates, these variables are taken first difference, denoted by \( \Delta \inf, \Delta \nir, \Delta \text{Deflator, and } \Delta \text{GDP} \), to ensure their stationary properties, as required in Galvao (2009). Then the \( t_n(\tau) \) test is applied to the unemployment rate with these covariates one by one. For saving space, we do not report the results for all of the four covariates. We only present the results corresponding to the covariate that has the smallest estimate of \( \hat{\delta} \) among the four covariates at the 50th quantile of unemployment. The reason is that a low \( \hat{\delta} \) indicates a precise estimation of the parameters.

### 4. Data and empirical results

#### 4.1. Data and preliminary results

Quarterly data for 12 OECD countries are used in this study, including Australia, Austria, Canada, France, Germany, Italy, Japan, the Netherlands, New Zealand, Sweden, the United Kingdom, and the United States. The sample periods of unemployment rates in the 12 countries have different start dates, but have the same end date of 2010:Q1 due to data availability. See details in Table 1. Sample lengths for the potential covariates—inflation rates, nominal interest rates, real GDPs, and GDP deflators, are consistent with those of the unemployment rates. Inflation rates are the annualized growth rate of consumer price indices between period \( t-1 \) and \( t \), and long-term government bond yields are chosen as the proxy of nominal interest rates. All the data were collected from the International Monetary Fund’s International Financial Statistics.

Preliminary testing results on the unemployment rates are shown in Table 1 where we give the sample moments, the Jarque-Bera (JB) normality tests, as well as the DF-GLS unit root test. Among the 12 countries, France has the highest average unemployment level at 9.033%, while Japan has the lowest one

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**Table 1**

Descriptive statistics on unemployment rates.

<table>
<thead>
<tr>
<th>Country</th>
<th>Sample mean (%)</th>
<th>Sample standard deviation (%)</th>
<th>DF-GLS statistic (lag length)</th>
<th>Jarque-Bera statistic [p-value]</th>
<th>Start date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>6.047</td>
<td>2.473</td>
<td>−0.735 (1)</td>
<td>4.171 [0.124]</td>
<td>1967Q1</td>
</tr>
<tr>
<td>Austria</td>
<td>4.503</td>
<td>0.983</td>
<td>−1.312 (4)</td>
<td>126.059 [0.000]</td>
<td>1993Q1</td>
</tr>
<tr>
<td>Canada</td>
<td>7.536</td>
<td>2.146</td>
<td>−1.653 (1)</td>
<td>3.363 [0.186]</td>
<td>1960Q1</td>
</tr>
<tr>
<td>France</td>
<td>9.033</td>
<td>1.632</td>
<td>−0.264 (1)</td>
<td>8.924 [0.011]</td>
<td>1978Q1</td>
</tr>
<tr>
<td>Germany</td>
<td>8.411</td>
<td>1.088</td>
<td>−1.355 (2)</td>
<td>0.820 [0.663]</td>
<td>1992Q1</td>
</tr>
<tr>
<td>Italy</td>
<td>8.644</td>
<td>1.770</td>
<td>−1.108 (4)</td>
<td>3.509 [0.172]</td>
<td>1979Q4</td>
</tr>
<tr>
<td>Japan</td>
<td>2.637</td>
<td>1.294</td>
<td>1.145 (0)</td>
<td>20.027 [0.000]</td>
<td>1960Q1</td>
</tr>
<tr>
<td>Netherlands</td>
<td>5.079</td>
<td>2.027</td>
<td>−0.933 (3)</td>
<td>0.000 [0.183]</td>
<td>1979Q1</td>
</tr>
<tr>
<td>New Zealand</td>
<td>6.243</td>
<td>2.096</td>
<td>−1.587 (2)</td>
<td>8.000 [0.018]</td>
<td>1985Q4</td>
</tr>
<tr>
<td>Sweden</td>
<td>4.531</td>
<td>2.724</td>
<td>−0.670 (3)</td>
<td>16.428 [0.000]</td>
<td>1970Q1</td>
</tr>
<tr>
<td>UK</td>
<td>6.843</td>
<td>2.485</td>
<td>−1.449 (2)</td>
<td>8.432 [0.014]</td>
<td>1971Q1</td>
</tr>
<tr>
<td>US</td>
<td>5.936</td>
<td>1.523</td>
<td>−2.062 (1)</td>
<td>23.383 [0.000]</td>
<td>1960Q1</td>
</tr>
</tbody>
</table>

Notes: The 10% and 5% critical values are −1.62 and −1.98 for the DF-GLS test. The optimal lag was selected by the MAIC with the maximum lag set to be 8.

\( ^1 \) Significance at 5% level.

\( ^1 \) Significance at 10% level.
Based on the asymmetric results from the $t_0(\tau)$ test, it is easy to find the largest quantile $y_{\tau}$, in which the unemployment rate exhibits stationary behavior. Then the observation of unemployment at $t$, $y_t$, can be identified as generated by a unit-root process if $y_t > \hat{Q}_0(y_{\tau}|y_{t-1})$, while it is generated by a stationary process if $y_t \leq \hat{Q}_0(y_{\tau}|y_{t-1})$. The “threshold level” $\hat{Q}_0(y_{\tau}|y_{t-1})$ is regarded as the maximum value of unemployment with stationary behavior, which can be calculated by plugging the quantile estimates from Eq. (3) into Eq. (2), conditional on its past history and the chosen covariate, i.e., $\hat{Q}_0(y_{\tau}|y_{t-1}) = \hat{z}^2(\hat{\beta}_0(y_{\tau}))$.

For example, in Table 2, unemployment in Australia exhibits stationary tendency at the quantiles $\tau = 0.1$, 0.2. Hence, the threshold level for the case of Australia is $\hat{Q}_0(0.2|y_{t-1}) = \hat{z}^2(\hat{\beta}(0.2))$. Then, with the aforementioned method, stationary observations of unemployment in Australia are identified, and plotted in Fig. 2. Note that only seven countries are plotted in Fig. 2 due to their asymmetric results, and the chosen quantile is different for each country; for example, $\tau = 0.2$ for Australia, $\tau = 0.3$ for Austria, Germany, the UK, and the US, as well as $\tau = 0.4$ for Canada and New Zealand.

In addition to the real time series of unemployment and its stationary parts, we also plotted the 10%-th and 90%-th quantiles of unemployment for comparison in Fig. 2.\(^{19}\) As shown in Fig. 2, the stationary observations (denoted by solid boxes in the graph) of unemployment seem to frequently fall into the periods when the unemployment rate is decreasing from a relatively higher level, while those nonstationary observations mostly exist during the periods when the unemployment is increasing from the bottom. In other words, unemployment exhibits stationary behavior in a booming economy, while shows hysteresis effect during a recession. This pattern is especially evident for Australia, Canada, New Zealand, the UK, and the US. Besides, the real series of unemployment usually falls into the region between the 10%-th quantile and the 90%-th quantile.

5. Concluding remarks

Investigating the dynamics in unemployment is an important empirical issue since it helps us to distinguish between two competing hypotheses—the natural rate hypothesis and the hysteresis hypothesis. The extant literature has examined this issue by using linear or non-linear unit root tests. Yet, these traditional tests usually assume that the speed of adjustment in unemployment towards its equilibrium is constant, without considering possible different effect of signs and sizes of a shock on unemployment. As a result, mixed results have been obtained in the literature.

A possible explanation for the mixed results is that unemployment may display asymmetric adjustment paths in response to positive and negative shocks. This possibility did not be well treated in the conditional mean approaches. In this paper, a general quantile approach, developed by Galvao (2009), is applied to detect possible asymmetric dynamics of unemployment, as well as testing for stationarity for 12 OECD countries. With the inclusion of stationary covariates, the test can provide more accurate estimation of conditional quantile functions than the test of Koenker and Xiao (2004). Also, it can demonstrate the asymmetric dynamics in unemployment since the adjustment speeds are different in response to positive and negative shocks. As a result, the unemployment rate may display unit-root dynamics in some quantiles, but exhibit stationary behavior in the others. Other features of the quantile approach are that it can estimate the actual magnitudes of shocks, and has high testing power to investigate the stationarity property of a series.

Our empirical results indicate that the unemployment rates in 11 OECD countries are globally stationary by using the quantile approach. Moreover, estimated shocks are generally larger in the upper quantiles than in the lower quantiles (in absolute value), implying that the impact of economic recessions on unemployment is larger than economic booms. Most importantly, unemployment rates in most countries exhibit asymmetric dynamics. In details, in the lower quantiles, large negative shocks tend to induce faster speeds of adjustment in unemployment towards the long-run equilibrium, while in the higher quantiles, hysteresis effect exists for positive shocks. This finding is consistent with the observation that unemployment rises suddenly and falls gradually.

A graphical examination of the quantile results is also provided in this paper, and they reveal that unemployment exhibits obvious stationary behavior in a recovering economy, while shows hysteresis effect during a recession. A possible explanation might be that because the authorities in most countries cannot tolerate a high level of unemployment, they may continuously conduct expansion demand policies to curb high unemployment, leading to stationarity in unemployment.

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