BRING QUANTILE UNIT ROOT TEST BACK IN TESTING HYSTERESIS IN UNEMPLOYMENT FOR THE UNITED STATES

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Abstract

We apply quantile unit root test to revisit the hysteresis in unemployment for the United States using data over 1928-2014. Conventional unit root tests indicate that hysteresis in unemployment does not hold in the United States over 1928-2014. Quantile Kolmogorov-Smirnov test also reject the hysteresis in unemployment hypothesis However, empirical results from quantile unit root test indicate that hysteresis in unemployment hold in both 0.3 and 0.4 quantiles. These empirical results are different from previous findings and have important policy implications for government to conduct economic stabilization policy in the United States.

Keywords: quantile unit root test; hysteresis in unemployment; the United States; stabilization policy

JEL Classification: C2, J6

I. Introduction

Whether unemployment hysteresis holds true remains a strong debate among applied econometric scholars, it is critical not only for empirical researchers but also for policymakers. Based on the assumption inherent in the hysteresis hypothesis in unemployment, if unemployment is an I(1) process, then any shock that affects the series will have permanent effects and thus shifts the unemployment equilibrium from one level to another level. If this is the case, then from the policy point of view, policy action should return unemployment to its original equilibrium level. On the other hand, if unemployment is an I(0) process, the effect of any shock is only transitory, the idea is that the unemployment rate should fluctuate around a long-run steady-state, or "natural

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rate," within this framework, deviations in unemployment from the natural rate should be temporary (e.g., Friedman, 1968; Phelps, 1968), and as a result, policy action is not mandatory because unemployment will eventually return to its original equilibrium level. Previous studies refer to the second case as the Non-Accelerating Inflation Rate of Unemployment (NAIRU) hypothesis because it characterizes unemployment dynamics as a mean reverting process. Because unemployment hysteresis is associated with non-stationary unemployment rates, unit root tests have been widely used in literature to empirically investigate its validity.

Started with Blanchard and Summers (1986) that they were pioneers in presenting the first empirical study that employed conventional unit root tests to investigate the effect of hysteresis in unemployment, they use data for France, Germany, the United Kingdom, and the United States from 1953 to 1984. Empirical results from their study show that they were unable to reject the non-stationarity of unemployment rates for most of the countries they studied, except for the United States, where they did find evidence of stationarity in only the United States. Brunello (1990) also failed to reject hysteresis unit root hypothesis, using Japanese unemployment data from 1955 to 1987. Mitchell (1993) later applied Perron's (1989) unit root test taking into account one exogenously given structural break, and similarly confirmed support for hysteresis unemployment in several Organization for Economic Co-operation & Development (OECD) countries. Empirical results from Jaeger and Parkinson (1994) further indicating that unemployment hysteresis exists in Germany, the United Kingdom, and Canada, but not in the United States. Roed (1996) empirically investigated the unemployment hysteresis in 16 OECD countries using data from 1970 to 1994 and found that hysteresis prevails in Australia, Canada, and Japan, as well as in several European countries; however, once again, hysteresis was rejected in the case of the United States. Lin *et al.* (2008) employ threshold unit root test of Caner and Hansen (2001) to reinvestigate hysteresis in unemployment for OECD countries and their empirical findings support hysteresis in unemployment for Australia, Finland, France, Germany, Japan and the United States. Chang and Lee (2011) also apply the threshold unit root test of Caner and Hansen (2001) to reinvestigate hysteresis in unemployment for G7 countries and their empirical findings merely support hysteresis in unemployment for three countries, namely France, Germany and Italy. Cheng et al. (2014) applied the flexible Fourier unit root test of Enders and Lee (2012) to re-examine the hysteresis unemployment hypothesis for PIIGS (Portugal, Ireland, Italy, Greece, and Spain) countries over the period from 1960 to 2011 and their study found that the hysteresis in unemployment is confirmed for all PIIGS countries, with the exception of Portugal and Spain, when the Fourier unit root test is conducted.[3] On the other hand, Bolat et al. (2014) employ panel KSS test with a Fourier Function for 17 Euro zone countries and found that unemployment in 11 countries are stationary and hysteresis unemployment only found in the other six countries, namely Netherlands, Slovakia, Slovenia, Italy, Portugal and Cyprus. Without considering the Fourier function for the test, the results strongly support hysteresis unemployment hypothesis for all 17 Euro zone countries.

[3] Cheng et al. (2014) also found that the Fourier unit root test has greater power than a linear method if the true data generating process of unemployment is a stationary and non-linear process of an unknown form with structural change.

However, the above 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 conventional unit root tests possibly lead to a widespread failure in the rejection of unit-root null hypothesis for unemployment rates. This paper intends to deal with the above deficiency by employing a newly developed Quantile unit root test in Koenker and Xiao (2004) to enhance estimation accuracy.

We hope our study can contribute to this line of research by determining whether hysteresis unemployment is a characteristic of the USA labour market. As the issue of unemployment is undoubtedly the USA's most pressing problem since global financial turmoil broke out during the period of 2007- 2008, the unemployment rate on January 2010 in the United States has reached at a 10.6%, this was a level not seen since 1963. Testing whether unemployment hysteresis prevails in the United States has not only become an important focus for empirical work, but also has strong policy implications. While previous studies most focus on conventional unit root tests, we test the hypothesis of hysteresis in unemployment from USA data sets for the first time using the Quantile Unit Root test proposed by Koenker and Xiao (2004) and we hope our study can bridge the gap of unemployment literature.

The remainder of this paper is organized as follows. Section 2 presents the data used in our study. Section 3 first briefly describes the Quantile Unit Root test proposed by Koenker and Xiao (2004) and then presents the empirical results. Section 4 concludes the paper and presents its policy implications.

II. Data

We use annual data on log US unemployment rate from 1928-2014. We choose the lag length based on the MAIC criterion suggested by Ng and Perron (2001). We find a lag length of $q = 6$ and use this for all considered quantiles τ.[1] Figure 1 displays the time paths of the unemployment rate. We can clearly observe structural shifts in the trend of the data and also we found there were several peaks in unemployment rate during this sample period. The most negative shocks to unemployment rate like the 1930/1940 recession, 1974/1976 and 1979/1981 (two-time oil shocks), 1987/1989 recession, and 2007/2008 global financial crisis, thus, increase unemployment rate (see all shadow areas).

Table 1 reports summary statistics of data and we find unemployment data series are no-normal. As pointed by Koenker and Xiao (2004), the Quantile-based unit root test has higher power than conventional unit root tests, because the Quantile-based unit root test is superior to standard unit root tests in case of departure from Gaussian residuals and these further confirm the use of our Qunatile Unit Root test.

III. Methodology and Empirical Results

III.1. Quantile Autoregressive Unit Root Test

Let ue_t denote the log of unemployment rate in our case and ε_t a serially uncorrelated error term. An AR(q) process for log unemployment rate with drift a and deterministic trend t is given by:

$$ue_t = a + bt + \sum_{i=1}^{q} \gamma_i ue_{t-1} + \varepsilon_t, \quad t = q+1, q+2, ..., n. \tag{1}$$

The sum of the autoregressive coefficients is $\alpha = \sum_{i=1}^{q} \gamma_i$ - a measure of persistence that we focus upon in our study. We can rewrite equation (1) as follows:

$$ue_t = \alpha ue_{t-1} + a + bt + \sum_{i=1}^{q-1} \phi_i \Delta ue_{t-i} + \varepsilon_t \tag{2}$$

Here we can run the usual unit root test. If $\alpha = 1$ then the unemployment rate has a unit root and, therefore, shocks have permanent effects on unemployment rate. If we have $\alpha < 1$, then unemployment rate is trend stationary. In this case shocks have only temporary effects on unemployment rate.

To gain more detailed estimates to analyze persistence, we can not only focus at the conditional mean, but also in the tails of the conditional distribution of ue_t and here we can estimate Equation (2) using quantile autoregression methods. The $\tau - th$ conditional quantile is defined as the value $Q_\tau(ue_t | ue_{t-1}, ..., ue_{t-q})$ such that the probability that output conditional on its recent and past history will be less than $Q_\tau(ue_t | ue_{t-1}, ..., ue_{t-q})$ is τ. For example, if unemployment rate is very high (low) relative to recent unemployment rate this means that a large positive (negative) shock has occurred and that ue_t is located above (below) the mean conditional on past observations $ue_{t-1}, ..., ue_{t-q}$ somewhere in the upper (lower) conditional quantiles.

The AR(q) process of unemployment rate at quantile τ can be written as:

$$Q_\tau(ue_t | ue_{t-1}, ..., ue_{t-q}) = \alpha(\tau) ue_{t-1} + a(\tau) + b(\tau)t + \sum_{i=1}^{q-1} \phi_i(\tau) \Delta ue_{t-i}. \tag{3}$$

By estimating Equation (3) at different quantiles $\tau \in (0,1)$ we can get a set of estimates of the persistence measure as $\alpha(\tau)$. We can test $\alpha(\tau) = 1$ at different values of τ to analyze the persistence of the unemployment impact of positive and negative shocks and shocks of different magnitude using the quantile autoregression based unit root test proposed by Koenker and Xiao (2004). The test has been extended by Galvao (2009) to include deterministic components which is essential for unit root tests of drifting time series like unemployment rate.

Let $\alpha(\tau)$ be the quantile regression estimator. To test $H_0 : \alpha(\tau) = 1$ we use the t-stat for $\alpha(\tau)$ proposed by Koenker and Xiao (2004) which can be written as

$$t_n(\tau) = \frac{f(F^{-1}(\tau))}{\sqrt{\tau(1-\tau)}} (ue_{-1}' M_Z ue_{-1})^{1/2} (\alpha(\tau) - 1), \tag{4}$$

where $f(u)$ and $F(u)$ are the probability and cumulative density functions of ε_t , ue_{-1} is the vector of lagged log-Unemployment rate and MZ is the projection matrix onto the space orthogonal to $Z=(1,t,\Delta ue_{t-1},\Delta ue_{t-2},...,\Delta ue_{t-q+1})$. We use the results derived by Koenker and Xiao (2004) and Galvao (2009) to find the critical values of $t_n(\tau)$ for different quantile levels. We can estimate $f\left(F^{-1}(\tau)\right)$ following the rule given in Koenker and Xiao (2004). Besides allowing for asymmetric effects of shocks on unemployment an important advantage of QAR-based unit root tests over standard unit root tests is that they have more power (Koenker and Xiao, 2004).

In contrast, a more complete inference of the unit root process based on the quantile approach involves exploring the unit root property across a range of quantiles. To this end, Koenker and Xiao (2004) suggest the Quantile Kolmogorov–Smirnov (*QKS*) test, which is given as

$$QKS=\sup_{\tau\in\Gamma}|t_n(\tau)| \tag{5}$$

where: $t_n(\tau)$ is given by Equation (4) and $\Gamma=(0.1,0.2,.....0.9)'$ in our later applications. In other words, we first calculate $t_n(\tau)$ for all τ_s in Γ, and then construct the *QKS* test statistic by selecting the maximum value across Γ. While the limiting distributions of both $t_n(\tau)$ and *QKS* tests are nonstandard, Koenker and Xiao (2004) suggest the use of a resampling (Number of bootstrap =10000 in our case) procedure to approximate their small-sample distributions. Interested readers can refer to Koenker and Xiao (2004) for more detailed description.

III.2. Empirical Results

For comparison purpose, we first incorporate three conventional unit root tests – ADF, PP and KPSS tests. Empirical results in Table 2 clearly indicate that both ADF and PP tests reject the null of non-stationary unemployment for the United States. KPSS test get similar result also fails to reject the null of stationary unemployment for the United States. This result is consistent with those of Blanchard and Summers (1986), Jaeger and Parkinson (1994), Roed (1996), and Lee *et al*. (2013), indicating that hysteresis in unemployment does not hold true in the United States.

Due to the deficiency of conventional unit root test, in the following we employ a newly developed Quantile unit root test proposed by Koenker and Xiao (2004) to enhance estimation accuracy. To test the null of $\alpha(\tau)=1$ for $\tau=0.1,0.2,0.3,04,...,0.9$ more formally, we use the t-statistic ($t_n(\tau)$) based on Eq. (4). Table 3 shows the point estimates, the t-statistics and the critical values. We find that $H_0:\alpha(\tau)=1$ be rejected at the 5% significance level over the whole conditional unemployment rate distribution based on Quantile Kolmogorov–Smirnov test (*QKS*). The test result confirms that all types of shocks to unemployment rate lead to temporary effects on unemployment rate. This result is in line with, for example, Campbell and Mankiw (1987) who find that an unexpected change in unemployment rate should change one's forecast temporarily only. By looking at each quantile (0.1, 0.2..., 0.9), we find that the null of $\alpha(\tau)=1$ can be rejected in each quanitle with the exception of 0.3 and 04. quantiles. These results indicate that shocks to unemployment in both 0.3 and 0.4 quantiles are permanent. The government in the United States should be caution when dealing with increasing unemployment. Due to stationarity found in 7 out of 9 quantiles, we also estimate Half-life (HL) of shock for those 7 quantiles. We find that HL shocks estimates range from 1.0381 years to 2.1806 years or 12 months to 25 months. Apparently our results are more reliable due to the speed of adjustment in unemployment towards its equilibrium is not constant and the commonly used conventional unit root tests fail to consider this situation and possibly lead to a widespread failure in the rejection of unit-root null hypothesis for unemployment rates. This paper intends to deal with the above deficiency by employing the Quantile unit root test of Koenker and Xiao (2004) to enhance estimation accuracy.

Figure 2 shows the estimates of $\alpha(\tau)$ for $\tau = 0.1, 0.2, 0.3, 0.4, ..., 0.9$ together with 95% bootstrapped confidence bands. The persistence parameter estimates range between 0.5129 and 0.8171 and are well below one for all the quantiles considered. The point estimate is slightly below one in the centre of the conditional distribution and at the lower tail. Overall the parameter estimates are not relatively homogeneous over the conditional unemployment distribution.

Persistence is highest only at the quantiles 30 and 40 of the conditional unemployment distribution. The most negative shocks to unemployment rate like the 1930/1940 recession, 1974/1976 and 1979/1981 (two-time oil shocks), 1987/1989 and 2008/ 2009 recession, thus, increase unemployment rate permanently. However, also the parameter estimates at the other parts of the conditional unemployment rate distribution are very quite lower than one indicating that not only large recessionary, but all shocks to unemployment rate have only a temporary impact. This result is in line with for example Jaeger and Parkinson (1994) and Roed (1996) who find that infrequent recessionary shocks have only temporary effects on unemployment rate, but that also the impact of all other shocks is of not substantial persistence. The parameter estimates for the trend are not significantly different from zero over the whole conditional distribution. The estimated constant is slightly larger than zero for most parts of the conditional distribution which is necessary to explain that the unemployment rate time series grows over time.

IV. Conclusions

In this study, we apply the quantile unit root test to revisit the hysteresis in unemployment for the United States using data over 1928-2014. Conventional unit root tests indicate that hysteresis in unemployment does not hold in the United States over 1928-2014. The Quantile Kolmogorov-Smirnov test also reject the hysteresis in unemployment hypothesis However, empirical results from quantile unit root test indicate that hysteresis in unemployment hold in both 0.3 and 0.4 quantiles. These empirical results are different from previous findings and have important policy implications for government to conduct economic stabilization policy in the United States. Our study implies a fiscal or monetary stabilization policy would not possibly have permanent effects on the unemployment rate for the US under study.

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Annexes

Table 1

Summary Statistics of Unemployment Rate (ue) in the United States (%)

	Mean	**Max.**	**Min.**	**Std. Dev.**	**Skew.**	**Kurt.**	**J.-B.**
UE	7.152	24.90	1.20	4.735	2.093	7.060	123.28***

Note: 1. Sample period is from 1928 to 2014.
*2. *** indicates significance at the 1% level.*

Table2

Unit Root Test – ADF and KPSS

ADF unit root test results				
series	Level		First Differences	
	Constant	Constant with Trend	Constant	Constant with Trend
UE	**-3.969*** **	**-4.085*** **	**-6.772*** **	**-6.725*** **
KPSS unit root test results				
series	Level		First Differences	
	Constant	Constant with Trend	Constant	Constant with Trend
UE	0.1241	0.1086	0.0368	0.0374

Note: 1. Sample period is from 1928 to 2014.
*2. *** indicates significance at the 1% level.*

Table 3

Quantile Unit Root Test Results – Unemployment Rate (UE) - 1928-2014

Quantile	α(τ)	t-statistics	C.V.	H-L Shocks	QKS test
0.10	0.6968	**-5.2972**	-2.6198	1.9188	**8.0915**
0.20	0.7277	**-3.5670**	-2.6072	2.1806	
0.30	0.8171	-2.1394	-2.3704		
0.40	0.7659	-2.5571	-2.7364		
0.50	0.7214	**-2.9030**	-2.8763	2.1223	
0.60	0.6437	**-2.9422**	-2.6781	1.5735	
0.70	0.6016	**-3.1822**	-2.6668	1.3640	
0.80	0.6128	**-3.5915**	-2.4265	1.4154	
0.90	0.5129	**-8.0915**	-2.4929	1.0381	

Notes: The table shows point estimates, t-statistics and critical values for the 5% significance level. If the t-statistic is numerically smaller than the critical value then we reject the null hypothesis of α(τ) = 1 at the 5% level. QKS is the quantile Kolmogorov–Smirnov test. 2.7944 is 5 % critical value for QKS is based on 10000 bootstrapping simulations.

Figure 1

Unemployment rate in the United States (1928-2014)

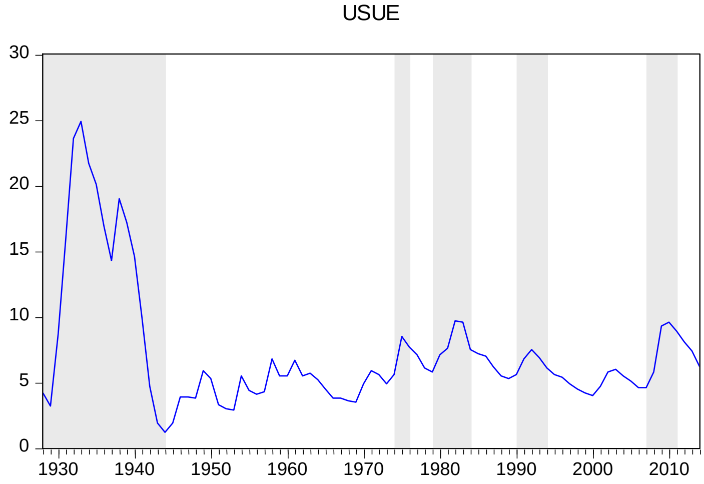
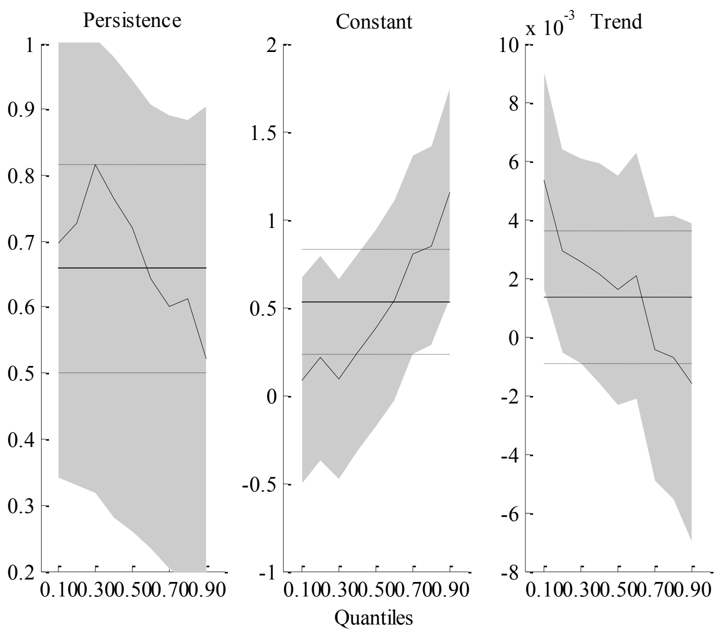


Figure 2

Quantile Regression Estimates



Notes: The graphs show estimates of the persistence parameter α(τ) and the deterministic parameters a(τ) and b(τ) at different quantiles τ = {0.1, 0.2, . . . , 0.9}. The grey areas indicate 95% bootstrapped confidence bands for the quantile autoregression estimates. The horizontal dashed line shows estimated parameters from a simple mean regression with 95% confidence bands (dotted) for comparison.