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# Unemployment and participation rates? Revisiting the US data

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This article applies the method of Gonzalo and Pitarakis (2006) to investigate the relationship of unemployment and labour force participation in the United States. Empirical analysis indicates the long-run relationships between these two variables are regime dependent.

**Keywords:** added worker effect; cointegration; discouraged worker effect; threshold effect

**JEL Classification:** E24; J60

## I. Introduction

This article seeks to investigate the nature of the long-run relationship between the civilian unemployment rate and labour force participation rate in the United States. Past studies by different authors involving different countries have found stable long-run linear relationships between these two variables, including Österholm (2010) for Sweden, Emerson (2011) for the United States and Kakinata and Miyamoto (2012) for Japan. These researchers limited their consideration exclusively to the possibility of a *linear* cointegrating relation between the two variables and not to a possible *nonlinear* cointegration arising from threshold effects due to differing responses of the variables under alternative regimes.[1] Enders and Siklos (2001) and Gonzalo and Pitarakis (2006) have all emphasized the fact that while threshold effects make testing for cointegration a more complicated statistical process, they also furnish a more complete, intuitive and informative analysis.

The idea that two or more nonstationary variables may adjust to two alternative long-run relations, depending on the behaviour of a separate exogenously given stationary threshold variable, has been shown to be both intuitively appealing and empirically rewarding. Specifically for the labour market, considerable frictions exist in finding a job during periods when the economy is slack, while search may be shortened during periods when employers are actively seeking workers and providing widespread information on employment opportunities. In addition, the stage of the business cycle, whether contractionary or expansionary, may bear significantly on workers' decisions about whether to retire, to re-educate, or perhaps to resign oneself to becoming a discouraged worker. These decisions will naturally have a profound impact on both the unemployment rate and the labour force participation rate. In the presence of such changes, there is no reason to believe that adjustments of the unemployment rate and the participation rate will be unique, uniform and consistent across all regimes. In this article, we will employ the method of Gonzalo and Pitarakis (2006) to investigate whether there are threshold effects in cointegrating relationships between unemployment rate and labour force participation rate in the United States. This article is organized as follows. Section II introduces the model. Section III examines the data and reports the results. Section IV concludes.

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[1] Cointegrating regressions remain linear in variables in the presence of threshold effects, but become nonlinear in parameters when threshold effects occur in the cointegrating relation.

## II. Method

Gonzalo and Pitarakis (2006) propose a test of the null of linear cointegration:

$$y_t = \beta' x_t + u_t \tag{1}$$

against the alternative hypothesis of cointegration with threshold effects:

$$y_t = \beta' x_t + \lambda' x_t \mathrm{I}(q_{t-d} > \gamma) + u_t \tag{2}$$

with $x_t = x_{t-1} + v_t$, where $u_t$ and $v_t$ are scalar and p-vector valued stationary disturbance terms, respectively; $q_{t-d}$ with $d \geq 1$ is a stationary threshold variable lagged by $d$ periods; and $\mathrm{I}(q_{t-d} > \gamma)$ is indicator function that equals one if $q_{t-d} > \gamma$, and zero otherwise.

A natural test of the hypothesis of linear cointegration versus the alternative of threshold cointegration takes the form of testing $H_0 : \lambda = 0$ against $H_1 : \lambda \neq 0$. Gonzalo and Pitarakis (2006) propose a supLM test based on the following statistic:

$$LM_T(\gamma) = \frac{1}{\tilde{\sigma}_0^2} \mathrm{u}'\mathrm{M}\mathrm{X}_\gamma(\mathrm{X}'_\gamma\mathrm{M}\mathrm{X}_\gamma)^{-1}\mathrm{X}'_\gamma\mathrm{M}\mathrm{u} \tag{3}$$

where $\mathrm{M} = \mathrm{I} - \mathrm{X}(\mathrm{X}'\mathrm{X})^{-1}\mathrm{X}'$, X stacks all values of $x_t$ in the linear model (1), and $\mathrm{X}_\gamma$ stacks the values of $x_t$ corresponding to the criterion $q_t > \gamma$ in the nonlinear model (2). $T$ is the length of full sample, u is the residual and $\tilde{\sigma}_0^2$ is the residual variance of the linear model (1).

The LM test statistic $LM_T(\gamma)$ calculated for all possible values of threshold variable $q_t$. A trimming parameter is employed to ensure a minimum number of observations on each side of the threshold. The supLM statistic is given by the following:

$$\mathrm{sup}LM = \mathrm{sup}_{\gamma\in\Gamma}\mathrm{LM}_\mathrm{T}(\gamma) \tag{4}$$

Critical values for this test statistics are taken from Andrews (1993).

## III. Data and Empirical Analysis

Data used in this study are taken from the US Department of Labor, Bureau of Labor Statistics, and consist of seasonally adjusted monthly observations on the unemployment rate ($unem_t$) and the labour force participation rate ($part_t$) for the period 1948:01 to 2013:08. A separate series on the monthly seasonally adjusted industrial production index was obtained from the Federal Reserve Board of Governors. The growth rate in the production index will serve as the threshold variable.

The basic model of the linear long-run relation between the participation rate and the unemployment rate can be written as follows:

$$part_t = \alpha + \beta unem_t + u_t$$

with $part_t =$ the labour force participation rate and $unem_t =$ the unemployment rate at time $t$. As shown in Table 1, standard unit root tests were applied to both subcategorized sets of unemployment and participation rates. The KPSS tests offer robust evidence of unit roots for both unemployment and participation rates across subcategories Males, Females and All. Clearly, the ADF and ADF-GLS unit root tests in Table 1 are sensitive to the inclusion or exclusion of constants and trends. However, the general weight of the evidence from Table 1 argues in favour of unit roots. We will therefore continue to infer, as others have in the past, that both unemployment and participation variables can be effectively modelled as nonstationary series.

Table 2 contains the results of residual based cointegration tests. The ADF test shows clearly that no cointegration is occurring between the unemployment rate and participation rate. However, when a threshold effect is allowed in the residuals, the Enders and Siklos (2001) TAR Φ tests provide evidence for cointegration of unemployment and participation rates for Females and All. The residuals appear stationary, once a threshold effect is accounted for in the test. Moreover, the corresponding $F_{\mathrm{equal}}$ tests for All and Females reject the null that the

**Table 1. Unit-root tests on individual series**

| | | All | | Males | | Females | |
|---|---|---|---|---|---|---|---|
| | | $part_t$ | $unem_t$ | $part_t$ | $unem_t$ | $part_t$ | $unem_t$ |
| ADF | $\tau_u$ | −1.278 | −2.937** | −0.298 | −2.995** | −2.687* | −3.073** |
| | $\tau_t$ | 1.115 | −3.229* | −1.365 | −3.529** | 2.210 | −3.075 |
| ADF-GLS | $\tau_u$ | 0.256 | −1.403 | 4.369 | −1.674 | 2.142 | −1.130 |
| | $\tau_t$ | 0.075 | −2.991** | −1.226 | −3.475** | 0.735 | −2.279 |
| KPSS | $\tau_u$ | 7.875*** | 1.603*** | 8.351*** | 2.667*** | 8.643*** | 0.881*** |
| | $\tau_t$ | 1.126*** | 0.402*** | 1.540*** | 0.275*** | 1.554*** | 0.685*** |

*Notes*: $\tau_u$ is the statistic with constant. $\tau_t$ is the statistic with constant and trend. ***significant at 1% level; **significant at 5% level; *significant at 10% level. Lag length in the ADF and ADF-GLS tests are chosen based on AIC under maximum lag 12.

**Table 2. Unit root tests on the residual of Engle–Granger regression**

| | | All | Males | Females |
|---|---|---|---|---|
| ADF | $\tau_u$ | −1.633 | −1.843 | −1.295 |
| TAR | $\Phi$ | 6.189* | 4.326 | 5.328* |
| | $F_{\text{equal}}$ | 10.62*** | – | 9.400*** |
| M-TAR | $\Phi$ | 3.344 | 7.508** | 3.124 |
| | $F_{\text{equal}}$ | – | 11.23*** | – |

*Notes*: $\tau_u$ is the ADF test on the residuals of Engle–Grange regression. $\Phi$ is the $F$-test statistic of Enders and Siklos (2001) for $\rho_1 = 0$ and $\rho_2 = 0$. The null hypothesis is nonstationary and the alternative is stationary. $F_{\text{equal}}$ is the $F$-test statistic of $\rho_1 = \rho_2$ in Table 7 of Enders and Siklos (2001) to test the null hypothesis of linear stationarity and the alternative of stationarity with asymmetric adjustment. –: when $\Phi$ fails to reject the null, we do not compute the $F_{\text{equal}}$. ***significant at 1% level; **significant at 5% level; *significant at 10% level.

**Table 3. The supLM test with annual growth rate of industrial production as threshold variable $q_{t-d}$**

| | $d$ | All | Males | Females |
|---|---|---|---|---|
| supLM | 1 | 124.3*** | 145.3*** | 109.1*** |
| | 2 | 130.5*** | 162.1*** | 112.6*** |
| | 3 | 132.0*** | 176.2*** | 114.0*** |
| $\gamma$(based on the parameter $d$=3) | | 3.222 | 0.997 | 3.222 |

*Note*: ***significant at 1% level.

**Table 4. Estimation result of threshold cointegration**

| regime | | All | Males | Females |
|---|---|---|---|---|
| $q_{t-3} > \gamma$ | $\alpha_1$ | 66.81*** | 85.53 | 62.06*** |
| (above- average | | (79.94) | (163.5) | (21.19) |
| growth) | $\beta_1$ | −0.371*** | −1.540 | −1.229*** |
| | | (–2.699) | (–16.45) | (–2.653) |
| $q_{t-3} \leq \gamma$ | $\alpha_2$ | 58.11*** | 87.87 | 35.93*** |
| (below- average | | (79.94) | (137.7) | (23.41) |
| growth) | $\beta_2$ | 0.745*** | −1.338 | 1.906*** |
| | | (11.31) | (–13.71) | (7.817) |
| $F_1$ | | 88.31*** | 7.998*** | 62.46*** |
| $F_2$ | | 53.54*** | 2.213 | 35.87*** |
| $F_3$ | | 65.59*** | 89.79*** | 56.70*** |

*Notes*: $F_1$ is the $F$-statistic of $H_0 : \alpha_1 = \alpha_2$.$F_2$ is the $F$-statistic of $H_0 : \beta_1 = \beta_2$.$F_3$ is the $F$-statistic of $H_0 : \alpha_1 = \alpha_2, \beta_1 = \beta_2$. $t$-Statistic are reported in parentheses. ***significant at 1% level.

adjustment is symmetric. However, with respect to the TAR $\Phi$, the null of no cointegration for Male cannot be rejected. A further testing of Males using Enders and Siklos (2001) M-TAR statistic shows that a momentum threshold effect is present in the residuals. A corresponding $F_{\text{equal}}$ test rejects the null of symmetric adjustment on either side of the threshold.

Having shown in Table 2 that both the unemployment rates and the participation rates are cointegrated for Males, Females and All with threshold adjustment effects in the residuals, we now test whether there is a threshold effect in the cointegrating regressions themselves. Following the methodology of Gonzalo and Pitarakis (2006), we write the cointegrating regression in its nonlinear threshold form as follows:

$$\begin{aligned} part_t &= (\alpha_1 + \beta_1 unem_t)(1 - \mathrm{I}(q_{t-d} > \gamma)) \\ &\quad + (\alpha_2 + \beta_2 unem_t)\mathrm{I}(q_{t-d} > \gamma) + u_t \\ &= \delta_1' X_t (1 - \mathrm{I}(q_{t-d} > \gamma)) + \delta_2' X_t \mathrm{I}(q_{t-d} > \gamma) + u_t \\ &= \delta_1' X_t + (\delta_2' - \delta_1') X_t \mathrm{I}(q_{t-d} > \gamma) + u_t \end{aligned} \tag{5}$$

where $\delta_k \equiv \begin{bmatrix} \alpha_k \\ \beta_k \end{bmatrix}$ for $k = 1, 2, X_t \equiv \begin{pmatrix} 1 \\ unem_t \end{pmatrix}$. The variable $q_{t-d}$ represents the annual growth rate of the industrial production index at lag $d$. The specific test of the existence of threshold effects in the cointegrating equation takes the form of $H_o : \delta_1 = \delta_2$.

Table 3 provides the statistical results of testing for threshold effects in the cointegrating regressions. The tests show that for all three categories, Males, Females and All, there is a significant threshold effect, regardless of the lag $d$ chosen.

Table 4 shows the results of the estimation of the threshold cointegration regressions.[2] The regime can be split into an above-average growth regime and a below-average growth regime. For both Females and All, we find that a rise in unemployment in a below-average performing economy results in a rise in the labour force participation rate. This is consistent with the so-called added worker effect. In a below-average growth regime, rising unemployment signals contraction and causes more women to enter the labour market to support the family's pecuniary income and benefits, thus expanding the labour supply and contributing to an added worker effect. This is especially true if female workers fear that a family member may become jobless and lose benefits such as health care. By contrast, during an above-average growth regime, a rise in the female unemployment rate may be due to greater structural unemployment or geographic mismatches. In addition, during expansions male members of the family may more readily find employment, thus reducing the need for females to seek employment. Females will therefore tend to show a more traditional discouraged worker effect or perhaps a decreased added worker effect. For the case of males, it is clear that during times of below-average economic performance, a rise in the unemployment rate leads to a discouraged worker effect as jobs are simply hard to find. During periods when industrial production is expanding in an

[2] We set the delay parameter $d$=3 by reference to the maximum supLM statistic.

above-average fashion, increased unemployment is likely due to structural and geographic factors, similarly leading to discouraged worker effects. Indeed, in Table 4, the Males cointegrating regression indicates that there is no difference in the slope coefficient across regimes. Thus, for males, an increase in the unemployment rate, regardless of the regime, lowers the participation rate and this is consistent with a discouraged worker effect. One possible explanation for the difference between male and female responses is that female workers are more likely to be employed in services, where structural unemployment is likely to be lower, whereas males are concentrated in manufacturing and industry, where increased productivity and innovation makes it more likely for workers to become structurally unemployed and thus more susceptible to the discouraged worker effect. Also, over the very long sample period considered, males have tended to be the primary source of income to the family, whereas females have worked mainly to supplement household pecuniary income.

## VI. Conclusion

In this article, we discuss the long-run relationship between labour force participation rates and unemployment rates in the United States. These two variables are found to be cointegrated when one considers a nonlinear stationarity alternative hypothesis based on the TAR and M-TAR tests. Further, we apply the method of Gonzalo and Pitarakis (2006) to investigate whether there are threshold effects in the cointegrating relationships and find there is evidence to support this hypothesis. From the empirical results, we conclude that for an above-average growth regime, both males and females display a discouraged worker effect, so that the overall labour force exhibits such effects, as well. However, during periods of below-average growth, females present an added worker effect which is sufficiently powerful to offset the concomitant discouraged worker effect for males, thereby generating an added worker effect in the aggregate data. Thus, the interactions between labour force participation and unemployment rates are not only gender dependent (Emerson, 2011) or age dependent (Kakinaka and Miyamoto, 2012), but also regime dependent.

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