# What's behind the fall of the unemployment rate ?

Louis de Charsonville*

May 2014

**Abstract**

The US unemployment rate has steadily declined since the end of 2009 while the decrease in labor force participation sharpened, casting doubt on the relevance of the unemployment gap as a labor market slack indicator. In this paper, I develop an extension of the Hodrick-Prescott filter to provide a trend-cycle decomposition of the US labor force participation rate. Using a decomposition by cohorts, I estimate the role of the demographic change in the lessenning of the US participation rate. I show that two fifth of the aggregate decline of the participation rate between 2009 and 2013 is due to demographic factors, two fifth is due to structural factors and one fifth is due to cyclical factors.

*This note was written while I was doing an internship at the *Direction Generale* du Tresor in Washington DC, USA. This note was later published as a policy note with Guillaume Cléaud. I'm grateful to Guillaume Cléaud, Chivoine Rem and Alexandre Baclet for insightful comments and discussions.

# 1 Introduction

The unemployment rate has steadily decreased since its apex in the midst of the financial crisis. Culminating at 10.0% of the labor force participation in July 2009, it stands nearby 6.5% in the beginning of 2014. In the meantime, the employment rate had largely decreased in the course of the 2008 recession but had remained mostly flat since 2010. The uncoupling of the unemployment rate, the share of unemployed people in the labor force participation, and the employment rate, the share of the employed people in the working age population, stems from the large decrease in the labor force participaiton rate. The participation rate is defined as the share of the population at least sixteen years old which either employed or actively looking for a job. A large decrease in the participation rate could lead to a reduction of the unemployment rate because people are leaving the labor force, not because they find a job. Thus, the simultaneous decrease of the unemployment rate and the labor force participation casts doubts on the real amount of slack in the US economy in late 2013.

In the postwar period, labor force participation had been mostly acyclical, leading many economists to use the unemployment gap, the difference between the unemployment rate and the NAIRU[1], as a business cycle indicator and a proxy for the amount of slack in the labor market. The unemployment rate is also critical for the optimal monetary path as extensively discussed in the monetary policy literature: Clarida, Galı, and Gertler 2000, Orphanides 2003 or Taylor 1993. Moreover, the Federal Reserve dual mandate explicitly refers to the unemployment rate as an objective for the conduct of monetary policy. Consequently, knowledge on the relevance of the unemployment gap to gauge the amount of slack in the labor market is crucial for monetary policy.

The recent lessening of the participation rate adds noise to the decline of the unemployment rate. In 2012[2], the Federal Reserve set 6.5% as the unemployment

[1]Non-Accelerated Inflation Rate of Unemployment

[2]Federal Open Market Committee, 12 December 2012: "the Committee decided to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent"

rate target for triggering rate hikes. The unemployment had fallen from 7.9% in December 2012 to 6.7% in March 2016. This rapid decline along with the strong decrease of the participation rate spurred the Federal Reserve to update its forward guidance and withdraw its target for the unemployment rate[3].

A few studies have documented the reasons of the decrease of the labor participation rate and its implications for monetary policy. Three categories of explanations had been put forward to explain the decline in the participation rate. Demographic factors related to the aging population, cyclical factor related to a weak job market and structural factors. Erceg and Levin 2013 used OLS regressions to linked the change in unemployment rate to the change in the labor force participation rate. They conclude that a cyclical factor related to the weak job market - discouraged workers leave the workforce without finding a job - explains most of the decrease of the labor force. Aaronson et al. 2006 built a cohort-based model for labor force participation. Their analysis focuses on a demographic composition effect related to the aging population and baby-boomers (people born from 1946 to 1964) reaching retirement age, with no connection to the economic situation. They estimate that most of the decline in the participation after 2003 is due to this demographic composition effect. Van Zandweghe 2012 estimates a Beveredidge Nelson decomposition to conclude that long-term factors accounts for half of the decline from 2007 to 2011, while cyclical factors accounts for the other half. Hotchkiss and Rios-Avila 2013 use a behavioral model on micro-data and found that cyclical factors for more than the entire drop of the labor force participation rate between 2007 and 2012. Following these works, this paper proposes a reassessment of the factors of the decline in the labor market participation rate with a new methodology for computing slack measures as well as a clear cut decomposition along the three dimensions: demographic, structural and cyclical.

I first build a demographic-adjusted labor force participation rate to pull out demographic composition effect. I then use a trend cycle decomposition model to investigate the part of structural factors in the evolution of the participation rate. I find that two fifth of the aggregate decline between 2009 and 2013 in due to

[3]for example Janet Jellen in 2014

demographic factors, two fifths is due to structural factors and one fifth is due to cyclical factors. More precisely, I show that cyclical factors account for a substantive part of the sharp drop of the LFPR in the years succeeding the recession, it shifted to structural factors in more recent years.

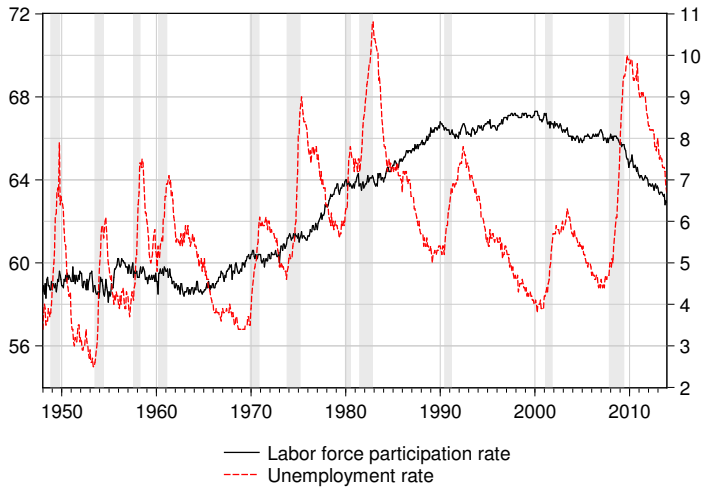



Figure 1: Labor Force Participation Rate and Unemployment rate

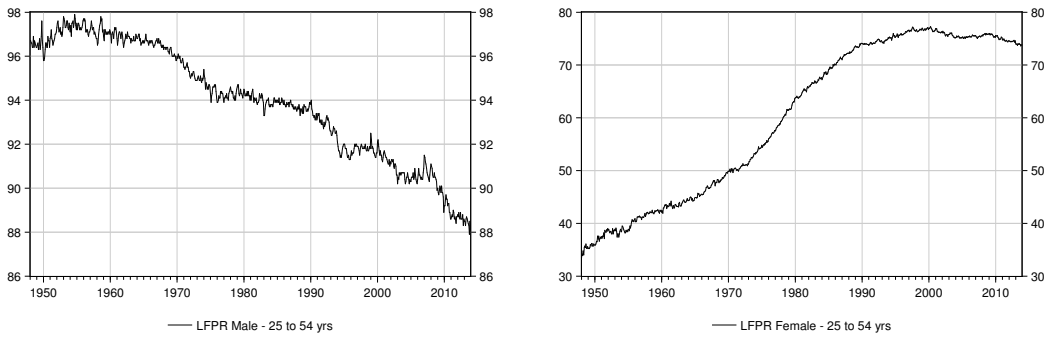
# 2 Demographics and labor force participation rate

## 2.1 Labor force participation since 1945

The labor force participation rate (LFPR) is defined as the percentage of the non institutional working-age population (those aged 16 and over) reporting themselves as either working or actively looking for work. Participation rate has steadily increase from the aftermath of the second world war to 2000. This increase largely stems from the steady increase in female labor force participation rate. Indeed, the baby-boom in the sixties and far-reaching institutional and technological changes had added millions of workers to the labor force. However, the evolution had differed among the different age-cohorts, as extensively discussed in Pencavel 1986 and Killingsworth and James J. Heckman 1986[4]. Prime-age males (aged between 25 to 54 years) LFPR is gradually decreasing since the after-war period. From

[4]For more details, see also Bowen and Finegan 1969, Mincer 1962, or Parsons 1980

97% in 1948, it reached 92% in 2000 (Figure 2a). Labor force withdrawal had been induced by the rapid expansion of welfare alternatives to work, like the Social Security Disability Program as discussed in Parsons (1980). Prime-age females (aged between 25 to 54 years) LFPR had been rising from the late 1940s to 2000 (Figure 2b). From 35% in 1948, it reached 77% in 1999. The widespread adoption of time-saving technologies (Greenwood, Seshadri, and Yorukoglu 2005), the medical advances and decreases in discrimination (Goldin 1990) had a great impact on the participation rate of married women. The steady increase of female labor participation contrasts with the decline of the male labor participation. These developments had been observed across most developed countries.

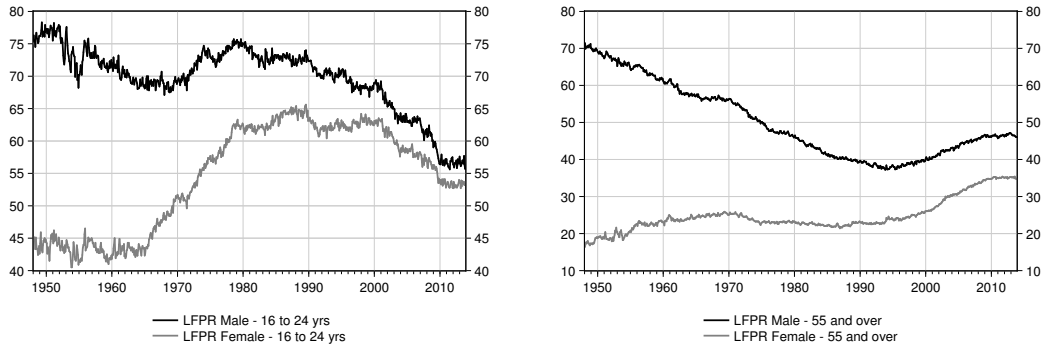



(a) Males - 25 to 54 yrs (b) Females - 25 to 54 yrs

Figure 2: Labor Force Participation Rate of Prime-age adults in the US

Youths (aged 16-24 years) labor force participation rate is decreasing since 1990: LFPR of male youths has decreased by 3.3pp while LFPR of female youths has decreased by 0.2pp (Figure 3a). The rising school enrollment is the major factor explaining this decline (Aaronson et al. 2006): the share of workers between 16 and 19 years old transitionning from high-school to college has increased and the longer of studies expanded (Figure 8).

Older males labor participation rate declined sharply from 70% in the 1950s to 35% in 1995 (Figure 3b), with the spread of early retirement as discussed in Peracchi and Welch 1994. Since 1995, both participation rate of male and female over 55 years old had been rising with the increase in retirement age.




(a) Workers - 16 to 24 yrs (b) Workers - 55 yrs and over

Figure 3: Labor Force Participation Rate in the US

## 2.2 Labor force participation rate and the unemployment rate since 2000

The labor force participation rate of prime-age adults (25-54) has decreased since 2000: from 84.4% in 2000 to 83% in 2007. Most of the decrease from 2000 to 2007 had been explained by demographic factors. Male participation rate had continued to steadily decrease while female participation rate had flatten, in partly due to the increase in child care costs[5]. The primary factor behind the male participation decline is the rising share of older workers. Indeed, the large increase of the fertility rate in the aftermath of the second world war had created an inflow of young workers in the workforce while there were few people in older age-cohorts. Since 2000, the retirement of the baby-boomers have entailed a decrease in the employed population. The increase in older workers pushed down the participation rate because their participation rate is lower (Figure 4b). A second factor is the reduction in labor force participation among youth. Longer studies and higher enrollment have entailed a decrease in the youth's participation rate.

Since 2007, the decrease of labor participation had sharpened. It reached its lowest levels in the past fourty years. The labor force participation rate decreased by 1pp between 2000 and 2007 and by 2.7pp between 2007 and 2013 (Figure 1). The female participation rate had declined along with the male participation rate.

[5]See Goldin (1990), Goldin and Katz (2002) and Connely (1992)

The participation rate of prime age adults, between 25 and 54 years old, which are not affected by longer studies or early retirement had also declined. Demographic factors have unlikely cause this sharp drop. However, since 1948, the participation rate has remained weakly pro-cyclical. Strong decline of the unemployment rate during recession did not lead to large decrease in the labor force participation rate. The 1982-83 recession resulted in the participation rate to stop increasing (Figure 1) but the effects were small and limited. The sharp drop suggests that cyclical weakness may explain part of the decline. A rolling regression of changes in labor force participation of prime-aged males and unemployment reveal that changes in the labor force and changes in the unemployment were uncorrelated from 1950 to 2007. Since 2010, the correlation is negative and significative, suggesting that labor force participation had become more sensitive to changes in slackness of the labor market (Figure 11).

However, since 2010, the participation rate had not recover despite the improvement of the economic outlook. Conversely, it has continued to decrease. This large decline contributed to the disconnection between the employment rate and the unemployment rate. Indeed, the relationship between the unemployment rate $u$, the employment rate $e$ and the participation rate $p$ writes:

$$e = p * (1 - u)$$

The employment rate had largely declined during the 2008 recession. Between 2008 and 2011, it fell by 5.2 percentage point. Since 2009, the employment rate had slighty increased despite a large decline in the unemployment rate. It suggests that other structural factors may have resulted in this decrease. The large amount of long term unemployed people and workers marginally attached to the labor force may result in hysteresis effects as discussed in Blanchard and Lawrence H. Summers 1986 and Clark and Lawrence H Summers 1982 . Indeed, long-term unemployed workers loose the opportunity to maintain and update their skills by working. After a long period of unemployment, the employability of these unemployed workers decrease. Discouraged workers can eventually leave the workforce, leading to a decrease in

the unemployment rate. One need to disentangle what portion of the decline can be attributable to changes in demographics, change in labor market conditions or structural changes.

## 2.3 Measuring the demographic composition effect

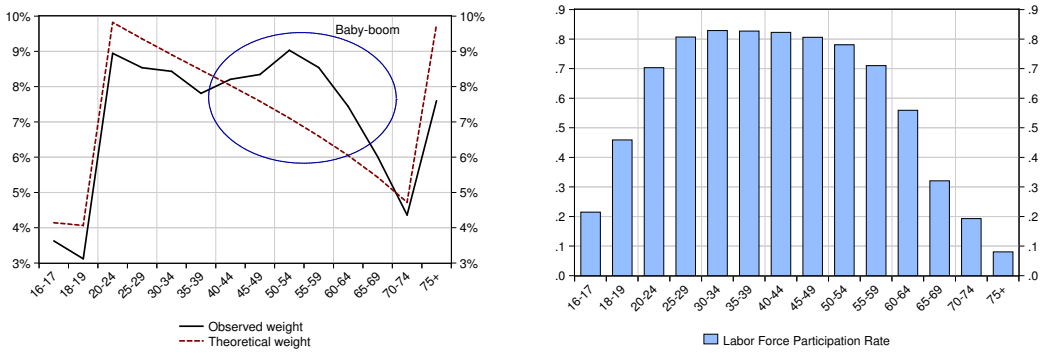
In order to measure the demographic composition effect, I construct a civilian labor force participation rate of people of 16 years old or more, adjusted for demographic composition. I divide the working age population in fine-grained age group of one year and compute a theoretic weight for each group given its observed survival rate. I discount that weight by the population growth rate. The weight of each age group represents the weight it would have had if survival rate and population growth had remained fixed at their 2009 level. The gap between the theoretical and real weights stems for the difference between past values of the population growth rate and its 2009 level[6]. Denoting $w_{jk}$ the demographic weight of people being age $j$ and $k$, $\alpha_i$ the survival rate of people of age $i$ and $g$ the population growth rate:

$$w_{jk} = \frac{\sum_{i=j}^{k} \omega_i}{\sum_{i} \omega_i} \tag{1}$$

$$with \ \ \omega_i = \frac{\prod_{l=1}^{i} (1 - \alpha_l)}{(1+g)^i} \tag{2}$$

I fix the population rate growth at its last know value 0.89% in 2009. Survival rate is the rate observed at each age[7].

[6] See Appendix A for data of population growth rate.
[7] See Appendix B for details on the data used.




(a) Adjusted weights per age-group (b) Participation rate per age cohorts

Figure 4: Weights and participation rate per age cohorts

The overrepresentation of working-age cohorts in the aggregate population is due to the baby boom contributed to a high labor force participation rate in the United States from 1970 to 1990 (Figure 4a). Indeed, the observed weight of the age classes between 50 and 69 years old is greater than the derived theoretic weight. This distinct bulge represents the baby-boom generation born in the United States between 1946 and 1964, when birth rates reached record highs. Since 1990, the retirement of the leading edge of the baby boom has driven down the US participation rate. The participation rate starts to decline after the age of 50, and then drops off sharply after the age of 60, which is the age that the first baby boomers born in 1946 reached in 2006 (see Figure 4b). Thus, the rising share of older age-cohorts pull down the participation rate. The retirement of the baby-boomers led to increasingly large negative contributions to changes in the US labor force participation rate.

Using this weights, I derived an adjusted labor force participation rate. The difference between the adjusted participation rate and the actual participation rate stems from the distortion in the distribution of age-cohorts. I find that the baby-boom generation contributes to a high participation rate: from 1970 to 1990, the participation rate had grown faster with the entrance of baby-boomers into the labor force. Conversely, from 2000, the retirement of baby-boomers induce the decline of the participation rate (see Figure 5).

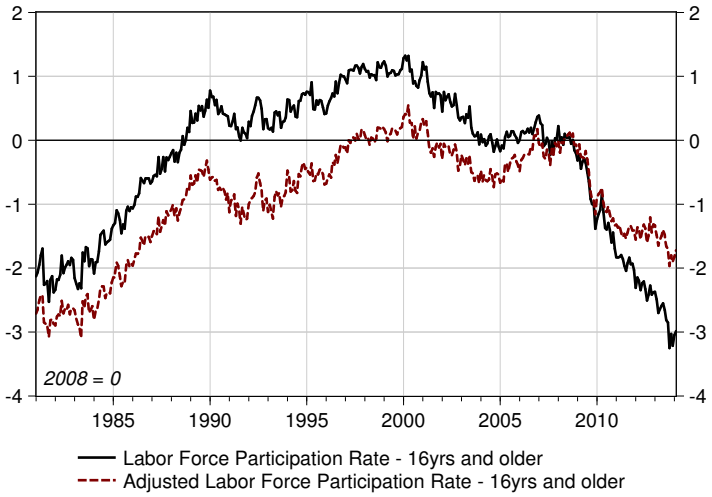



Figure 5: Adjusted Labor force participation rate

This findings suggest that the demographic composition effect account for nearly half of the drop in the labor force participation rate since 2007. From 2008 to February 2014, the labor force participation rate of 16yrs and older adults had declined by 3.3pp. The adjusted participation rate declined by 1.9pp. Demographic effects accounts for 1.4pp of the decline in the labor force participation rate. These results are in line with previous findings (see Aaronson et al. 2006).

# 3 Disentagling structural from cyclical factors

## 3.1 The model

The model is an extension an Hodrick-Prescott filter that takes into account the effects of unemployment on the structural and cyclical components of the labor force participation rate. The participation rate is adjusted for demographic composition, denoted $\tau_t^c$, is the sum of a structural participation rate, $\tau_t^*$, a cyclical component governed by the amount of slack in the labor market $x_{t-l}$ and an error term, $\epsilon_t$. The slack term captures the discouraged workers effect. In adverse labor market conditions, some workers temporarily quit the workforce due to a lack of job prospects. From 2007 to 2011, the number of discouraged workers, who are

not actively searching for work, has increased from 460,000 in 2008 on average to 120,000 in 2011. When the labor market tighten, workers rejoin the workforce. During economic expansions, entry on the labor market is easier and wages grow faster. Some youths might shorten their studies and older workers postpone their retirement.

$$\tau_t^c = \tau_t^* + \alpha(x_{t-l}) + \epsilon_t \tag{3}$$

A change in the slack measure temporarily alters the participation rate. Hence, the structural participation rate is also affected by a change in the slack measure due to hysteresis effects. Indeed, long-term unemployment leads to a decrease in skills and employability, as argued in Pissarides 1992. Long-term unemployed workers are more likely to quit the workforce to become discouraged workers. The structural participation is the sum of a slope, $\mu_t$ and the m-lagged slack measure:

$$\tau_{t+1}^* = \tau_t^* + \mu_t + \beta x_{t-m} \tag{4}$$

Finally, the slope of the structural participation rate follows a random walk :

$$\mu_{t+1} = \mu_t + \nu_t \tag{5}$$

The residuals of the model are defined by:

$$\epsilon_t = N(0, \sigma_\epsilon^2)$$
$$\nu_t = N(0, \sigma_\epsilon^2)$$
$$\sigma_\epsilon^2 = \lambda \sigma_\nu^2$$

The lags $l$ and $m$ on the slack measure are chosen in order to maximize the likelihood of the model using a grid-search algorithm (see heatmaps in Appendix A). The variations in the participation rate are proportionnal to the gap in the slack measure. The slope of the structural participation rate, $\mu$, may vary over time to allow for changes in the participation rate trend. Note that if $\alpha$ and $\beta$ are fixed at

zero in equation (3) and (4), the trend-cycle decomposition obtained is an Hodrick-Prescott filter of parameter $\lambda$.

## 3.2 Slack measures

Other studies have used the unemployment rate has a measure for slack in the trend-cycle decomposition (for example Van Zandweghe (2012)). However, the unemployment gap should be used as a slack measure with caution since its computation depends on the labor force participation level[8]: a change in the structural participation rate where people change from employed to either non-employed and non-looking for a job affects the unemployment rate while it does not affect the number of unemployed people. Therefore, besides the unemployment gap, I use alternative measure of the unemployment: the ratio of the unemployed population on the civilian working age population, the employment-population ratio and the ratio of unemployed and marginally-attached workers. For each measure of unemployment, I follow the same procedure to compute the gap between its current level and its natural long-term level. I use this gap as a slack measure. In order to assess the natural long-term level of unemployment measures, I estimate a Phillips curve in the spirit of Ball and Mankiw (2002):

$$\pi_t = \pi_{t-1} + \gamma \left(u_t - u_t^*\right) \tag{6}$$

where $\pi$ is the inflation rate, $u$ is the unemployment measure and $u^*$ its natural level. An increase the gap between the unemployment measure and its natural level results in the decrease of inflation (or an increase for the case of the employment ratio). I estimate $\gamma$ by OLS in:

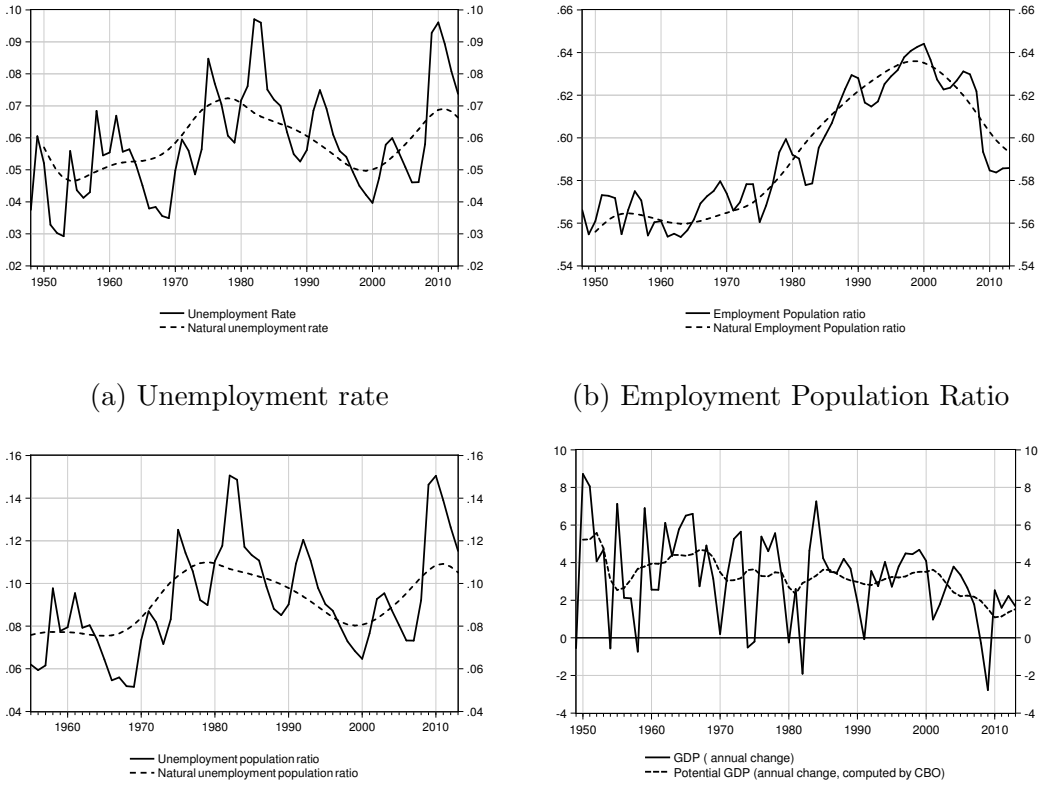
$$\pi_t = \pi_{t-1} + \gamma \left(u_t - \eta\right) + \epsilon_t \tag{7}$$

[8]The unemployment rate is the ratio of the unemployed and the civilian labor force.

Following Ball (2009), I interpret $\epsilon$ as a supply-shock. In equation (7) $\eta$ is the natural level of the unemployment measure and it is obtained by rewriting (6):

$$\eta - \frac{\epsilon}{\gamma} = u_t - \frac{\pi_t - \pi_{t-1}}{\gamma} \tag{8}$$

I smooth $\eta - \frac{\epsilon}{\gamma}$ with an Hodrick-Prescott filter to obtain $u^*$. Equation (7) is then estimated again with $u^*$ in lieu of $\eta$. This iterative procedure is done until $\gamma$ and $u^*$ converge. Figure 6 represents the different unemployment measures and their respective natural long-term level.




(a) Unemployment rate

(b) Employment Population Ratio

(c) Unemployment Population ratio

(d) Output

Figure 6: Slack measures

I then use $u - u^*$ with $u$ the unemployed ratio as a labor market slack measure in equations (3) and (4).

### 3.3 Results

Data is monthly[9]. The sample of estimation January 1981 to February 2014. Following Ravn and Uhlig 2002, I assume that $\lambda = 129,000$. I estimate the space-state model with different measures of slack. The estimation are presented in Table (1). The first one (1) is computed with the unemployment ratio gap as described in the previous section. The second one (2) uses the natural rate of unemployment as published by the Congressional Budget Office (CBO). The third model (3) uses the unemployment gap computed with the procedure described in the previous section. The fourth model (4) uses the output gap computed by the CBO. The fifth model (5) uses the employment gap computed with the procedure described above. The findings are consistent between the five measures of slack (see Figure 10).

Table 1: Structural labor force participation rate, Space-State Models

| Slack | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Lags | (7,1) | (7,1) | (7,1) | (3,1) | (1,5) |
| $\alpha$ | $-0.19^{***}$ | $-0.14^{***}$ | $-0.14^{***}$ | $0.06^{***}$ | $0.26^{***}$ |
| | (0.02) | (0.01) | (0.01) | (0.006) | (0.01) |
| $\beta$ | $-0.006^{***}$ | $-0.004^{***}$ | $-0.004^{***}$ | $0.005^{***}$ | $0.008^{***}$ |
| | (0.001) | (0.0007) | (0.0008) | (0.0004) | 0.0008 |
| Observations | 398 | 398 | 398 | 398 | 398 |
| Log likelihood | 1896.1 | 1889.0 | 1896.0 | 1892.3 | 1932.2 |

Standard errors in brackets.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

The model predicts that a widening of the slack measure leads to a lessening of the structural participation rate. Using model (2) and the standard measure of the unemployment gap, an increase by $1pp$ of the unemployment gap lead to a decrease of the participation rate by $0.14pp$ due to cyclical factors and a decline of the structural participation rate by $0.004pp$. The results show that, contrary to conventional wisdowm, the participation rate has a cyclical component: after deep recessions, the

[9]Refer to appendix for information regarding the source used here.

unemployment rate decrease partly due to the lessening of the participation rate. It also confirms the increasing correlation between the participation rate and the unemployment rate as suggested by the OLS regressions computed in the previous section. Indeed, during recessions, the participation gap, the difference between the adjusted participation rate and the structural participation rate, widen (see Figure 7). Moreover, large and lengthy rise in the unemployment gap entails a decline in the structural participation rate.

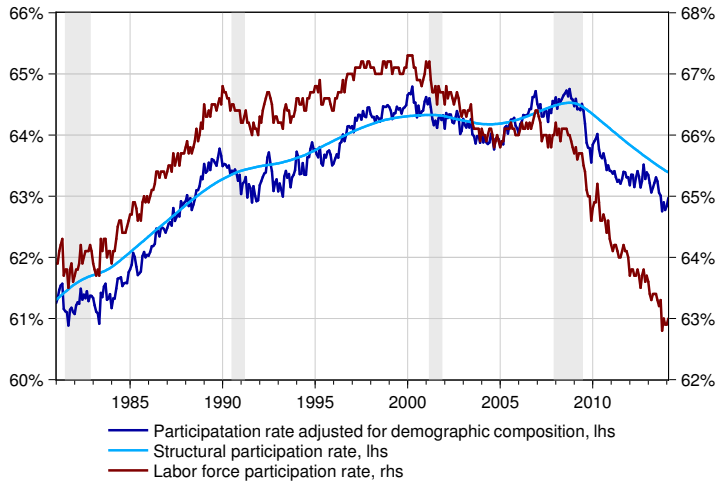



Figure 7: Structural and cyclical labor force participation rate

Table 2 reports statistics summarizing the aggregate change of the participation rate and along the five dimensions. Results are computed using model (1) of the Table 1. Other models lead to very similar results (see Appendix A, Figure 10)The decline in the participation rate is increasingly structural as the crisis recedes and the job market improves. The participation rate has decreased by -2.8% since 2013. Demographic composition effects explains 1.1pp of this decrease. The structural participation rate is estimated to have decreased by 1.1 percentage points between 2008 and 2013. Cyclical factors explains -0.4 points of the decrease of the participation rate.

In 2009 and 2010, discouraged workers leaving the labor force accounts for 0.8pp of the 1.3 decline the participation rate, explaining most of its decrease. This is line with results by Erceg and Levin (2013) which estimate that the decline in

the after-crisis period is mostly cyclical. Nonetheless, the continuing decline of the participation rate as the unemployment rate edges downwards, is increasingly structural. The closing of the unemployment gap had reduced the effect of cyclical factors in 2012-2013. As job creations abide at a brisk pace, the labor market tightened again and discourage workers thin out. In 2013, most of the decline of the participation rate is due to structural factors. Hysteresis effects accounts for -0.5pp of the decline between 2007 and 2013 as long-term unemployed are pushed away of the labor force participation rate despite improvement on the labor market. Other structural factors explained 0.6pp of the decline in the participation rate. These factors represents the contribution of non-business cycles changes. Since 2000, they represent a sizeable contribution to the changes in the labour force participation rate.

Table 2: Decomposition of contributions to the participation rate

| | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| Cumulative change in the participation rate | -0.6 | -1.3 | -1.9 | -2.3 | -2.8 |
| Demographic composition effects | -0.1 | -0.3 | -0.5 | -0.9 | -1.1 |
| Hysteresis effects | -0.1 | -0.2 | -0.4 | -0.5 | -0.5 |
| Other structural factors | 0.0 | -0.1 | -0.2 | -0.4 | -0.6 |
| Discouraged worker effects | -0.4 | -0.7 | -0.6 | -0.4 | -0.3 |
| Other cyclical factors | 0.0 | 0.0 | -0.2 | -0.1 | -0.1 |

*Notes:* contributions are in percentage deviation from 2008.
*Source:* BLS, Household Survey

## 3.4 Projections

In projection, the model forecasts a continuing decline in the labor force participation rate to 62.4% in December 2015. Our projections are based on the assumption that the unemployment rate will continue its steady decline to reach 5.5% in December 2015. Demographic composition effects are expected to be the primary reason for this decline. When adjusted for demographic composition effects, the participation rate should be much more stable, owing to the decrease of the discouraged worker effect as the unemployment rate falls. However, it is assumed that other structural factors will maintain their trend and should cause a slight decrease

in the participation rate. On the whole, the projections seem to be in line with the findings in the recent relevant literature. The BLS (2013)[10] projects that the labour force participation rate in the United States will fall by an average of 0.2 percentage points per year up until 2022. The complete clearing of the cyclical component of the declining participation rate (discouraged worker effects and other cyclical factors) could contribute to an increase in the participation rate of up to 0.3 percentage points, as some 700,000 non-participants to return to the labour market.

# 4 Conclusion

From 2009 to 2013, the labor participation rate had decreased by 2.8 points. Demographic factors, mainly through the retirement of baby-boomers cohorts, resulted in a decline in the labor force participation by 1.1pp. Hysteresis effects accounts for 0.5pp of the decline while other structural factors account for 0.6pp. Cyclical factors had accounted for a great part of the decline of the participation in the succeeding years after the recession. However, as the job market improves, discouraged workers are brought back into the workforce while long-term unemployed might be alienated from the labor force. In 2013, cyclical factors account for 0.4pp of the decline. I estimate the number of remaining discouraged worker in mid-2014 to be close to 700,000, which would add 0.3% of the unemployment rate. The findings suggest that the unemployment rate correctly accounts for the degree of slack in the labor market. On the other hand, the decline in the participation rate is unlikely to reverse in the medium run, adversely affecting the labor supply.

[10] See "Labor force projections to 2022: the labor force participation rate continues to fall," Bureau of Labor Statistics, December 2013.

# References


Aaronson, Stephanie et al. (2006). "The Recent Decline in the Labor Force Participation Rate and Its Implications for Potential Labor Supply". In: *Brookings Papers on Economic Activity* 1, pp. 69–154. ISSN: 1533-4465.

Ball, Laurence M. (2009). "Hysteresis in Unemployment: Old and New Evidence". In: *NBER Working Papers*, pp. 1–37.

Ball, Laurence and N N Gregory Mankiw (2002). "The NAIRU in Theory and Practice The Role of NAIRU". In: *Journal of Economic Perspectives—Volume* 16.4, pp. 115–136. ISSN: 0895-3309.

Ben-Porath, Yoram (1973). "Labor-Force Participation Rates and the Supply of Labor". In: *Journal of Political Economy* 81.3, p. 697. ISSN: 0022-3808.

Blanchard, Olivier and Lawrence H. Summers (1986). *Hysteresis and the European Unemployment Problem*. Vol. 1, pp. 15–78. ISBN: 0262061058. arXiv: arXiv:1011.1669v3.

Bowen, William G and T Aldrich Finegan (1969). *The Economics of Labor Force Participation*. Princeton, NJ: Princeton University Press.

Clarida, R., J. Galı, and M. Gertler (2000). "Monetary policy rules in practice: some international evidence". In: *The Quarterly Journal of Economics* 115.1, pp. 147–180. ISSN: 0033-5533, 1531-4650.

Clark, Kim B and Lawrence H Summers (1982). "Labour Force Participation: Timing and Persistence". In: *Review of Economic Studies* 49.5, pp. 825–844. ISSN: 0034-6527.

Connelly, Rachel (1992). "The Effect of Child Care Costs on Married Women's Labor Force Participation". In: *The Review of Economics and Statistics* 74.1, pp. 83–90. ISSN: 0034-6535.

Erceg, Christopher J and Andrew T Levin (2013). "Labor Force Participation and Monetary Policy in the Wake of the Great Recession". In: *IMF Working Paper*.

Gali, Jordi (2010). "The return of the wage Phillips curve". In: *National Bureau of Economic Research Working Paper Series* 16758, pp. 261–335. ISSN: 0304-3932.

Goldin, Claudia (1990). *Understanding the Gender Gap: An Economic History of American Women*. Oxford University Press. ISBN: 978-0195072709.

Goldin, Claudia and Lawrence F. Katz (2002). "The Power of the Pill: Oral Contraceptives and Women's Career and Marriage Decisions". In: *Journal of Political Economy* 110.4, pp. 730–770. ISSN: 00223808.

Greenwood, Jeremy, Ananth Seshadri, and Mehmet Yorukoglu (2005). "Engines of liberation". In: *Review of Economic Studies* 72.1, pp. 109–133. ISSN: 00346527.

Heckman, James J (1974). "Effects of Child-Care Programs on Women ' s Work Effort Effects of Child-Care Programs on Women ' s Work Effort". In: *Journal of Political Economy* 82.2, pp. 136–169.

Hotchkiss, Julie L. and Fernando Rios-Avila (2013). "Identifying Factors behind the Decline in the U.S. Labor Force Participation Rate". In: *Business and Economic Research* 3.1. ISSN: 2162-4860.

Killingsworth, Mark R. and James J. Heckman (1986). "Chapter 2 Female labor supply: A survey". In: *Handbook of Labor Economics* 1.C, pp. 103–204. ISSN: 15734463.

Mincer, Jacob (1962). *Labor Force Participation of Married Women: A Study of Labor Supply Chapter*. Vol. 1. 06, pp. 63–106. ISBN: 0870143050.

Nelson, Charles R. and Charles Plosser (1982). "Trends and random walks in macroeconomic time series". In: *Journal of Monetary Economics* 10.1, pp. 139–162. ISSN: 01640704.

Orphanides, Athanasios (2003). *Historical monetary policy analysis and the Taylor rule*.

Parsons, Donald O. (1980). "The decline in teen labor force participation". In: *Journal of Political Economy* 88.1, pp. 117–134. ISSN: 0022-3808.

Pencavel, John (1986). "Chapter 1 Labor supply of men: A survey". In: *Handbook of Labor Economics* 1.C, pp. 3–102. ISSN: 15734463.

Peracchi, Franco and Finis Welch (1994). "Trends in Labor Force Transitions of Older Men and Women". In: *Journal of Labor Economics* 12.2, pp. 210–242. ISSN: 0734-306X.

Pissarides, Christopher (1992). "Loss of skill during unemployment and the persistence of employment shocks". In: *The Quarterly Journal of Economics* 107.4, pp. 1371–1391. ISSN: 0033-5533.

Ravn, Morten O. and Harald Uhlig (2002). "Notes on adjusting the Hodrick-Prescott filter for the frequency of observations". In: *The Review of Economics and Statistics* 84.2, pp. 371–380. ISSN: 0034-6535.

Shimer, Robert (2008). "The Probability of Finding a Job". In: *American Economic Review* 98.2, pp. 268–273.

Taylor, John B. (1993). "Discretion versus policy rules in practice". In: *Carnegie-Rochester Confer. Series on Public Policy* 39.C, pp. 195–214. ISSN: 01672231.

Van Zandweghe, Willem Van (2012). "Interpreting the Recent Decline in Labor Force Participation". In: *Federal Reserve Bank of Kansas City*, pp. 5–34.

# Appendix A - Tables and graphs

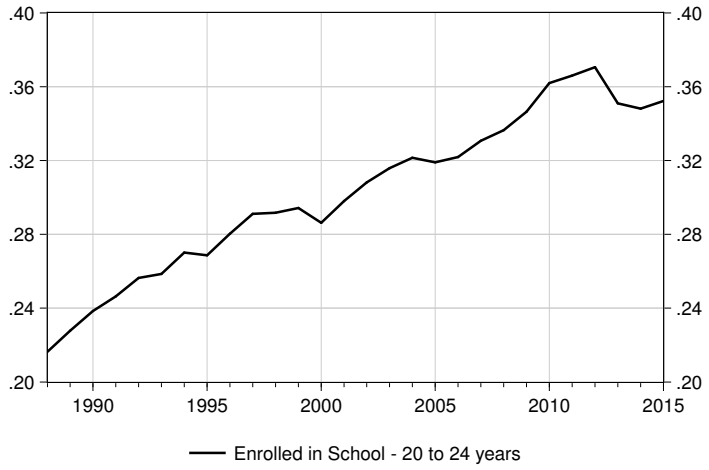



Figure 8: Rate of youths between 20 and 24 years enrolled in school

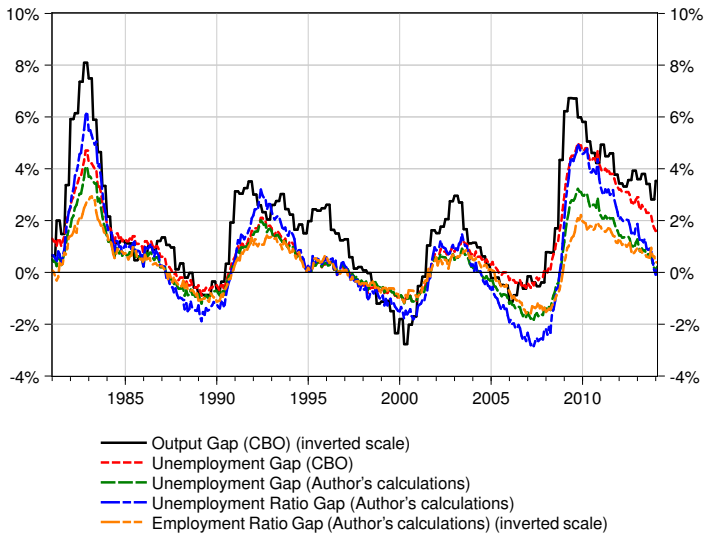



Figure 9: Slack measures

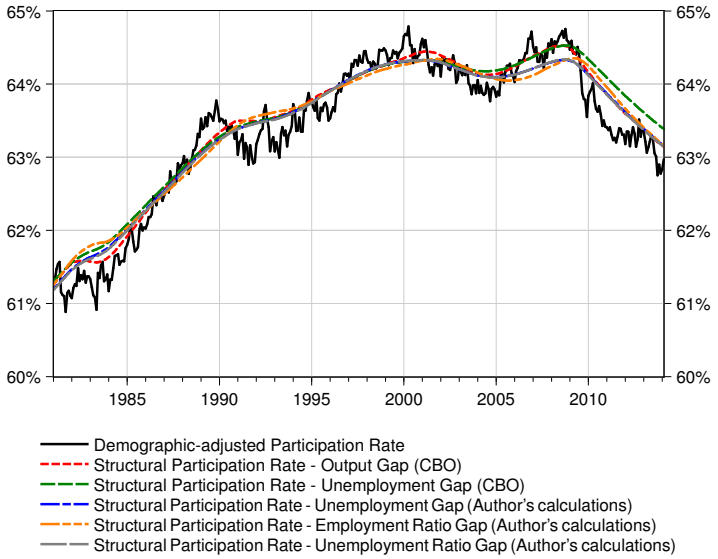



Figure 10: Structural Participation Rate for different slack measures

## Heat Maps

The figures displayed the log-likelihood as a function of lags of the slack in the space-state model.

**Unemployment Gap - Ball**

| Lags Structural \ Lags - cyclical | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1892.97676 | 1892.7812 | 1892.4065 | 1891.7631 | 1890.8089 | 1889.5841 | 1887.8509 | 1885.6421 | 1882.9441 | 1879.6951 | 1875.938 | 1871.5482 |
| 2 | 1893.69734 | 1893.6972 | 1893.5316 | 1893.1562 | 1892.5731 | 1891.7869 | 1890.6181 | 1889.0838 | 1887.1566 | 1884.7675 | 1881.9294 | 1878.4784 |
| 3 | 1894.11851 | 1894.0112 | 1894.0111 | 1893.8178 | 1893.4713 | 1893.0123 | 1892.2489 | 1891.2299 | 1889.9199 | 1888.2443 | 1886.1995 | 1883.6224 |
| 4 | 1895.34017 | 1895.1925 | 1895.1215 | 1895.1211 | 1894.9792 | 1894.7689 | 1894.3481 | 1893.7351 | 1892.9275 | 1891.8466 | 1890.4842 | 1888.6667 |
| 5 | 1895.8 | 1895.5733 | 1895.4258 | 1895.3228 | 1895.3229 | 1895.2583 | 1895.0373 | 1894.7045 | 1894.2292 | 1893.5702 | 1892.7143 | 1891.5014 |
| 6 | 1894.67487 | 1894.3003 | 1894.0267 | 1893.8044 | 1893.6567 | 1893.6566 | 1893.5187 | 1893.3096 | 1893.0265 | 1892.6101 | 1892.0754 | 1891.282 |
| 7 | 1895.95468 | 1895.5359 | 1895.2153 | 1894.9673 | 1894.7942 | 1894.7344 | 1894.7343 | 1894.6692 | 1894.5632 | 1894.3857 | 1894.1252 | 1893.6836 |
| 8 | 1895.28216 | 1894.7721 | 1894.3747 | 1894.051 | 1893.8162 | 1893.6843 | 1893.5916 | 1893.5915 | 1893.5551 | 1893.479 | 1893.3692 | 1893.128 |
| 9 | 1893.61772 | 1893.031 | 1892.5647 | 1892.1857 | 1891.8899 | 1891.6974 | 1891.5459 | 1891.4593 | 1891.4593 | 1891.4301 | 1891.3879 | 1891.2715 |
| 10 | 1891.78184 | 1891.1573 | 1890.6623 | 1890.2623 | 1889.9505 | 1889.7262 | 1889.551 | 1889.4319 | 1889.3726 | 1889.3721 | 1889.3632 | 1889.3118 |
| 11 | 1888.64464 | 1888.0117 | 1887.5252 | 1887.1436 | 1886.8527 | 1886.6473 | 1886.4831 | 1886.3705 | 1886.2971 | 1886.2608 | 1886.2616 | 1886.2385 |
| 12 | 1888.25135 | 1887.7225 | 1887.3465 | 1887.0838 | 1886.9105 | 1886.8017 | 1886.7305 | 1886.6892 | 1886.6677 | 1886.6549 | 1886.6519 | 1886.652 |

**Unemployment Gap - CBO**

| Lags Structural \ Lags - cyclical | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1884.19832 | 1883.9889 | 1883.6012 | 1882.978 | 1882.0759 | 1880.923 | 1879.325 | 1877.3193 | 1874.8869 | 1871.9861 | 1868.6785 | 1864.8769 |
| 2 | 1885.59472 | 1885.5954 | 1885.4305 | 1885.0786 | 1884.5306 | 1883.7907 | 1882.7038 | 1881.2894 | 1879.5185 | 1877.3319 | 1874.7722 | 1871.7136 |
| 3 | 1886.40188 | 1886.3294 | 1886.3296 | 1886.1575 | 1885.8368 | 1885.4016 | 1884.6844 | 1883.7329 | 1882.5023 | 1880.9278 | 1879.0355 | 1876.6893 |
| 4 | 1887.58659 | 1887.4775 | 1887.4182 | 1887.4182 | 1887.282 | 1887.0696 | 1886.6588 | 1886.0665 | 1885.2801 | 1884.2235 | 1882.9115 | 1881.2061 |
| 5 | 1888.27066 | 1888.0938 | 1887.9725 | 1887.8902 | 1887.8902 | 1887.8213 | 1887.6001 | 1887.2695 | 1886.7913 | 1886.1222 | 1885.2653 | 1884.0901 |
| 6 | 1887.55331 | 1887.2404 | 1887.0062 | 1886.8182 | 1886.6915 | 1886.6914 | 1886.5565 | 1886.3492 | 1886.0584 | 1885.623 | 1885.0706 | 1884.278 |
| 7 | 1888.99623 | 1888.6329 | 1888.3491 | 1888.1334 | 1887.9822 | 1887.9319 | 1887.9318 | 1887.866 | 1887.7489 | 1887.5459 | 1887.2577 | 1886.7973 |
| 8 | 1888.59818 | 1888.1296 | 1887.7579 | 1887.4567 | 1887.2371 | 1887.1134 | 1887.0242 | 1887.0242 | 1886.9792 | 1886.8809 | 1886.7451 | 1886.4797 |
| 9 | 1887.58961 | 1887.0275 | 1886.5708 | 1886.1997 | 1885.9075 | 1885.7171 | 1885.5656 | 1885.4813 | 1885.4812 | 1885.4404 | 1885.3833 | 1885.2491 |
| 10 | 1886.62689 | 1886.0016 | 1885.4911 | 1885.0722 | 1884.742 | 1884.5026 | 1884.3134 | 1884.1866 | 1884.124 | 1884.1234 | 1884.1123 | 1884.0519 |
| 11 | 1884.06368 | 1883.3869 | 1882.8356 | 1882.3875 | 1882.032 | 1881.7696 | 1881.5549 | 1881.403 | 1881.304 | 1881.2494 | 1881.2493 | 1881.2159 |
| 12 | 1883.83997 | 1883.197 | 1882.6921 | 1882.2955 | 1881.9961 | 1881.78 | 1881.613 | 1881.4926 | 1881.417 | 1881.3686 | 1881.3527 | 1881.3522 |

**Unemployment Gap - CBO**

| Lags Structural \ Lags - cyclical | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1889.97277 | 1889.7251 | 1889.2319 | 1888.4375 | 1887.3094 | 1885.8989 | 1883.9678 | 1881.5984 | 1878.7462 | 1875.3368 | 1871.4094 | 1866.83 |
| 2 | 1891.50221 | 1891.5026 | 1891.2771 | 1890.8163 | 1890.1184 | 1889.207 | 1887.8902 | 1886.2392 | 1884.1999 | 1881.6712 | 1878.6834 | 1875.0497 |
| 3 | 1892.94435 | 1892.8957 | 1892.8956 | 1892.6813 | 1892.2928 | 1891.7765 | 1890.9318 | 1889.8543 | 1888.4864 | 1886.7229 | 1884.5675 | 1881.8352 |
| 4 | 1894.49526 | 1894.4178 | 1894.3651 | 1894.3651 | 1894.2062 | 1893.9722 | 1893.5035 | 1892.8637 | 1892.0278 | 1890.8946 | 1889.4562 | 1887.519 |
| 5 | 1895.2672 | 1895.108 | 1894.9857 | 1894.8931 | 1894.8931 | 1894.8259 | 1894.5849 | 1894.2494 | 1893.7703 | 1893.0841 | 1892.1842 | 1890.8891 |
| 6 | 1894.25639 | 1893.9343 | 1893.6723 | 1893.453 | 1893.301 | 1893.301 | 1893.1502 | 1892.9484 | 1892.6711 | 1892.2408 | 1891.6771 | 1890.8251 |
| 7 | 1895.75234 | 1895.378 | 1895.0664 | 1894.8178 | 1894.642 | 1894.5856 | 1894.5856 | 1894.5391 | 1894.4557 | 1894.2836 | 1894.0162 | 1893.5415 |
| 8 | 1894.4138 | 1893.9105 | 1893.4892 | 1893.1355 | 1892.8688 | 1892.7144 | 1892.5982 | 1892.5982 | 1892.5665 | 1892.4857 | 1892.362 | 1892.0866 |
| 9 | 1892.59288 | 1891.9876 | 1891.4797 | 1891.0559 | 1890.7155 | 1890.4875 | 1890.3042 | 1890.2062 | 1890.2063 | 1890.1711 | 1890.1192 | 1889.9773 |
| 10 | 1891.10894 | 1890.4492 | 1889.9026 | 1889.4526 | 1889.0919 | 1888.8305 | 1888.6218 | 1888.4874 | 1888.4234 | 1888.4237 | 1888.4136 | 1888.3486 |
| 11 | 1888.22038 | 1887.5325 | 1886.9762 | 1886.529 | 1886.1821 | 1885.9293 | 1885.7273 | 1885.5898 | 1885.505 | 1885.4598 | 1885.4581 | 1885.4296 |
| 12 | 1888.21302 | 1887.6111 | 1887.159 | 1886.8233 | 1886.5849 | 1886.4274 | 1886.3148 | 1886.2417 | 1886.2006 | 1886.1795 | 1886.1726 | 1886.1727 |

**Employment / Population Ratio**

| Lags Structural \ Lags - cyclical | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1931.67578 | 1931.7061 | 1931.8615 | 1932.1345 | 1932.228 | 1931.9981 | 1931.3257 | 1930.3196 | 1928.7383 | 1926.7999 | 1924.462 | 1921.7982 |
| 2 | 1923.14446 | 1923.144 | 1923.176 | 1923.3526 | 1923.4417 | 1923.2895 | 1922.7978 | 1922.0832 | 1920.984 | 1919.5814 | 1917.9198 | 1916.0464 |
| 3 | 1915.16369 | 1914.7805 | 1914.7803 | 1914.838 | 1914.8633 | 1914.7453 | 1914.3738 | 1913.841 | 1913.0382 | 1912.0582 | 1910.8624 | 1909.5476 |
| 4 | 1906.54224 | 1905.9567 | 1905.6283 | 1905.6286 | 1905.5553 | 1905.4013 | 1905.0907 | 1904.671 | 1904.059 | 1903.3393 | 1902.5039 | 1901.574 |
| 5 | 1903.57033 | 1902.9596 | 1902.5812 | 1902.4214 | 1902.4213 | 1902.3246 | 1902.1291 | 1901.8785 | 1901.4878 | 1901.0223 | 1900.4841 | 1899.9043 |
| 6 | 1902.94596 | 1902.383 | 1902.0257 | 1901.8502 | 1901.7653 | 1901.7652 | 1901.6672 | 1901.5439 | 1901.3381 | 1901.0814 | 1900.776 | 1900.4503 |
| 7 | 1904.34815 | 1903.9069 | 1903.623 | 1903.4788 | 1903.404 | 1903.3663 | 1903.3666 | 1903.3326 | 1903.2554 | 1903.1572 | 1903.0286 | 1902.8879 |
| 8 | 1901.84384 | 1901.5352 | 1901.3419 | 1901.2361 | 1901.1751 | 1901.1365 | 1901.1083 | 1901.1089 | 1901.0844 | 1901.0553 | 1901.0204 | 1900.9827 |
| 9 | 1902.50679 | 1902.4126 | 1902.3868 | 1902.3911 | 1902.4028 | 1902.417 | 1902.4294 | 1902.436 | 1902.4363 | 1902.44 | 1902.4474 | 1902.4546 |
| 10 | 1898.58453 | 1898.7258 | 1898.9031 | 1899.0644 | 1899.2076 | 1899.3296 | 1899.4332 | 1899.4995 | 1899.5515 | 1899.5516 | 1899.5692 | 1899.5826 |
| 11 | 1893.87836 | 1894.2997 | 1894.7431 | 1895.1307 | 1895.4716 | 1895.7747 | 1896.0453 | 1896.2413 | 1896.3997 | 1896.4913 | 1896.4915 | 1896.5024 |
| 12 | 1886.74601 | 1887.4703 | 1888.2145 | 1888.8969 | 1889.51 | 1890.0695 | 1890.5875 | 1891.0091 | 1891.364 | 1891.6113 | 1891.7611 | 1891.7601 |

**Output - Gap**

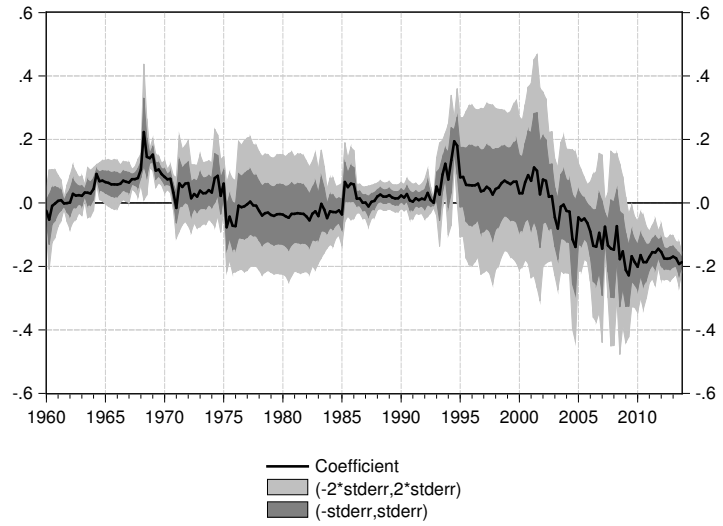
| Lags Structural \ Lags - cyclical | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1864.61883 | 1864.3403 | 1863.8334 | 1863.2226 | 1862.3451 | 1861.0539 | 1859.296 | 1856.9339 | 1853.828 | 1850.0035 | 1845.6181 | 1840.7142 |
| 2 | 1865.15041 | 1865.1502 | 1864.9243 | 1864.5841 | 1864.2105 | 1863.4603 | 1862.2776 | 1860.7203 | 1858.4588 | 1855.4793 | 1851.9535 | 1847.8131 |
| 3 | 1865.24681 | 1865.0515 | 1865.0516 | 1864.9305 | 1864.7602 | 1864.4564 | 1863.7583 | 1862.7172 | 1861.2127 | 1859.0328 | 1856.3145 | 1853.0073 |
| 4 | 1864.06009 | 1863.6371 | 1863.3371 | 1863.3371 | 1863.2776 | 1863.0789 | 1862.7196 | 1862.0552 | 1860.9763 | 1859.431 | 1857.399 | 1854.8158 |
| 5 | 1862.12007 | 1861.4869 | 1860.9299 | 1860.5964 | 1860.5964 | 1860.457 | 1860.1563 | 1859.7648 | 1859.0078 | 1857.8412 | 1856.3725 | 1854.4166 |
| 6 | 1861.5235 | 1860.6788 | 1860.0146 | 1859.5237 | 1859.2901 | 1859.2901 | 1859.1291 | 1858.8678 | 1858.4419 | 1857.6483 | 1856.5832 | 1855.1936 |
| 7 | 1861.45788 | 1860.4875 | 1859.665 | 1859.1024 | 1858.7431 | 1858.5532 | 1858.5533 | 1858.4468 | 1858.1759 | 1857.7337 | 1857.0472 | 1856.0669 |
| 8 | 1860.58581 | 1859.49 | 1858.5247 | 1857.7835 | 1857.3214 | 1856.9843 | 1856.7794 | 1856.7794 | 1856.6212 | 1856.298 | 1855.8981 | 1855.2409 |
| 9 | 1861.15112 | 1859.9519 | 1858.9533 | 1858.1534 | 1857.5925 | 1857.227 | 1856.9549 | 1856.8308 | 1856.8309 | 1856.6726 | 1856.432 | 1856.0836 |
| 10 | 1861.9602 | 1860.6946 | 1859.624 | 1858.7947 | 1858.1746 | 1857.7174 | 1857.4211 | 1857.2307 | 1857.1199 | 1857.1198 | 1857.0346 | 1856.8437 |
| 11 | 1861.01431 | 1859.6423 | 1858.4773 | 1857.5522 | 1856.8728 | 1856.3409 | 1855.9412 | 1855.6977 | 1855.5072 | 1855.3849 | 1855.3851 | 1855.2901 |
| 12 | 1861.17961 | 1859.7568 | 1858.5747 | 1857.6381 | 1856.9386 | 1856.4162 | 1856.0094 | 1855.7311 | 1855.5438 | 1855.4004 | 1855.3301 | 1855.3319 |

## Rolling estimation

The following equation is estimated from 1950 to 2013 on a 10 years rolling window.

$$\Delta p_t = c + \alpha \Delta u_t + \epsilon_t$$

Figure 11 represents $\alpha$.




Notes: Rolling regressions performed on 10-years between change in participation rate and change in unemployment rate.

Figure 11: Coefficients of unemployment rate in the rolling OLS regression.

# Appendix B - Data and Sources

Main timeseries used and sources are provided below:

| Variable | Source |
|---|---|
| Labor force participation rate | Current Population Survey - Bureau of Labor Statistics |
| Unemployment rate | Current Population Survey - Bureau of Labor Statistics |
| Unemployment Level | Current Population Survey - Bureau of Labor Statistics |
| Number Unemployed for 27 Weeks & over | Current Population Survey - Bureau of Labor Statistics |
| Civilian Labor Force Level | Current Population Survey - Bureau of Labor Statistics |
| Survival rate | Household Survey 2009 - Bureau of Labor Statistics |
| Working Age Population: Aged 15-64 | OECD |
| Real Potential Gross Domestic Product | US. Congressional Budget Office |
| Natural Rate of Unemployment | US. Congressional Budget Office |

# Appendix C

FOMC STATEMENT - DECEMBER 12, 2012

Information received since the Federal Open Market Committee met in October suggests that economic activity and employment have continued to expand at a moderate pace in recent months, apart from weather-related disruptions. Although the unemployment rate has declined somewhat since the summer, it remains elevated. [...] To support continued progress toward maximum employment and price stability, the Committee expects that a highly accommodative stance of monetary policy will remain appropriate for a considerable time after the asset purchase program ends and the economic recovery strengthens. In particular, **the Committee decided to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent**. [...]

FOMC STATEMENT - MARCH 19, 2014

Information received since the Federal Open Market Committee met in January indicates that growth in economic activity slowed during the winter months, in part reflecting adverse weather conditions. Labor market indicators were mixed but on balance showed further improvement. The unemployment rate, however, remains elevated. [...] **With the unemployment rate nearing 6-1/2 percent, the Committee has updated its forward guidance.** The change in the Committee's guidance does not indicate any change in the Committee's policy intentions as set forth in its recent statements. [...]