

What's behind the fall of the unemployment rate ?

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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 lessening 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.

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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 participation 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 NAIRU¹, 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, Galí, 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 2012², the Federal Reserve set 6.5% as the unemployment

¹Non-Accelerated Inflation Rate of Unemployment

²Federal 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 rate³.

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 Beveridge 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 is due to

³for 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.

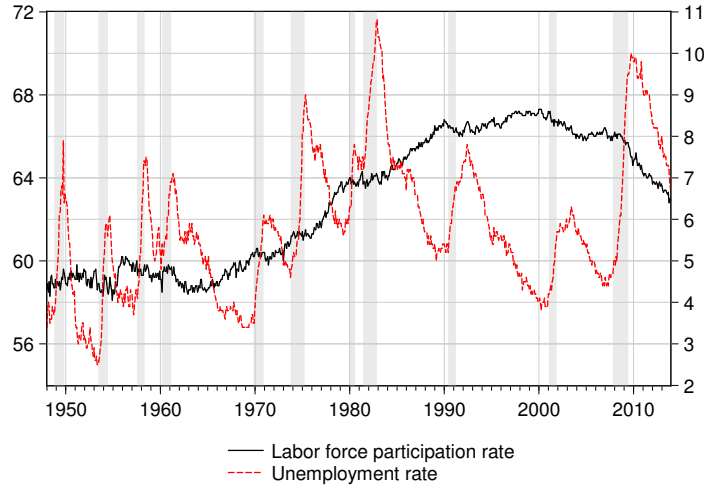


Figure 1: Labor Force Participation Rate and Unemployment rate

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

⁴For 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.

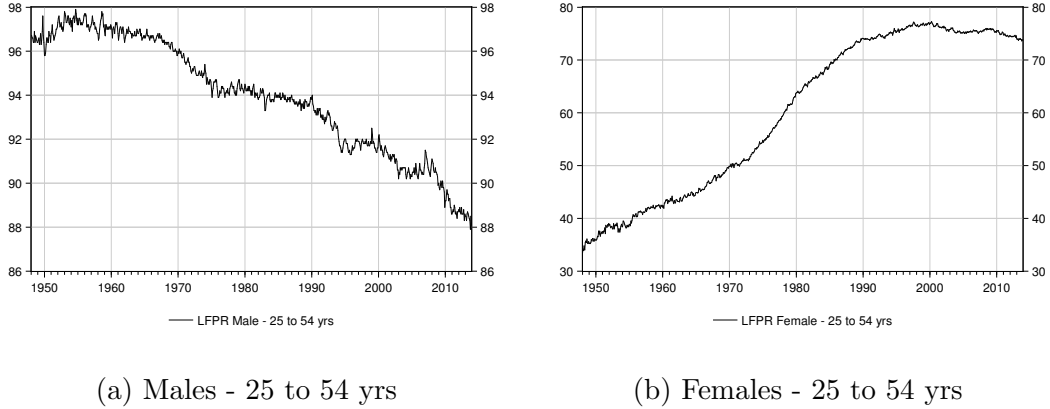
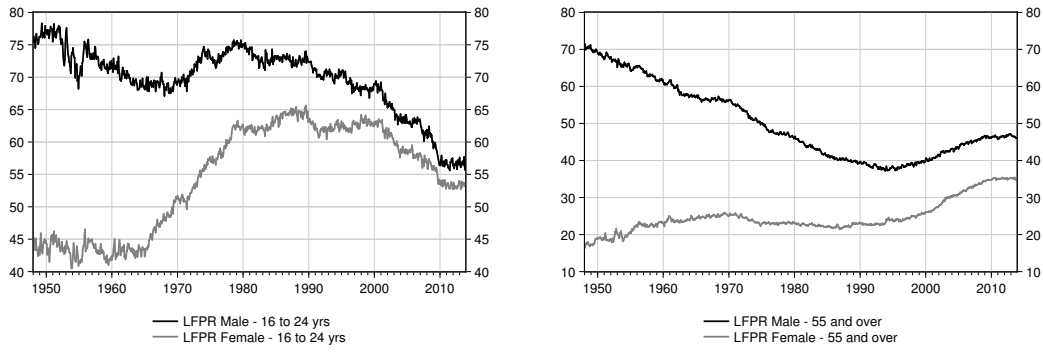


Figure 2: Labor Force Participation Rate of Prime-age adults in the US

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 flattened, in partly due to the increase in child care costs⁵. 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 forty 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.

⁵See 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 slightly 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 level⁶. Denoting w_{jk} the demographic weight of people being age j and k , α_i the survival rate of people of age i and g the population growth rate:

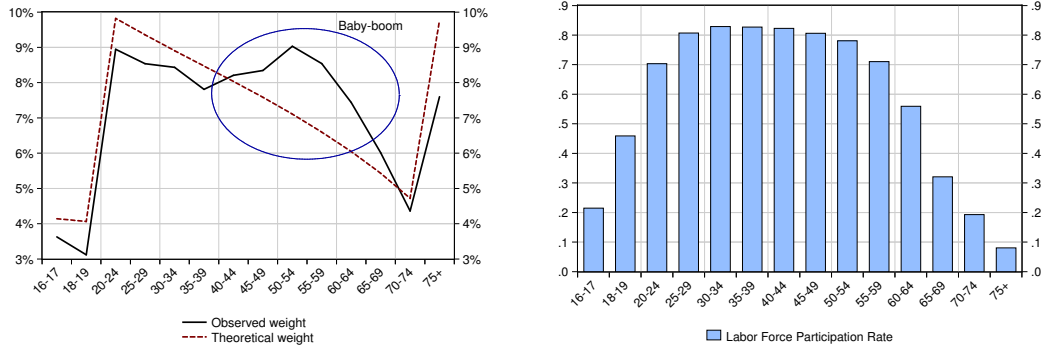
$$w_{jk} = \frac{\sum_{i=j}^k \omega_i}{\sum_i \omega_i} \quad (1)$$

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

I fix the population rate growth at its last know value 0.89% in 2009. Survival rate is the rate observed at each age⁷.

⁶See Appendix A for data of population growth rate.

⁷See 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).

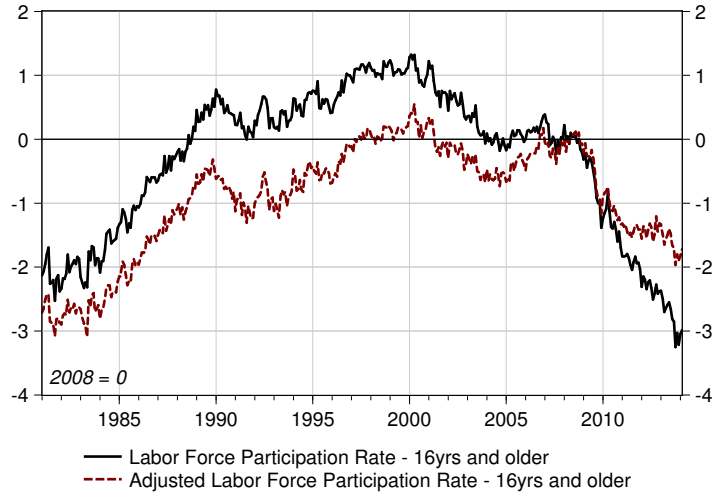


Figure 5: Adjusted Labor force participation rate

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 τ_t^c , is the sum of a structural participation rate, τ_t^* , a cyclical component governed by the amount of slack in the labor market x_{t-l} and an error term, ϵ_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 tightens, 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.

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

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, μ_t and the m-lagged slack measure:

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

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

$$\mu_{t+1} = \mu_t + \nu_t \quad (5)$$

The residuals of the model are defined by:

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

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

$$\sigma_\epsilon^2 = \lambda \sigma_\nu^2$$

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, μ , may vary over time to allow for changes in the participation rate trend. Note that if α and β are fixed at

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

3.2 Slack measures

Other studies have used the unemployment rate as 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 level⁸: 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):

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

where π 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 γ by OLS in:

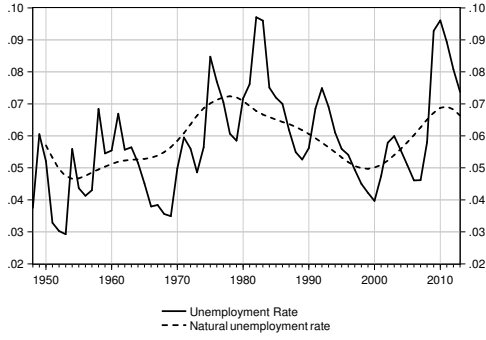
$$\pi_t = \pi_{t-1} + \gamma (u_t - \eta) + \epsilon_t \quad (7)$$

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

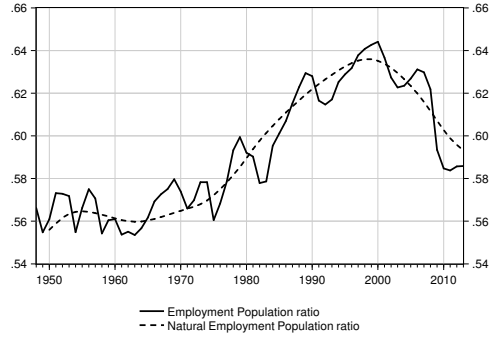
Following Ball (2009), I interpret ϵ as a supply-shock. In equation (7) η is the natural level of the unemployment measure and it is obtained by rewriting (6):

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

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 η . This iterative procedure is done until γ and u^* converge. Figure 6 represents the different unemployment measures and their respective natural long-term level.



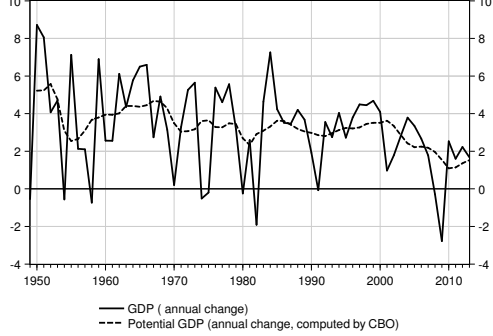
(a) Unemployment rate



(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 monthly⁹. 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)
α	−0.19*** (0.02)	−0.14*** (0.01)	−0.14*** (0.01)	0.06*** (0.006)	0.26*** (0.01)
β	−0.006*** (0.001)	−0.004*** (0.0007)	−0.004*** (0.0008)	0.005*** (0.0004)	0.008*** 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 wisdom, the participation rate has a cyclical component: after deep recessions, the

⁹Refer 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.

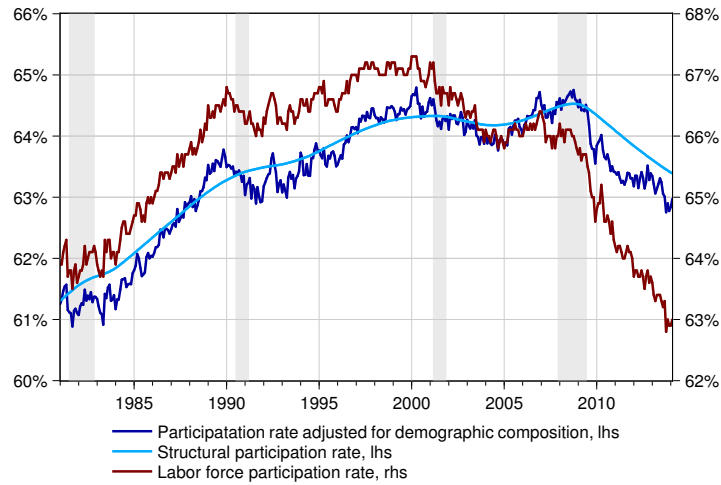


Figure 7: Structural and cyclical labor force participation rate

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 explain 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 explain -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.

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

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Appendix A - Tables and graphs

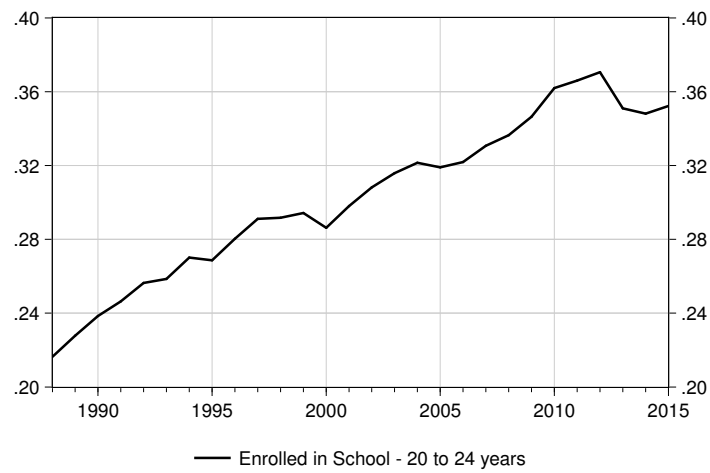


Figure 8: Rate of youths between 20 and 24 years enrolled in school

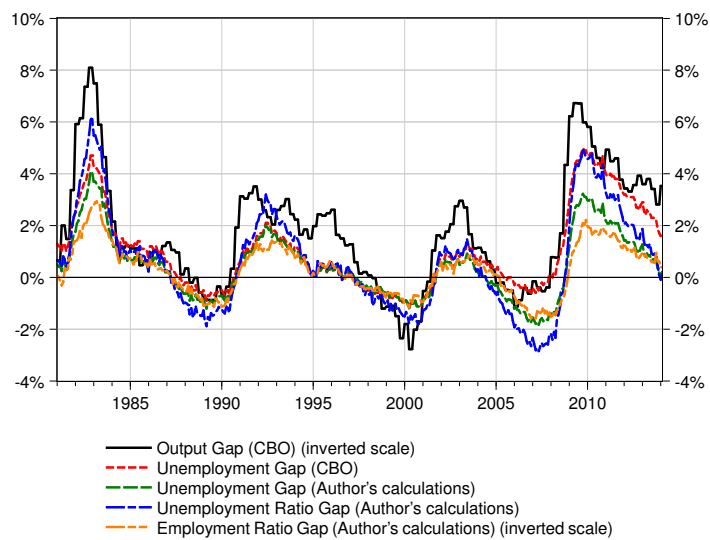


Figure 9: Slack measures

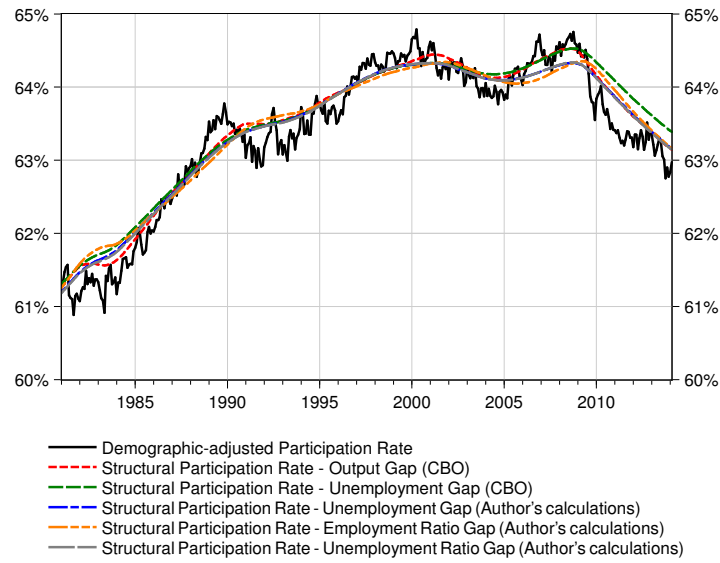


Figure 10: Structural Participation Rate for different slack measures

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 - cyclical											
		1	2	3	4	5	6	7	8	9	10	11	12
Lags Structural	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 - cyclical											
		1	2	3	4	5	6	7	8	9	10	11	12
Lags Structural	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	

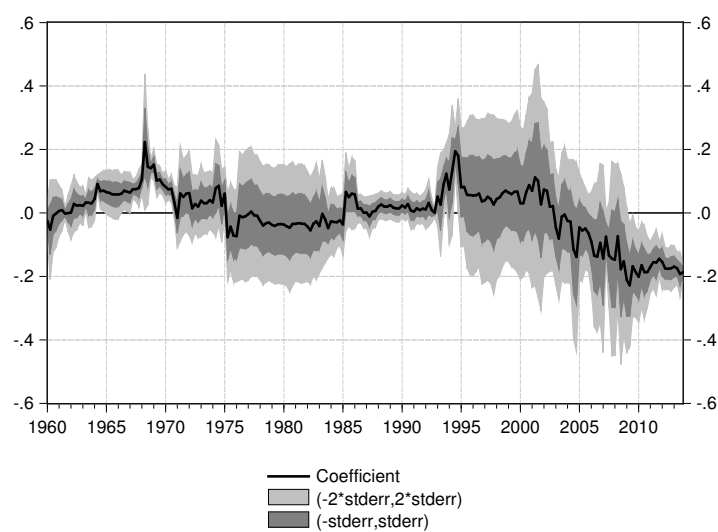
Output - Gap												
Lags Structural	Lags - cyclical											
	1	2	3	4	5	6	7	8	9	10	11	12
	1864.61883	1864.3403	1863.8334	1863.2226	1862.3451	1861.0539	1859.296	1856.9339	1853.828	1850.0035	1845.6181	1840.7142
	1865.15041	1865.1502	1864.9243	1864.5841	1864.2105	1863.4603	1862.2776	1860.7203	1858.4588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



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. [...]