Quantifying the Lasting Harm to the U.S. Economy from the Financial Crisis *

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Abstract

The financial crisis and ensuing Great Recession left the U.S. economy in an injured state. In 2013, output was 13 percent below its trend path from 1990 through 2007. Part of this shortfall—3.0 percentage points of real GDP—was the result of lingering slackness in the labor market in the form of abnormal unemployment and substandard weekly hours of work. The single biggest contributor was a shortfall in business capital, which accounted for 3.9 percentage points. The second largest was a shortfall of 3.5 percentage points in total factor productivity. The fourth was a shortfall of 2.4 percentage points in labor-force participation. I discuss these four sources of the injury in detail, focusing on identifying state variables that may or may not return to earlier growth paths. The conclusion is optimistic about the capital stock and slackness in the labor market and pessimistic about reversing the declines in total factor productivity and the part of the participation shortfall not associated with the weak labor market.

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The years since 2007 have been a macroeconomic disaster for the United States of a magnitude unprecedented since the Great Depression. The disaster has spawned a literature in macroeconomics that emphasizes the collapse of product and labor demand and the inability to offset the collapse with conventional monetary expansion because of the zero lower bound. For a discussion along these lines with cites to that literature, see Hall (2013).

Here I take for granted that the financial crisis was the cause of the collapse in product and labor demand and that expansionary policy was unable to offset the collapse. I offer a complementary analysis of other aspects of the post-crisis economy, focusing on the durable effects of the crisis that a boost in product demand would not correct quickly. These effects are

- Lost total factor productivity
- Lost investment resulting in a lower capital stock
- Unemployment and short weekly hours of work lingering after job-creation incentives have returned to normal
- A persistent decline in labor-force participation

Table 1 provides estimates of these and other changes in the economy following the crisis (an appendix and accompanying spreadsheets describe the calculations in detail). For the U.S. business sector, it calculates the shortfall of output from trend after 2007 and breaks the shortfall into components of total factor productivity, capital, and labor. The trend for each variable is measured from 1990 through 2007. The rows for years show the values of variables as the difference the variable would have contributed to output growth, had the variable continued on its pre-crisis trend, and its actual contribution in each year. For example, output in 2009 grew 7.4 percent less than its pre-crisis trend. The bottom panel shows the cumulative shortfall, in percentage points, over the two and five years following the crisis in 2008. For example, as of 2013, output was 13.3 percent below trend, the sum of the numbers in the first column of the top panel. The basic data come from John Fernald's calculations of annual total factor productivity—see Fernald (2012). Fernald breaks productivity growth into a component reflecting changes in factor utilization and a residual, but I combine the two into an overall measure of productivity change. He reports labor input as total hours worked. Using additional data from the Bureau of Labor Statistics, I have decomposed the

Year (s)	*Output*	*Produc-tivity*	*Capital contri-bution*	*Popu-lation*	*Labor-force partici-pation*	*Employ-ment rate*	*Hours per week*	*Labor quality*	*Business fraction*
2008	4.9	3.0	0.2	0.3	0.0	0.8	0.5	-0.3	0.3
2009	7.4	1.7	0.8	0.3	0.6	2.4	1.6	-0.4	0.4
2010	0.1	-1.6	1.0	0.3	0.6	0.3	-0.5	0.0	0.0
2011	0.5	0.3	0.8	0.4	0.5	-0.4	-0.2	0.1	-0.9
2012	-0.1	0.1	0.6	-0.1	0.4	-0.6	-0.4	0.0	-0.1
2013	0.5	0.1	0.5	0.3	0.3	-0.3	-0.2	0.3	-0.3
2007 through 2010	12.4	3.1	2.1	0.8	1.2	3.5	1.6	-0.6	0.7
2007 through 2013	13.3	3.5	3.9	1.3	2.4	2.2	0.8	-0.3	-0.5

Table 1: Components of the Shortfall of Output Two and Five Years after the Crisis

total into those arising from changes in population, labor-force participation, the employment rate (one minus the unemployment rate), hours per week, labor quality (from Fernald), and the fraction of total labor input that the business economy employs (as opposed to government and households). I calculate hours per week as a residual, by dividing total hours by the product of the population growth factor, the participation growth factor, and the employment rate growth factor. The change in the resulting measure has a correlation of 0.81 with the change in weekly hours from the Current Population Survey. The sources of this moderate discrepancy is mainly that Fernald uses hours per job and I use hours per worker. These differ because a fraction of workers have two or more jobs.

The shortfall shown in the bottom panel is on a different conceptual basis from the output gap. The gap is usually viewed as the amount that output would rise if frictions and distortions suddenly disappeared. It may also be the amount that expansionary monetary and fiscal policy could raise output. Key state variables such as total factor productivity and the capital stock are taken at their actual current values, not at hypothetical values that would have prevailed if earlier frictions and distortions had not impaired the performance of the economy. My framework is to use pre-crisis trends to provide a benchmark for understanding the effects of the crisis. I do not take a stand on the economic cost of the crisis, a concept with meaning only by describing a superior policy that could have avoided some of the effects of the crisis. Even to begin to think about the cost, it would be essential to focus on consumption rather than output.

The column headed *Capital contribution* is the elasticity of the production function with respect to the capital stock (about 0.38) times the log-change in the stock. Similarly, the columns relating to the components of labor input report the product of the labor elasticity (about 0.62) times the percentage shortfall in those components.

The period from 2007 through 2010 captures the Great Recession. I depart from the NBER's identification of the end of the recession in 2009 because the labor-market indicators continued to decline through 2010. During the three-year period, the shortfall in output cumulated to 11.3 percent. Shortfalls in output occurred because of higher unemployment and a correspondingly lower employment rate (2.3 percentage points), lower productivity (3.0 percentage points), the reduction in the capital contribution on account of the collapse of investment (3.5 percentage points), declining labor-force participation (1.2 percentage points), and declining weekly hours of work (1.6 percentage points). The only component moving in the opposite direction was rising labor quality, which cut the shortfall by 0.6 percentage points.

By 2013, the picture changed. The total shortfall in output was only slightly larger, at 13.3 percent compared to 12.4 percent two years earlier. The continuing shortfall in plant and equipment investment cumulated to account for 3.9 percentage points, well above its earlier contribution of 2.1 percentage points.The shortfall in labor-force participation grew to 2.4 percentage points. On the other hand, the part of the shortfall associated with unemployment declined, from 3.5 percentage points to 2.2. hours per week returned to 0.8 percent below its trend path in 2012. Low utilization of labor, in the form of high unemployment and low hours, subsided, while depleted capital and a shift of the population away from the labor market cut more sharply into output growth.

This paper concentrates on four of the larger components in the bottom line of Table 1: productivity, capital, unemployment, and participation.

The analysis reaches the following conclusions:

Productivity: The post-crisis slowdown in total factor productivity growth may be a result of the crisis, but the evidence is weak. Similar slowdowns over 6-year periods have been common. A study of detailed industries does not point toward diminished factor utilization or any other causal mechanism. A boost to product demand seems unlikely to induce a catch-up in productivity.

Capital stock: Discount rates applicable to capital formation rose sharply during the crisis and have remained high in the following years, notwithstanding a drop in low-risk interest rates. This force and the other adverse forces unleashed in the crisis lowered output, compounding the adverse effect on investment from the rise in the discount. The result is a capital stock 13.2 percent below its level had the economy grown along its earlier trend during the post-crisis years and a capital contribution 10.2 percent below trend (growth in capital's share accounts for the difference). Despite this shortfall, the capital/output ratio was above its trend value in 2013. Only when output begins to grow fast enough to offset the large output shortfall will investment begin to move back to its pre-crisis trend path. Because the capital stock is a state variable incapable of making jumps, it would be impossible for a boost to product demand to restore the crisis-induced shortfall in capital. As time passes and the adverse effects of the crisis on product demand and discount rates dissipate, capital will return to its pre-crisis growth path.

Unemployment: Job-creation incentives returned to normal soon after the crisis. Hours of work of employed individuals also returned a good part of the way back to normal. These two facts would normally coincide with a return to normal unemployment rates in the range of 5.5 to 6.0 percent. And the unemployment rate in early 2014, at 6.7 percent, is most of the way back toward its normal range. But the labor market looked different to jobseekers in the post-crisis years than it did to employers and employed individuals. In 2013, the average job-finding rate of the unemployed was only barely higher than at the trough of the recession in 2009. The decline in that rate is entirely the result of a dramatic shift—arguably the result of the crisis—in the composition of the unemployed, toward those with low job-finding rates even in normal times. A boost to product demand would quickly tighten the labor market and reduce unemployment, but the crisis-induced decline in matching efficiency would remain in place and dissipate only slowly. An unusually tight market from the perspective of employers and employed individuals would accompany the decline in unemployment.

Labor-force participation: The labor-force participation rate was essentially constant between 1990 and 2007, then plunged by 3 percentage points from the crisis through 2013. It has shown no sign of flattening out, much less returning to its pre-crisis level. About one percentage point of this fall is demographic—during the post-crisis period, baby-boomers began to reach the age when participation drops rapidly through retirement. About 0.5 percentage points arise from low job-finding rates, which result in the classification of many people as out of the labor force when they are actually searching, as is apparent from their job-finding rates. Dependence on disability benefits has risen by almost another half percent of the working-age population. Dependence on earnings-contingent benefit programs—mainly food stamps and Medicaid—rose substantially after the crisis and has not declined as the labor market has tightened. These programs impose tax rates on earnings that, according to a model of participation, could account for some part of the remaining one percentage point decline in participation. The effect of low job-finding rates would respond to a boost in product demand. The relation between labor-market conditions and disability-food stamps-Medicaid dependence is uncertain. Thus the reversal of the decline in participation resulting from these programs by a boost in product demand is equally uncertain.

1 Total Factor Productivity

Fernald (2014) discusses many aspects of productivity growth in the post-crisis years. I confine my treatment to a limited set of observations incremental to his.

Table 1 shows that total factor productivity (TFP)—inclusive of utilization fluctuations—contributed a shortfall in output through 2010 of 3.1 percentage points, nothwithstanding growth above trend in 2010. Productivity growth was essentially on its normal track in 2011 through 2013. Though the real business cycle model launched a tradition of treating TFP as an exogenous driving force, there seems a potential case that the crisis caused the shortfall in TFP in the years immediately following the crisis.

The statistical evidence on this point is remarkably weak. The standard deviation of 6-year changes in Fernald's measure of TFP over the period 1948 through 2007 was 4.4 percentage points, so the 3.4 percentage point shortfall during the years following the crisis is well under one standard deviation.

1.1 Findings from cross-industry data on TFP

The Bureau of Labor Statistics compiles a database of inputs and outputs for 56 industries covering the entire private economy. Growth rates of inputs are measured by their Tørnqvist indexes (log changes weighted by the average of the current and lagged factor shares) and TFP growth is Solow's residual calculated as the difference between output growth and sum of the growths of all inputs. I study the changes between 2007 and 2011 in TFP and the inputs.

Fernald (2012) attributes some of the fluctuations in TFP to changes in the utilization of capital and of hours of work. The basis for this adjustment is the observed correlation of measured TFP without adjustment for utilization with hours of work. The logic is that the first-order condition for cost minimization equalizes the marginal factor cost of all margins of adjustment, so utilization should move in proportion to hours. The net effect of his utilization adjustment is small, but it is the method finds large increases in utilization in 2008 and 2009 matched by decreases in 2010 and 2011.

I investigated the utilization issue in the industry cross section of four-year changes in output and inputs. Suppose the true change in log TFP a is

$$a = y - x - v, \tag{1}$$

where y is the log-change in output, x is the sum of the log-changes in capital and labor, properly adjusted for utilization, and v is the sum of the log-changes in factors without utilization variations: materials, energy, and services. Let $\hat{x} = x - u$: Observed log-changes in capital and labor are the true changes less the unobserved change in utilization, u. Measured TFP change is $\hat{a} = y - \hat{x} - v$. The covariance of measured TFP change with the correctly measured change in variable factors is

$$\mathrm{Cov}(\hat{a}, v) = \mathrm{Cov}(a + u, v) = \mathrm{Cov}(a, v) + \mathrm{Cov}(u, v). \tag{2}$$

By Fernald's logic, if unmeasured utilization changes are contaminating TFP measures, $\mathrm{Cov}(u, v) > 0$. The sign of $\mathrm{Cov}(a, v)$ is controversial. The real business cycle model found this covariance to be positive in the aggregate (and therefore on the average in a cross section of industries). Basu, Fernald and Kimball (2006) find it to be negative.

In the cross-section of industries over the four-year period from 2007 through 2011, the covariance of TFP growth and the change in variable inputs is unambiguously negative. The regression coefficient with the change in log TFP as the left-hand variable and the sum of the weighted changes in log materials, energy, and services is -0.248 with a standard error of 0.086. Thus any utilization effects are swamped by the adverse effects of TFP growth on output and variable inputs. This evidence suggests that utilization variations are not an important element of fluctuations in measured TFP growth.

This finding may be consistent with the idea that the crisis resulted in cuts in inputs that were redundant even before the shock hit. Many commentators have attributed the burst of TFP growth just after the crisis in these terms.

Changes in output are somewhat positively correlated with measured TFP growth, but there are many industries with very large declines in output but with positive TFP changes and many with large increases in output but small increase or even decreases in TFP, such as oil and gas extraction.

The three largest industries, finance, insurance, and real estate (NAICS 52-53), trade (NAICS 42, 44-45), and real estate (NAICS 531), all had essentially zero TFP growth over the four years.

There seems to be little evidence that a decline in capital utilization was important over the four years. No single explanation of the decline in TFP growth stares out of the data.

1.2 Conclusions about productivity growth

Given the volatility of medium-term TFP growth, Fernald's hypothesis is plausible that rapid TFP growth in the decade before the crisis was the result of an unsustainable burst of production and adoption of information technology, so part of the post-crisis slowdown was not the result of the crisis.

Because TFP evolves as a trended random walk, any shock, such as the shortfall below trend that cumulated to 3.4 percentage points by 2013, is presumptively permanent or nearly so. Technological advance is cumulative. The interruption that apparently (but hardly conclusively) resulted from the crisis will hold back output well into the future. Some theories of productivity growth predict gradual reversion to a growth path and others predict that shocks have permanent effects.

2 Capital Contribution

I noted in the introduction that one of the most important legacies of the disaster that began in 2008 is the shortfall in capital resulting from the cumulation of low investment after the crisis. The business capital stock at the end of 2013 was 13.2 percent below its trend path. Here I include three kinds of business investment—plant, equipment, and intellectual property. I also discuss two kinds of household investment—housing and consumer durables—but these are not included in the capital stock in Table 1, which refers to business and excludes both capital and output in households and government.

Investment theory emphasizes two key factors in capital accumulation: the risk-adjusted cost of capital and the demand for output. Although exceptions to the Modigliani-Miller principle abound, it remains the case that the cost of funds, hurdle rate, or discount appropriate for a given type of investment depends on the financial risk of the investment, not the mode of financing. Financial risk involves the correlation of the return with returns in general or with the marginal utility of consumption.

2.1 Risk premiums in the stock market

The stock market appears to be the best source of information about risk premiums for business earnings. The discount applicable to the earnings of a publicly traded corporation is the expected return to an investor holding the corporation's securities. Financial economics has evolved a two-step approach to measurement of the expected return. The first is to estimate the expected return to the stock market as a whole, usually stated as an equity premium over a safe interest rate. The second step is to regress the return for a specific investment on the general stock-market return. The expected return on the investment is inferred as the coefficient multiplied by the equity premium plus the safe interest rate.

Although it has been common to take the equity premium as essentially a constant, around 6 percent per year, modern thinking in finance stresses variations over time—see Cochrane (2011) for a recent review of this issue. In particular, when the level of the stock market is high, relative to a benchmark such as dividends, expected returns are lower. Normalized consumption is another reliable predictor of returns. Figure 1 shows the equity premium for the S&P stock-price index from a regression of annual returns on those two variables (see Hall (2014) for further discussion and details of its construction). The risk premium spiked in 2009, an event surely of importance to investment.

2.2 The capital wedge

The risk premium is one component of the wedge between the return to business capital and the risk-free interest rate. Other components are taxes, financial frictions, and liquidity premiums. To measure the total wedge, I calculate the annual return to capital and subtract the one-year safe interest rate from it.

The calculation of the return to capital uses the following thought experiment: A firm purchases one extra unit of investment. It incurs a marginal adjustment cost to install the investment as capital. During the year, the firm earns incremental gross profit from the

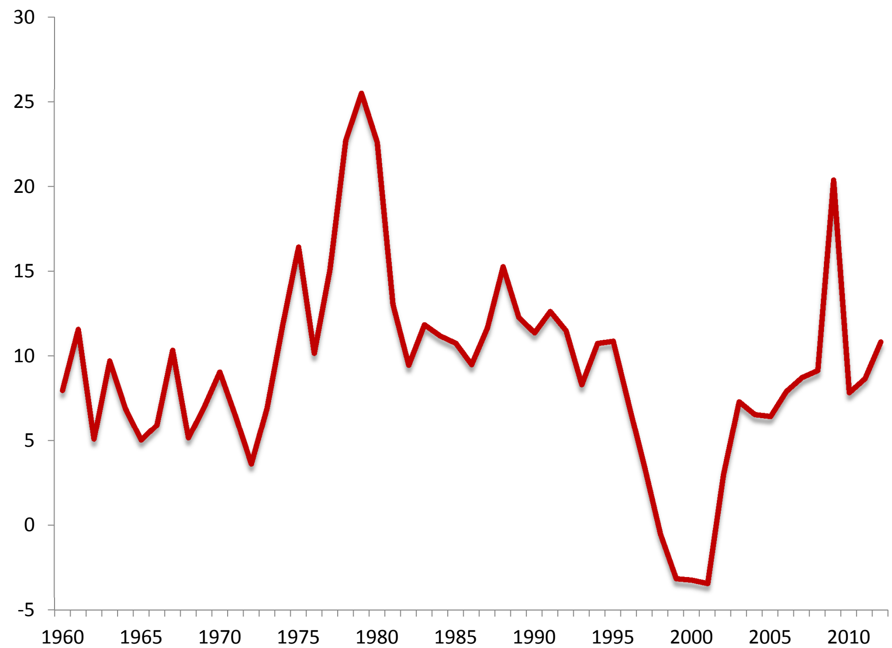


Figure 1: The S&P Risk Premium, 1960 through 2012

extra unit. At the end of the year, the firm owns the depreciated remainder of the one extra unit of installed capital. Installed capital has a shadow value measured by Tobin's q.

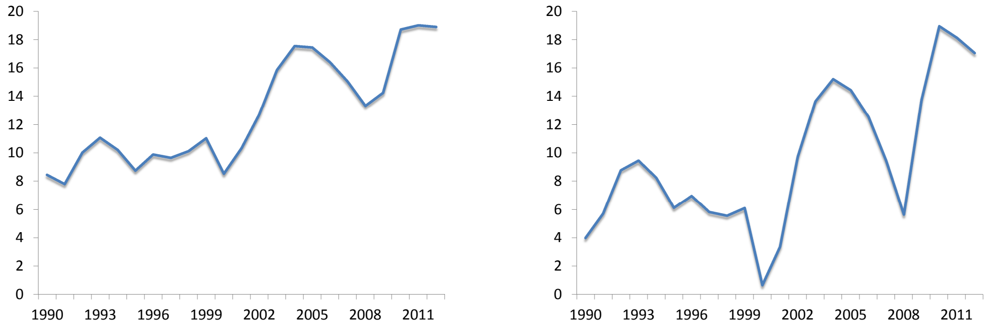
Installation incurs a marginal cost at the beginning of the period of $\kappa(k_t/k_{t-1} - 1)$. Thus the shadow value of a unit of installed capital at the beginning of the year is

$$q_t = \kappa \left(\frac{k_t}{k_{t-1}} - 1 \right) + 1 \tag{3}$$

units of capital. From its investment of a unit of capital at the beginning of year t together with the marginal installation cost—with a total cost of $q_t p_{k,t}$—the firm's nominal return ratio is the gross profit per unit of capital π_t/k_t plus the depreciated value of the capital in year $t+1$, all divided by its original investment:

$$1 + r_{k,t} = \frac{1}{q_t p_{k,t}} \left[\frac{\pi_t}{k_t} + (1 - \delta_t) q_{t+1} p_{k,t+1} \right]. \tag{4}$$

Gross profit includes pre-tax accounting profit, interest payments, and accounting depreciation. In principle, some of proprietors' income is also a return to capital— non-corporate business owns significant amounts of capital—but attempts to impute capital income to the sector result in an obvious shortfall in labor compensation measured as a residual. The reported revenue of the non-corporate business sector is insufficient to justify its observed use of human and other capital. Note that corporate capital as measured in the NIPAs now includes a wide variety of intangible components in addition to plant and equipment.



(a) $\kappa = 0$ (b) $\kappa = 2$

Figure 2: The Capital Wedge for Two Values of the Adjustment Cost κ

The implied wedge between the return to capital and the risk-free real interest rate $r_{f,t}$ is the difference between the nominal rate of return to capital and the one-year safe nominal interest rate:

$$g_t = r_{k,t} - r_{f,t}. \tag{5}$$

This calculation is on the same conceptual footing as the investment wedge in Chari, Kehoe and McGrattan (2007), stated as an interest spread. Note that g_t is in real units—the rate of inflation drops out in the subtraction.

Figure 2 shows the values of the business capital wedge for two values of the adjustment cost parameter κ, calculated from equation (5), combining plant, equipment, and intellectual property. On the left, κ is taken as zero and on the right, as 2. The former value accords with the evidence in Hall (2004) and the latter with the consensus of other research on capital adjustment costs. The value $\kappa = 2$ corresponds to a quarterly parameter of 8.

The two versions agree about the qualitative movements of the wedge since 1990, but differ substantially in volatility. The wedge was roughly steady or falling somewhat during the slow recovery from the recession of 1990, rose to a high level in the recession of 2001, declined in the recovery, and then rose to its highest level after the crisis. The two calculations agree that the wedge remained at a high level of about 18 percent per year through 2013.

Hall (2011) discusses the surprising power of the financial wedge over general economic activity. In an economy with a significant fraction of workers near the margin of market-participation, the adverse effect of the wedge on capital formation cuts market activity in much the same way as taxes on consumption or work effort.

A comparison of the stock-market risk premium in Figure 1 with the capital wedge in Figure 2 suggests that the effect of the financial crisis on the stock-market premium was transitory while its effect on the capital-formation risk premium was persistent. Hall (2014) discusses recent thinking in finance that emphasizes the weights that different investments give to near, intermediate, and distant cash-flow claims. The stock market values flows that grow over time, so it emphasizes distant claims. Business capital pays off over intermediate terms—its average life is currently 8 years. Investments in job creation last about 3 years, the expected duration of a new hire. All are subject to large fluctuations in annual discount rates—there appears to be no tendency for the volatility of annual forward discount rates to rise with futurity. And discount rates at different futurities appear to be only moderately positively correlated. Thus it is entirely possible that, soon after the crisis, the long forward discounts for the stock market returned to normal, while the short and medium discounts for capital and job creation remained high.

2.3 Investment

Modern investment theory, combining the ideas of Jorgenson and Tobin, views investment in general equilibrium as satisfying equation (5) with a value of the wedge reflecting the financial risk of r_k and any other factors such as taxes and frictions that separate r_k from the safe real rate r_f. In particular, forces that result in a low value of output will depress investment, along with those that raise the risk premium or frictions. And a decline in the safe rate will stimulate investment to the extent that it does not widen the spread.

Figure 3 shows the paths of the five categories of investment in 2009 dollars, along with trends fitted by least squares to the data for the period 1990 through 2007. All show a negative response to the crisis sufficient to depress them below trend. The bulk of the decline below trend occurred in business equipment and in housing. Business investment plunged in 2009 at the same time that the discount in the stock market spiked. As that discount returned to normal and output began to grow, business investment returned to close to its growth path, as did consumer durable investment. However, none of those categories of investment has yet begun to make up for the shortfall in the overall capital stock described in the introduction.

By 2012, the shortfall of housing investment below trend remained huge, and accounted for most of the total shortfall in investment. The bulge in housing capital that occurred in the middle of the previous decade and the long lifetimes of houses presumably account for this fact.

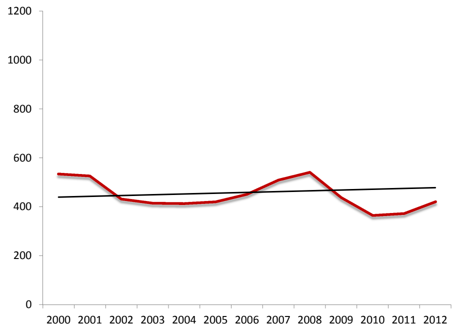
2.4 Evolution of the capital/output ratio

In balanced growth, the capital/output ratio is constant. After a disturbance, the ratio will return to normal—the ratio is mean-reverting, a basic property of almost all growth models. Over U.S. history since World War II, the ratio for the business sector has grown slowly from 0.8 to 1.1, with strong mean reversion to the trend path. Figure 4 shows the ratio and the trend path, fitted as elsewhere in the paper over the period from 1990 through 2007. Immediately after the crisis, in 2009, the ratio jumped upward. Even though capital formation dropped precipitately, the capital stock remained about constant while output fell, so the ratio rose. Since then, through 2013, the normal pattern of mean-reversion has operated, as output has grown faster than has the capital stock, thanks to depressed investment.

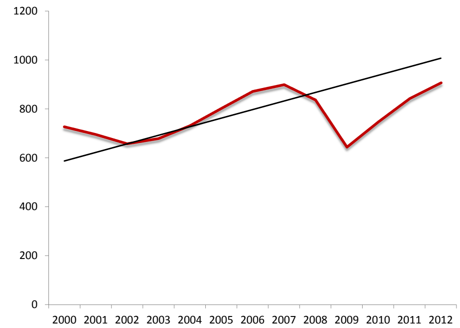
The figure also shows a ten-year forecast for the capital/output ratio, based on the CBO's February 2014 forecast. I say "based on" because the CBO does not forecast real business output, the relevant concept according to a growth model, but rather real GDP, including government and household production. I apply the CBO's growth rates for GDP to the 2013 level of real business output in the figure. The forecast has the capital/output ratio deviating from its normal pattern of mean reversion and, rather, converging to a higher growth path. In effect, the forecast applies normal growth rates to both capital and output, rather than having output grow relative to capital. A growth model would have output grow faster than in the forecast.

2.5 Conclusions about the capital stock

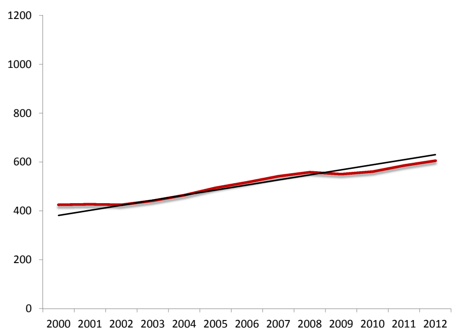
The capital stock is an unambiguous state variable. At the end of 2013, it was 13.2 percent below its normal trend path. The crisis and Great Recession, including amplification mechanisms, appear to be responsible for the shortfall. Restoration of the shortfall can only occur gradually over a decade or more. Restoration will occur naturally because of the mean-reversion tendencies of the economy. A policy or other force that stimulates product demand may hasten the move, through the accelerator effect. On the other hand, the stimu-



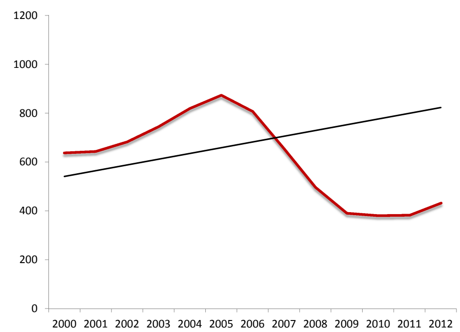
(a) Plant



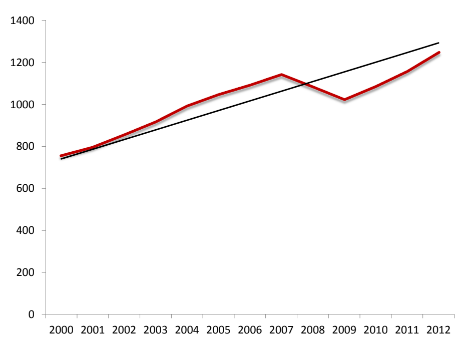
(b) Equipment



(c) Intellectual property



(d) Housing



(e) Consumer durables

Figure 3: Components of Investment Compared to Trend

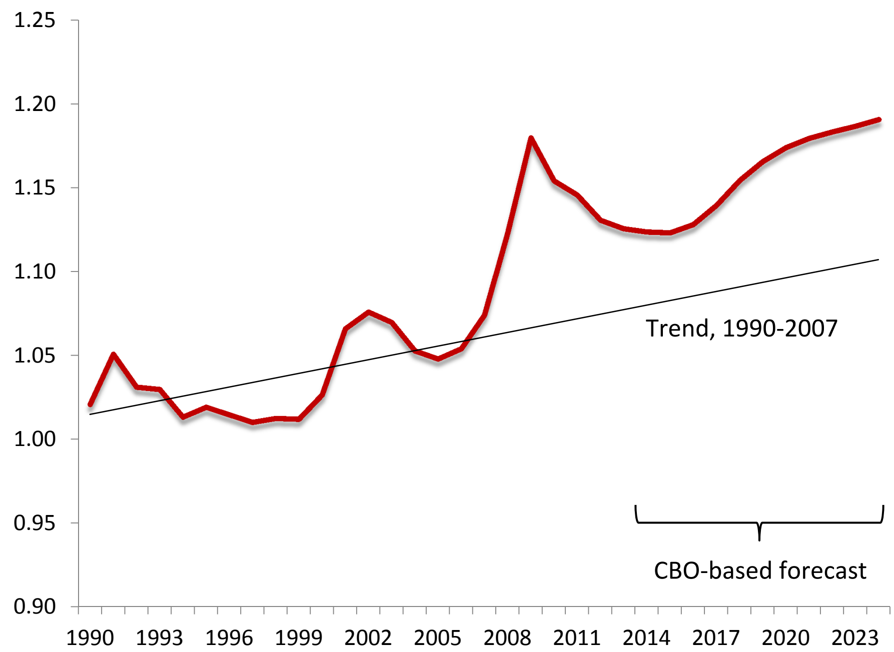


Figure 4: Capital/Output Ratio, with 1990-2007 Trend and CBO-Based Forecast

lus may raise the discount rate for investment and thereby slow down the process of putting the capital stock back on its normal growth path.

3 Unemployment

The fraction of the labor force actually at work declined in the Great Recession as unemployment rose. On account of lower labor input attributable to unemployment, output was 0.9 percent lower in 2013 than it would have been along its earlier trend.

The Diamond-Mortensen-Pissarides (DMP) model provides a coherent account of labor-market tightness and its various indicators, including the unemployment rate. The model, as presented in Mortensen and Pissarides (1994), takes $\theta = V/U$, the vacancy/unemployment ratio, as the central indicator. Two other indicators, the vacancy-filling rate for employers and the job-finding rate for jobseekers, are functions of θ. Unemployment, on the other hand, is a state variable that converges over time to a value determined by θ. Compared to the other state variables considered in this paper, unemployment converges rapidly to that target. Even with the low job-finding rates that occurred during the Great Recession, unemployment moves almost all the way to the value consistent with the rates of flow into

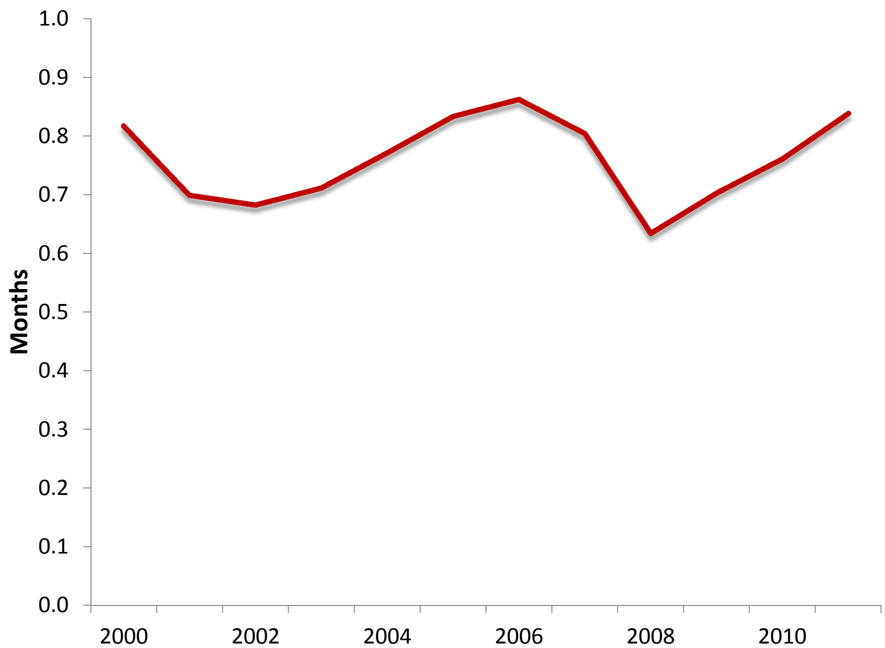


Figure 5: Average Time to Fill a Job Vacancy, JOLTS, 2001 through 2012

and out of unemployment within a year after a shock. In that respect, unemployment is not a state variable.

The simplest DMP model treats the working-age population as homogeneous. U.S. experience since 2007 has made clear that heterogeneity has important roles in the labor market. I begin this section by contrasting tightness in the market from the points of views of three classes of agents: employers, employees, and jobseekers. Unifying the three apparently divergent views requires consideration of the heterogeneity of the labor force.

3.1 Labor-market tightness from the point of view of an employer

The employer encounters a flow of new hires per posted vacancy equal to the market-wide average, the vacancy-filling rate H/V. Its reciprocal, $T = V/H$, is the expected time to fill a job. T is a natural measure of tightness from the perspective of the employer. In a tight market, jobs take longer to fill. Starting at the end of 2000, the BLS has conducted the Job Opportunities and Labor Turnover Survey (JOLTS), to gather data on vacancies, hires, and related variables. Figure 5 shows the history of this measure of labor-market tightness.

Tightness by the T measure was high in the strong labor market of 2000, fell steeply in the recession of 2001, rose to a peak in 2006, fell sharply to a trough in 2008, and then rose back to a high value in 2012. From the employer's perspective, the labor market was as tight in 2012 as in the boom year of 2006 and a bit higher than in the boom year of 2000. Business profitability has reached high levels. Incentives to create jobs are strong. Businesses have responded by recruiting aggressively and driving up the vacancy rate. The DMP model with a homogeneous labor force would say that jobs are easy to find. The job-finding rate should be high, the time to find a job short, and the unemployment rate low.

3.2 Tightness from the point of view of the employed

The hours of work of the employed are assumed constant in the basic DMP model, but a straightforward extension can include endogenous hours. It is based on the idea that workers and employers agree on the efficient number of hours for the worker to put in each week. Efficient means that the worker's marginal rate of substitution between hours and pay is the same as the employer's value of the marginal product of an hour of work. The efficient number of hours rises if a transitory increase in the marginal product of labor occurs.

As Figure 6 shows, American workers' weekly time on the job fell along a pronounced trend from 1948 until 1980 and has been stable except for cyclical movements since then. Workers spend more time on their jobs when the labor market is tight than when it is slack. Hours reveal the tightness of the labor market as it affects people with jobs—hours are not subject to the friction of matching jobseekers and job openings. In the severe recession of 1981-82, average weekly hours fell by about one, and the fall was even greater in 2008. In both cases, recovery of hours occurred fairly quickly, though it is uncertain what the counterfactual normal level of hours would have been absent the crisis.

Many discussions of hours use data on hours per job, from payroll data. From the perspective of employment theory, however, hours per worker, as measured in the Current Population Survey (CPS), is more appropriate. Note that Figure 6 uses the CPS numbers directly, whereas Table 1 uses the hours figure implicit in Fernald's data.

3.3 Labor-market tightness from the point of view of the unemployed

The CPS includes data on the monthly fraction of the unemployed who are employed in the subsequent month—the job-finding rate. This rate is the natural measure of market tightness for the unemployed. Figure 7 shows that the rate in 1990, a recession year, was about 22 percent per month, so the average duration of unemployment was $1/0.22 = 4.5$

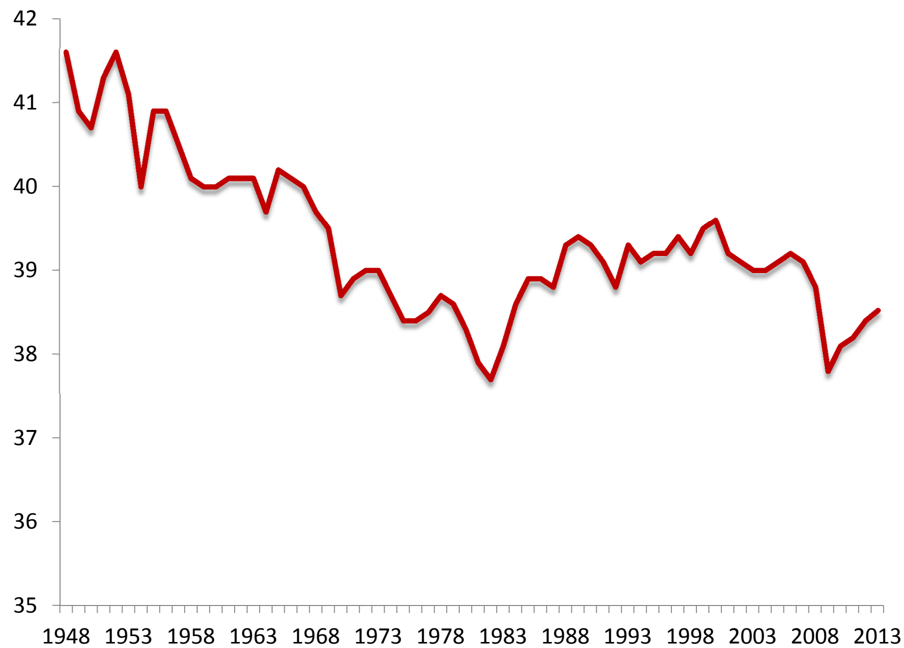


Figure 6: Average Weekly Hours of Work, Current Population Survey, 1948 through 2013

months. During the long boom of the 1990s, the rate rose to a peak of 32 percent. The recession of 2001 and ensuing period of slack labor-market conditions saw it decline to 24 percent in 2003. In the following boom, it rose to 28 percent in 2007, then collapsed to a low point of 17 percent in 2009 and 2010. By 2013 it had recovered slightly to 18 percent. Although it is hard to discern over the period covered in the figure what the normal job-finding rate would have been in 2013 absent the disaster, it seems reasonable to say that this measure was below normal even five years after the crisis.

The failure of the job-finding rate to return to normal, despite high job-vacancy rates and recovering weekly hours, is the central topic of this section of the paper. The phenomenon has attracted attention in another form—unemployment is high in relation to the vacancy rate, meaning that the labor market is off its normal Beveridge curve. Because the Beveridge curve has one axis, the vacancy rate, that is a jump variable, and another, the unemployment rate, that is a state variable, it incorporates the dynamics I mentioned earlier. The Beveridge curve tells two stories simultaneously, so I avoid casting the discussion in its form.

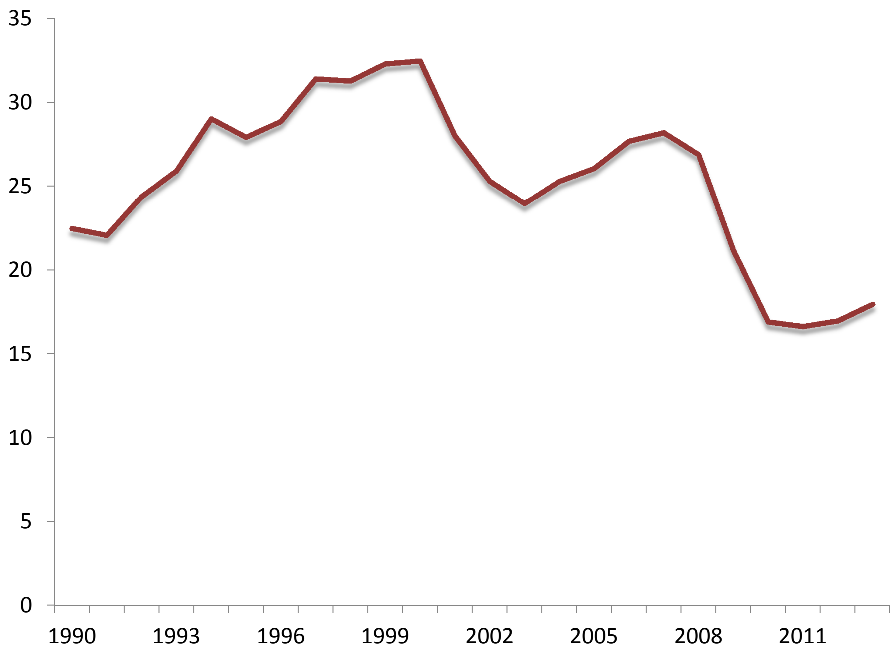
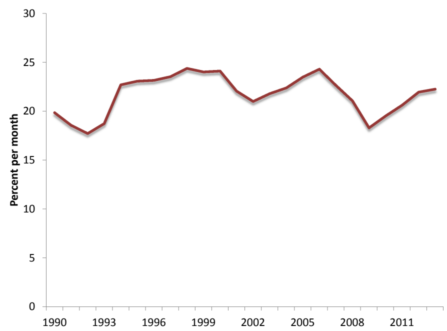


Figure 7: Job-Finding Rate among the Unemployed, 1990 through 2013

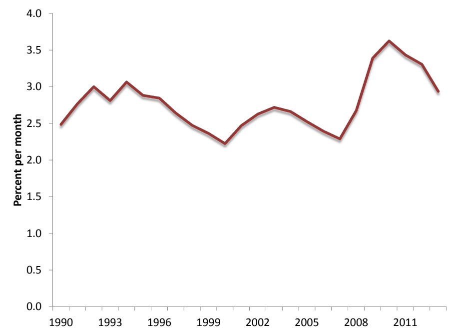
3.4 Flows back and forth between unemployment and out-of-labor-force

The boundary between unemployment and out of the labor force is inherently ambiguous, whereas the boundaries with employment are well defined—an individual is employed who worked at least one hour in the week before the survey. Those not employed are classified as unemployed if they have done any of a list of specific job-seeking activities in the four weeks before the survey. The remainder are out of the labor force. But some are close to the boundary of jobseeker or employment—it is common for an individual who is out of the labor force to be looking actively in the following month or to be in a job. One of the most common errors in interpreting data on the work status of the population is to presume that exit from the labor force is permanent—that out of the labor force is an absorbing state. The process goes both ways: It is common for a jobseeker in one month to be out of the labor force in the succeeding month.

Figure 8 shows the flows back and forth between unemployment and out of the labor force. The first is the percent of unemployed workers who leave the labor force each month. The fraction is fairly stable around 20 percent. It declines in recessions and rises in recoveries. In 2013, it was at its normal value. Though one might think that leaving the labor force



(a) Fraction of unemployed out of the labor force in the next month



(b) Fraction of those out of labor force unemployed in the next month

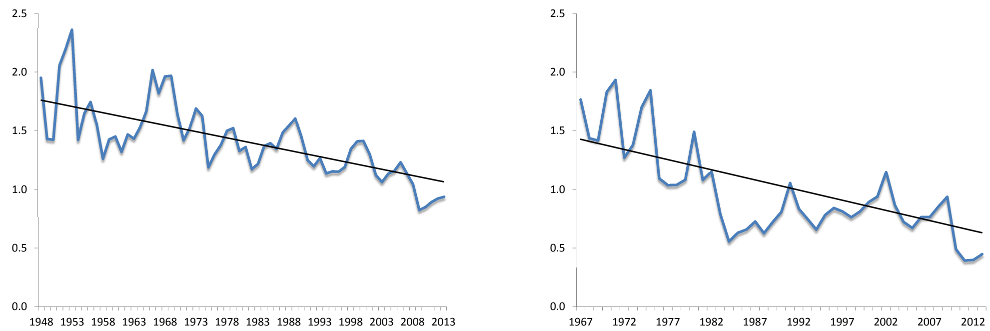
Figure 8: Flows out of and into Unemployment

while searching for work occurs when individuals become discouraged about the prospects of finding a job, the evidence points in a different direction—a fraction of the population tends to oscillate between job search and other activities when not at work. Graph (b) of the figure shows the reverse flow, from out of the labor force to job search. This flow rises sharply in recessions; the rise was particularly large after the crisis in 2008. It appears that contractions increase the fraction of the population in the oscillation mode. The increase in the unemployment to out of labor force flow is not long-term exit from the labor force, but a move that may well be reversed soon. Unfortunately, the CPS is not well suited to confirming this view, because its panel dimension is so short.

3.5 Heterogeneity among jobseekers

Two dimensions of observable heterogeneity among jobseekers are important in understanding the puzzles of labor-market tightness and unemployment in the post-crisis U.S. economy: duration of unemployment and the source of joblessness. By source, I mean specifically a six-way breakdown in the CPS of the events leading to job search: on layoff (with distinct possibility of recall), lost job permanently, temporary job ended, quit, new entrant, and reentrant.

Job-finding rates tend to be higher among workers who became unemployed recently and those who have been unemployed for many months. Further, the decline in high-duration rates tends to be greater in a recession than the decline in low-duration rates. The BLS



(a) Low duration (b) High duration

Figure 9: Indexes of the Job-Finding Rate by Duration of Unemployment

does not report the rates by duration directly, but the agency has reported unemployment by duration categories for many years. The ratio of the number unemployed for less than 5 weeks to the number unemployed for 5 to 15 weeks is an index of job-finding rates for the low-duration unemployed—when the rate is high, few of the unemployed will remain in that state for, say, 10 weeks, so the higher-duration category will be depleted in relation to the low-duration category. Similarly the ratio of those unemployed 27 to 51 weeks to those unemployed 52 weeks or more is an index of the job-finding rate among the high-duration unemployed. Figure 9 compares the two indexes.

The figure shows that the proportional decline in the job-finding rate was much higher for long-duration unemployment than for short-duration unemployment. To put it differently, the monthly rate of exit from unemployment shifted down much more after the crisis for high durations than for short durations. It is generally the case that exit rates decline with duration, but the decline was much greater in 2009 than in normal years.

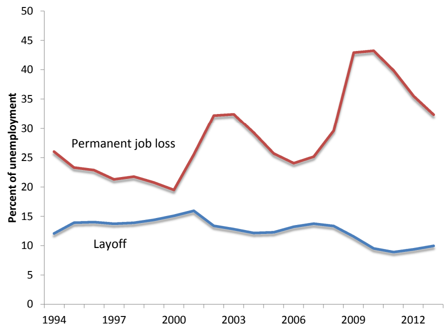
The downward trend in the job-finding rate is one aspect of the general phenomenon of declining turnover in U.S. life. Separation rates in the labor market are on a long downward trend, as is geographic mobility. Jobs are harder to find, but they last correspondingly longer, so unemployment has no upward trend. Now that the recovery from the crisis is more than 5 years old, it is important to keep trends in mind in studying post-crisis data to understand the effect of the crisis.

3.6 The crisis-induced change in the mix of sources of unemployment

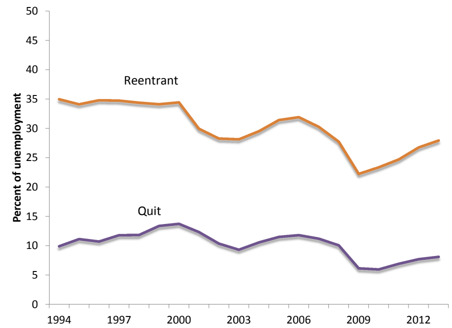
Figure 10 describes the second type of observable heterogeneity, that associated with the event that resulted in the onset of jobseeking. Since 1994 the CPS has recorded the event in its current six-way classification. Graph (a) shows the number of unemployed workers who are off work at their employers' initiative, as a percent of all unemployment. They have suffered either permanent job loss, with no indicated likelihood of recall, or are on layoff, with a likelihood of recall. Permanent job loss rose from about 25 percent of total unemployment in 2006 to almost 45 percent in 2009, just after the crisis. Layoff unemployment—never a large fraction of the total–fell slightly as a percent of total unemployment after the crisis. Graph (b) shows categories reflecting decisions by individuals to enter unemployment, either by moving into the labor force (reentrants) or by leaving jobs voluntarily (quits). Reentrant unemployment fell sharply around the crisis and then rose back to a normal level. Quit unemployment–also not a large fraction of the total—fell almost in half at the crisis and has returned partway to its normal fraction. Graph (c) shows the remaining two source categories, temporary job ended and new entrant. These are generally small fractions of unemployment and did not respond much to the crisis.

Table 2 shows that the composition of the unemployed shifted dramatically in the direction of permanent job loss and away from layoffs, reentrants, and quits. The composition shift matters a lot because exit rates from unemployment are considerably lower for permanent job losers than for other sources of unemployment, as the left column of the table shows. The exit rate is the sum of the flow rate from unemployment to jobs and the rate from unemployment to out of labor force. The composition effect would have lowered the exit rate by 2.5 percentage points had it occurred with the normal set of exit rates shown in the table, calculated as the averages over 2004 through 2007.

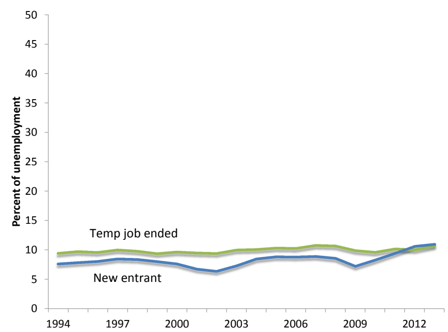
The shift of jobseekers toward types less likely to exit unemployment each month resulted in higher unemployment as long as the composition shift lasted. Figure 10 shows that the composition gradually moved back to normal, but was probably not complete even five years after the crisis, in 2013. The composition is, in effect, a state variable that keeps unemployment high for a number of years but eventually returns to normal.



(a) Permanent job loss and layoffs



(b) Reentrants and quits



(c) New entrants and end of temp job

Figure 10: Composition of Unemployment by Source

Source	*Normal exit rate, percent per month*	*Change in percent of unemploy-ment, 2007 to 2009*
Layoff	64.7	-2.2
Permanent loss	41.4	17.7
Temp job	51.1	-0.9
Quit	55.7	-5.0
New entrant	49.2	-1.6
Reentrant	48.7	-8.0

Table 2: Unemployment Exit Rates and Change in Composition of Unemployment, 2007-2009

3.7 Long-duration unemployment and the decline in matching efficiency

My discussion of the changing composition of unemployment toward high-duration jobseekers uses measures of matching efficiency, a concept rooted in the search-and-matching model. The model portrays the process of filling jobs in terms of a production function, the matching function, with output taken as the flow of hires H and factor inputs taken as the stocks of jobseekers X and vacancies V:

$$H_t = m_t(X_t, V_t). \tag{6}$$

Petrongolo and Pissarides (2001) suggest that the matching function is well approximated by

$$H_t = \mu_t \sqrt{X_t V_t}. \tag{7}$$

The quantity μ_t is the efficiency of matching, analogous to the index of total factor productivity in the case of a production function. To simplify the discussion, I assume this form, but none of the conclusions here depends on this particular choice. See Hall and Schulhofer-Wohl (2013) (HS-W) for a more extensive treatment.

The jobseeker faces a monthly probability of finding and taking a job equal to H/X. Labor-market statistics for the U.S. do not include direct measures of the number of jobseekers. Those counted as unemployed in the Current Population Survey—who did not work in the week prior to the survey and who looked actively for work in the four weeks prior to the survey—are presumably included in X. But the CPS shows that only a minority of new hires were unemployed prior to being hired. The majority moved directly from earlier jobs or were out of the labor force.

Under conditions laid out in HS-W, data from JOLTS make up for the absence of data on the total jobseeker count X. In the total labor market, counting jobseekers who are unemployed, employed, or out of the labor market, we normalize efficiency at one, so the total volume of hires is

$$H_t = \sqrt{X_t V_t}. \tag{8}$$

The effect of the normalization is to define the aggregate X_t as measured in efficiency units. Thus

$$X_t = \frac{H_t^2}{V_t} \tag{9}$$

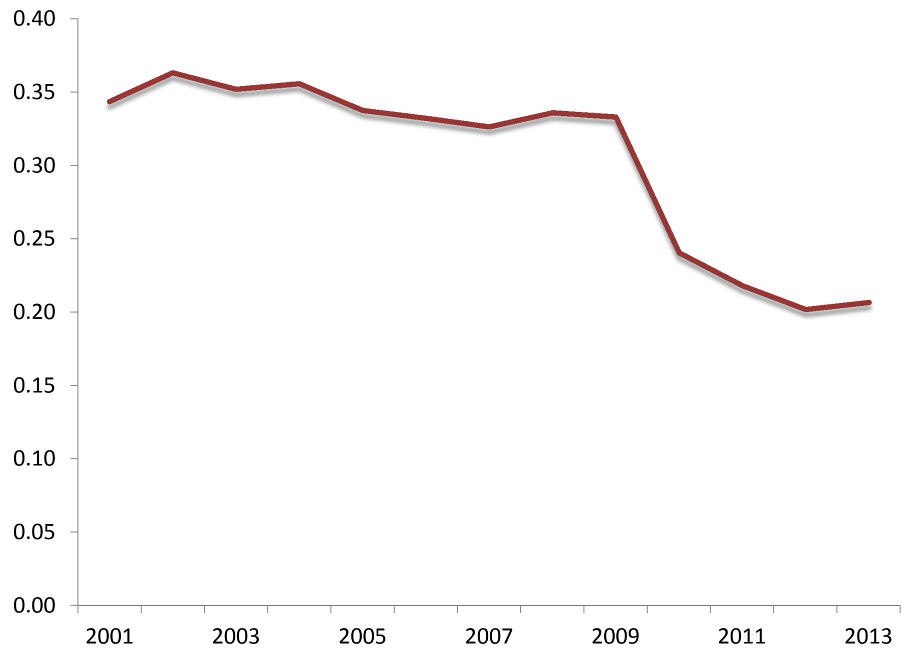


Figure 11: Matching Efficiency for Unemployed Jobseekers, Treated as Homogeneous

and, in consequence,

$$\frac{H_t}{X_t} = \frac{V_t}{H_t} = T_t. \tag{10}$$

The job-finding rate for unemployed jobseekers is

$$f_t = \mu_t \frac{H_t}{X_t} = \mu_t T_t \tag{11}$$

so to calculate the efficiency of matching for unemployed jobseekers, we divide the job-finding rate by the tightness measure T_t:

$$\mu_t = \frac{f_t}{T_t}. \tag{12}$$

This calculation treats jobseekers as homogeneous.

Figure 11 shows the results of the calculation. Matching efficiency declined gradually until the crisis, then fell dramatically, reaching a low point in 2012 and rising slightly in 2013. Neglect of heterogeneity turns out to be a huge influence in these movements.

To deal with heterogeneity, we apply the same approach but to jobseekers differentiated by permanent demographic characteristics and changing personal state variables, notably the six categories of unemployment source and multiple categories of duration of unemployment to date. We fit seven trinomial logit models to the job-finding hazards for the six unemployment source categories and for out-of-the-labor-force, with variables capturing demographics

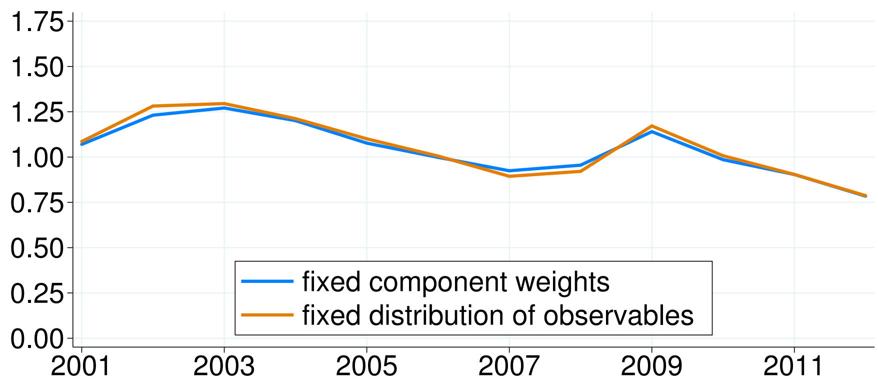


Figure 12: Overall Composition-Adjusted Matching Efficiency

and unemployment duration to date. Our work studies other transition probabilities, but for the purposes of this paper, only the job-finding hazard equations are relevant.

In this setup, we define a set $\mathbb{I}$ of buckets, crossing the seven categories of jobseekers with five categories of unemployment duration. Then for each $i \in \mathbb{I}$, we calculate specific matching efficiency,

$$\mu_{i,t} = \frac{f_{i,t}}{T_t}. \tag{13}$$

To measure overall matching efficiency, we form a fixed-weight index,

$$\bar{\mu}_t = \sum_{i \in \mathbb{I}} w_i \mu_{i,t}. \tag{14}$$

The weights are the population fractions in the base period before the crisis. Figure 12 shows the resulting index of overall matching efficiency. The index has a downward trend, but rose in the 2001 recession and again in 2009. The collapse of matching efficiency in Figure 11 is entirely the result of a sudden shift in the composition of unemployment toward hard-to-match groups, not a true decline in efficiency. Figures in the HS-W paper show that each of the seven groups had fairly smoothly declining matching efficiency from 2000 through 2012, with no significant special decline in the post-crisis years.

The finding that the large decline in matching efficiency is entirely a mix effect implies that, as the legacy of unemployment works off, efficiency should return to its gradually declining path of the pre-crisis years. Historically, another gradual decline, in the inflow to unemployment, has offset the gradual decline in efficiency and the unemployment rate has remained remarkably steady.

The bulge in long-duration unemployment is partly the result of the crisis-induced shift toward permanent job loss. Jobseekers in this category have lower exit rates from unem-

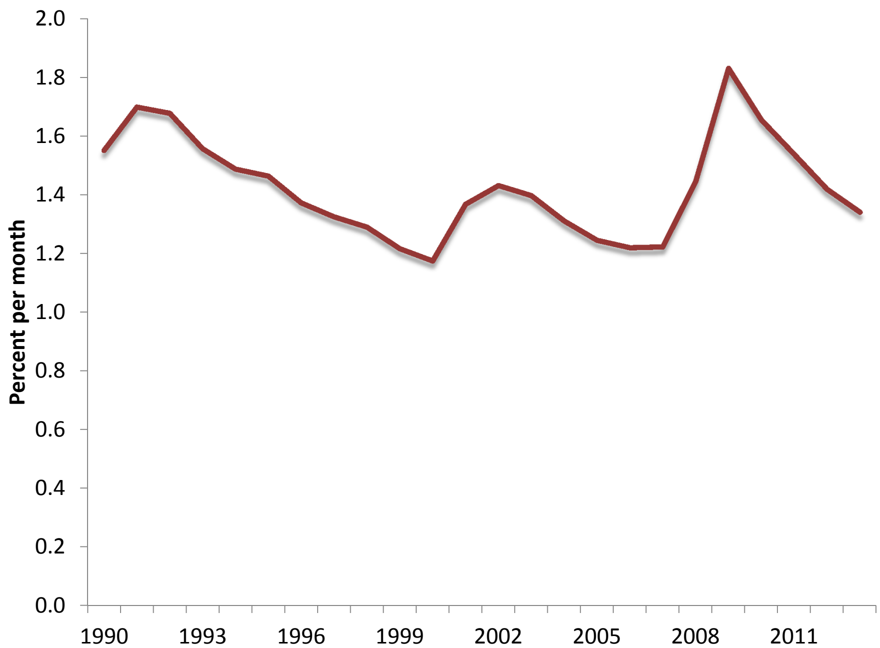


Figure 13: Flow from Jobs to Unemployment

ployment and so are more likely to advance to higher duration categories, with even lower exit rates.

3.8 Flow from jobs to unemployment

The unemployment rate depends on the inflow to unemployment from jobs and from the out-of-the-labor-market population as well as the exit rate just discussed. Figure 13 shows the more volatile of the two components, the fraction of people employed in one month who are unemployed the next month. Like many turnover measures, this one has a noticeable downward trend, interrupted by a spike in 2009. In 2013, this flow was back to its trend. Remaining high unemployment is not the result of continuing high flows from jobs into unemployment, but from low flow rates out of unemployment, as shown in Figure 7.

3.9 Unemployment-conditioned benefits

A jobseeker taking a job loses benefits from unemployment insurance. Recent papers by Nakajima (2012), Valletta and Kuang (2010), Fujita (2011),and Daly, Hobijn, Şahin and Valletta (2011), culminating in Farber and Valletta (2013), ask whether higher UI benefits result in lower search effort and higher reservation wages, both of which would raise unemployment in a standard DMP model. This research compares the job-finding rates of covered workers to uncovered workers. The answer is fairly uniformly that the effects of UI enhancements during times of high unemployment in raising unemployment still further are quite small, in the range of 0.3 percentage points of extra unemployment.

Hagedorn, Karahan, Manovskii and Mitman (2013) (HKMM) tackle a more challenging question, whether more generous UI benefits result in higher wages and higher unemployment by raising the flow value of unemployment and thus shrinking the gap between productivity and that flow value. They compare labor markets with arguably similar conditions apart from the UI benefits regime. In their work, the markets are defined as counties and the similarity arises because they focus on pairs of adjacent counties. The difference in the UI regimes arises because the two counties are in different states and UI benefits are set at the state level and often differ across state boundaries. The research uses a regression-discontinuity design, where the discontinuity is the state boundary and the window is the area of the two adjacent counties. The authors conclude that, absent the increase in UI benefits, unemployment in 2010 would have been about 3 percentage points lower.

Many commentators have dismissed HKMM's conclusion on the grounds that the research implies that unemployment would have hardly risen at all absent the financial crisis and resulting collapse of product demand. But that dismissal is unwarranted. HKMM's work fully recognizes that the enhancements of UI benefits was itself the result of the forces that caused the Great Recession. The proper interpretation, within the framework of the paper, is that feedback from enhanced UI benefits was a powerful amplification mechanism of a negative impulse arising from the crisis.

The issues that arise in evaluating the paper are those for any regression-discontinuity research design: (1) Are there any other sources of discontinuous changes at the designated discontinuity points that might be correlated with the one of interest? (2) Is the window small enough to avoid contamination from differences that do not occur at the discontinuity point but rather elsewhere in the window? The authors explore a number of state-level economic policies that could generate cross-border effects that might be correlated with the UI effects, but none seem to matter. The authors are less persuasive on the second point. Many counties are large enough to create substantial contamination. Far from being atoms, single counties are often large parts of their states, both geographically and in terms of the share of the population. The extreme case is Washington, DC, treated as a state with only one county.

Measure	*Source*	*Units*	*Effect*	*Standard error*	*p-value*
Log employment	Payroll survey	Percent	0.25	(0.21)	0.24
	LAUS	Percent	-0.20	(0.16)	0.21
	Household survey	Percent	0.17	(1.57)	0.91
Unemployment rate	LAUS	Percentage points	-0.06	(0.10)	0.54
	Household survey	Percentage points	-0.33	(0.89)	0.71
Labor force participation rate	Household survey	Percentage points	-0.46	(0.94)	0.63

Table 3: Evidence on Labor-Market Differences between North Carolina and Neighboring States after the End of Extended UI Benefits in North Carolina

Hagedorn, Karahan, Manovskii and Mitman (2014) treat the termination of extended UI benefits in North Carolina as a case study for their research. These benefits ended in June 2013. In the neighboring states of South Carolina and Virginia, extended benefits continued until the end of 2013. Employment expanded and unemployment contracted in North Carolina in the second half of 2013. To study the difference between North Carolina and the two other states, I estimated the expectation of North Carolina's values of the labor-market variables conditional on the variables in the two other states, together with a shift variable for the six months in 2013 when North Carolina's UI policy changed. I obtained the data from a spreadsheet posted on Mitman's website. Table 3 shows the results. The top panel uses the three available measures of employment, from the BLS's payroll survey, its Local Area Unemployment Statistics database, and the CPS. The left-hand variable is in natural-log form—I multiply the coefficient of the dummy variable by 100 so that its units are percents. The regressions cover 1990 through 2013 for the payroll survey and LAUS data and 2000 through 2013 for the household survey. They include an AR(1) term to account for the high serial correlation of the disturbances. The estimated effects for employment are close to zero for the payroll and LAUS data and are precisely estimated, as shown by the small standard errors. The hypothesis of no difference during the policy-change period is easily accepted. For the household survey, the point estimate also close to zero, but the standard error implies that the confidence interval includes many negative values as well as positive values. Overall, there is no evidence of an important employment effect.

The middle panel in the table gives results for the unemployment rate, in percentage points, from the two sources that measure unemployment. Both show small reductions of fractions of a percentage point, measured precisely for the LAUS and imprecisely for the household survey. Again, there is no evidence of an important effect. The bottom line in the table reports a small negative difference in the labor-force participation rate between North Carolina and the neighboring states, with a standard error of nearly one percentage point. This finding rules out large participation effects and gives no positive support to any meaningful effect.

Overall, the case study of North Carolina does not appear to support HKMM's finding of large effects from changes in UI benefits. But HKMM have ignited an important debate. Further discussion may help resolve the issue of the reliability of their finding of such large effects on wages and unemployment.

Chodorow-Reich and Karabarbounis (2013) study movements of a variety of unemployment-conditioned benefits including UI. They conclude that both the level and movements of the effective subsidy for unemployment are trivial. From microdata, they measure the effect of unemployment on the opportunity cost of taking a job, stated as a percent of average worker productivity. One component is the loss of benefits that occurs upon taking a job. On average, the loss of benefits—UI, food stamps, welfare, and Medicaid—contributes only 3.5 percentage points to the opportunity cost. Although that contribution is higher when unemployment is high, the fluctuations are necessarily small and other components of the opportunity cost offset them.

With respect to UI, the authors observe that only around a third of the unemployed receive benefits. The others are ineligible or unwilling to apply. Further, about a quarter of UI benefits go to people who are not unemployed because they do not meet the standard criterion of search effort or because they work part time but earn less than the applicable cap. Almost all of the increase in benefits in general arises from UI, however, as they find that the unemployment-conditioned part of food stamps, welfare, and Medicaid is tiny. The first two of these programs are fairly small, and Medicaid, though large, goes mainly to people who are disabled or elderly.

Figure 14 shows the findings of the paper for UI and for other benefits. The highest line shows the results of the regression at the micro level of UI benefits on the incidence of unemployment (annual UI receipts divided by fraction of the year unemployed). The lower

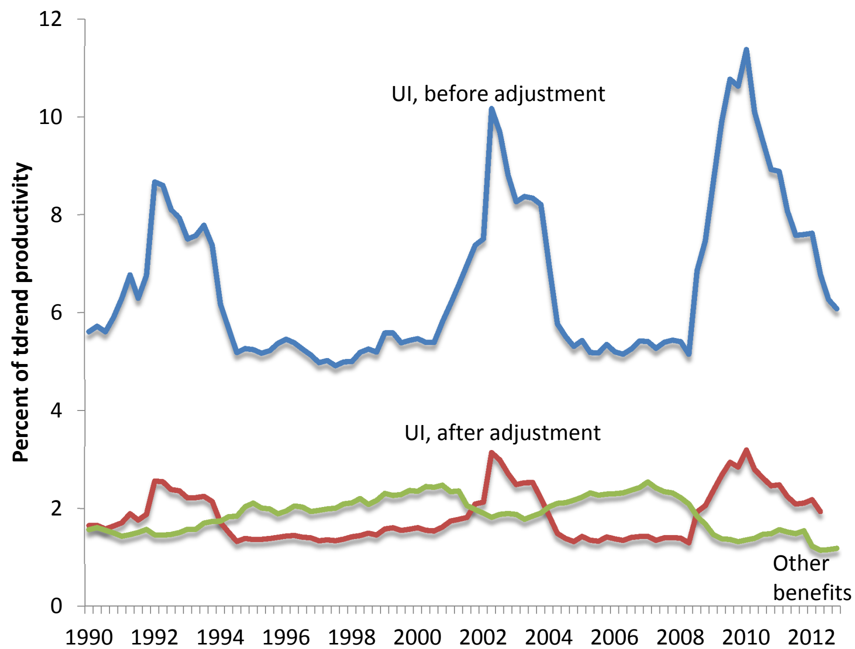


Figure 14: Unemployment-Conditioning of UI and Other Benefits, from Chodorow-Reich and Karabarbounis (2013)

line, labeled "UI, after adjustment" adjusts downward dramatically to account for (1) the probability that benefits will exhaust before the individual finds a later job, if the individual declines a job offer while receiving UI benefits, and (2) the costs to the individual of participating in UI. UI benefits spike in recessions, reaching around four percent of productivity in those of 1973-1975, 2001, and 2007-2009. The spike in the Great Recession was only about 0.5 percentage points above the two earlier major spikes. By 2012, the benefit rate was about halfway back to its pre-crisis level. The behavior of the unemployment-conditioned component of food stamps, welfare, and Medicaid combined was altogether different. It had a steep upward trend from 1982 through 2005, then fell substantially during the period this paper studies.

The magnitude of the downward adjustment to UI benefits is surprisingly large. Most of it reflects an imputation of compliance cost to the UI recipient. The authors make this adjustment by asking why so many eligible workers decline to apply for UI benefits. They fit a convex cost function to time-series data on the takeup rate for benefits. They believe that their imputation is in line with the findings of earlier research on UI benefits, based on how much reported reservation wages respond to benefit levels.

Though Chodorow-Reich and Karabarbounis focus on measuring the benefits lost when a worker moves from unemployment to employment as a topic in fluctuations modeling, their findings are important for broader issues. First, their findings appear to be quite inconsistent with the mechanism that HKMM describe. Not only is the UI effect small and transitory, but the decline in unemployment-conditioning for other benefits offsets a good part of that effect. The small remaining net effect of increased attraction to remaining unemployed seems incapable of explaining the wage increase that HKMM found, along with declines in vacancies and increases in unemployment caused by that increase, according to the HKMM model.

Second, CRK's results—and even more, results that a related research strategy might generate—bear on the role of benefits in the substantial decline in labor-force participation that followed the crisis. CRK ask what would be on the mind of an unemployed individual considering a job offer. A similar strategy could study what would be on the mind of an individual not currently in the labor force who was considering entering the labor force by starting a job search.

3.10 Conclusions about unemployment

Although unemployment is a state variable in the search-and-matching model with homogeneous jobseekers, exit rates from unemployment are so high, even after a shock as great as the crisis in 2008, that unemployment melts away rapidly once the labor market returns to normal tightness. In a model that recognizes the role of heterogeneity, a force that shifts the inflow to unemployment toward individuals with low exit rates will cause elevated unemployment as long as that shift lasts. Further, the decline in exit rates with unemployment duration amplifies the effect. The evidence is compelling that this mechanism kept unemployment high for at least five years after the crisis.

The response of policy to high unemployment through the extension of UI benefits is another amplification mechanism. Its strength is a matter of intense debate, but all research and economic logic confirms that some amplification occurred.

4 Labor-force Participation

Table 1 shows a growing shortfall of the labor-force participation rate during the post-crisis period. Unlike the employment rate and hours per week, which closed some of their shortfalls by 2010 or 2011, participation has continued to shrink. A key issue in the analysis of the

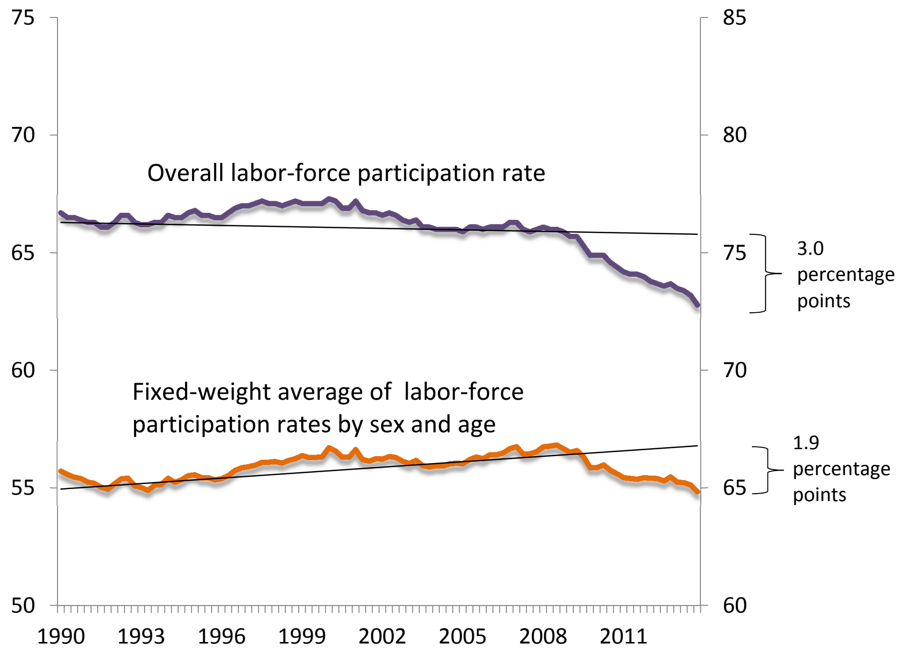


Figure 15: Standard and Fixed-Weight Measures of Labor-Force Participation, 1990 through 2013

effects of the crisis is whether participation will ever return to normal once the adverse effects of the crisis dissipate, or whether participation will remain at its current low level or fall even more.

Figure 15 shows two measures of the labor-force participation rate. The upper line is the standard measure—the ratio of the number of people over age 16 in the labor force (employed + unemployed) to the population over 16. The measure includes mix effects. Most of these arise from the oldest age group, which accounts for a growing fraction of the population. That group also has the lowest participation rate. So part of the decline in the standard measure arises from the aging of the population associated with declining mortality rates for people in their sixties and seventies.

The thin line in the upper part of the figure is the linear trend fitted by least squares for the years 1990 through 2007, as in Table 1. The standard measure follows a slight downward trend with mild cyclical movements through 2007, then drops by 3.0 percentage points from 2007 to 2013.

The lower line in the figure, with scale on the right, shows a fixed-weight index that is immune to sex and age mix effects (age is 16 through 19, 20 through 24, 25 through 34, 35 trough 45, 45 through 54, and 55 and older). It applies the average population fraction over

Age	Men	Women	Sum
16-19	0.06	0.17	0.23
20-24	0.18	0.05	0.24
25-34	0.20	0.11	0.31
35-44	0.04	0.13	0.17
45-54	0.19	0.35	0.53
55+	0.27	0.43	0.70
All	0.95	1.24	2.19

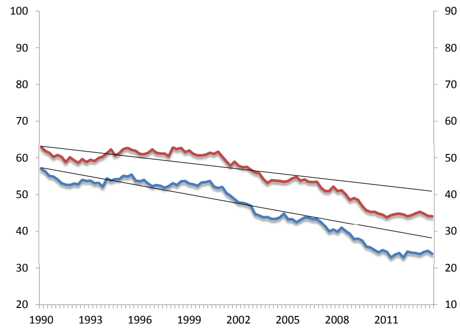
Table 4: Contributions of Sex-Age Groups to Participation Shortfall, 2007 through 2013

the period 1990 though 2013 to the participation rates within each of the 12 demographic groups. Its trend is noticeably upward. During the post-crisis period, it drops below trend by 1.9 percentage points.

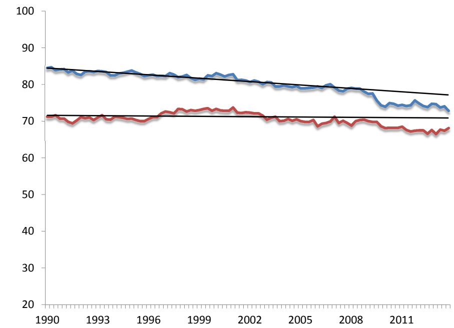
The conclusion is that mix effects special to the post-crisis period account for 1.1 percentage points of the decline in participation. The increase in the population fraction from 2007 to 2013 was 2.0 percentage points for men 55 and over and 1.9 percentage points for women in that age group. The youngest member of the group in 2007 was born in 1952 and the youngest in 2013 was born in 1958. The extra 1.1 percentage points were the effect of the entry of the baby-boomers to the lower-participation age group. Forecasts of future participation rates show similar declines as the boomers retire in larger numbers.

Figure 16 shows the participation rates for the 12 demographic groups, along with linear least-squares trend lines estimated from 1990 through 2007. The line for teenage women uses the right-hand scale so that it does not lie atop the line for men. In the other age groups, the upper (blue) line is for men and the lower (red) line is for women. During the post-crisis period, the declines below trend occurred among those aged 16 through 34 and women aged 25 through 54. During the crisis period starting in 2008, the upward trend in participation among both men and women aged 55 and above was only slightly less than in the period from 1990 through 2007.

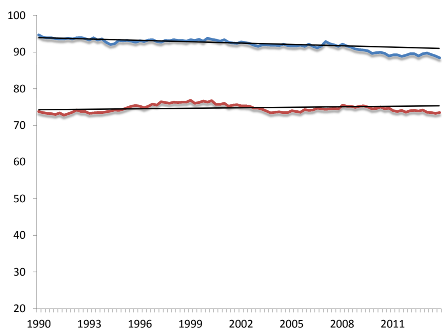
Table 4 shows that people aged 45 and above contributed disproportionately to the post-2007 shortfall of participation relative to trend, and that women played a larger role in the disproportion than men. Rising take-up rates for disability may play a role among the older groups.



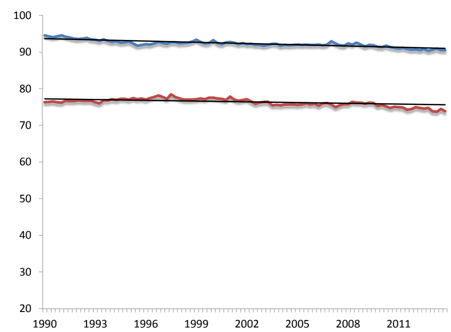
(a) Aged 16 through 19



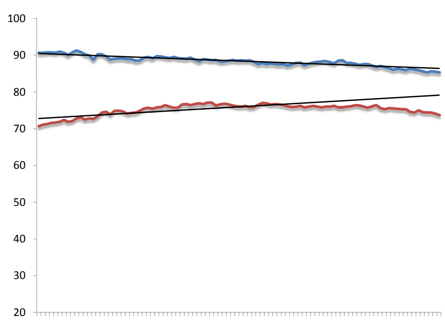
(b) Aged 20 through 24



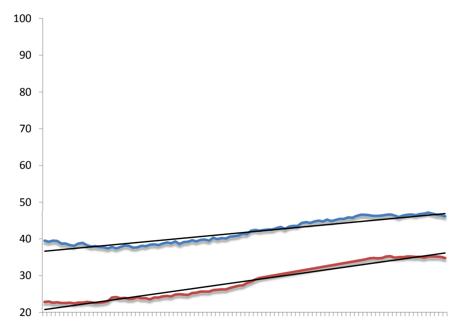
(c) Aged 25 through 34



(d) Aged 35 through 44



(e) Aged 45 through 54



(f) Aged 55 and over

Figure 16: Labor-Force Participation Rates by Sex and Age

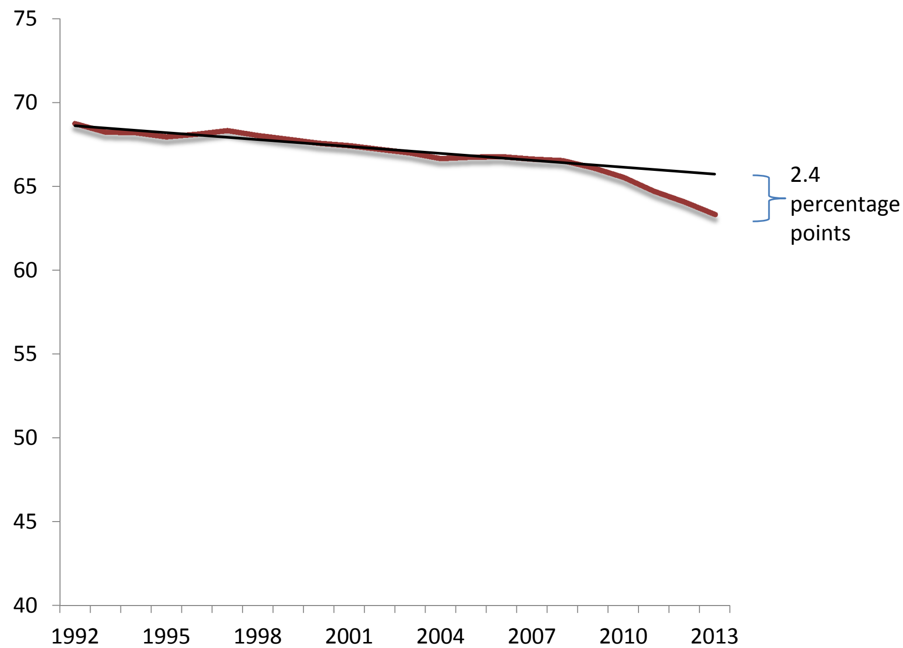


Figure 17: Fixed-Weight Index of Participation by Education, with 1992 through 2007 Trend

Figure 17 shows a comparison of the trend of pre-crisis participation by education groups (less than high-school graduation, high-school graduation only, some college, and college graduation) to post-crisis participation. The figure displays a fixed-weight index over the period from 1992 through 2013. Note that the trend of the fixed-weight index is downward whereas the fixed-weight index based on sex-age groups is upward. Participation rises sharply with education, and education advanced steadily during the three decades. The shortfall from trend in 2013 based on education was 2.4 percentage points. This figure overlaps somewhat but not entirely with the earlier one based on sex and age. Calculations based on sex-age-education groups would yield a larger estimate of the participation shortfall, I believe.

4.1 Turnover and participation

As the participation rate has continued to decline at the same time as unemployment, many commentators have concluded that unemployment is declining because unemployed individuals are leaving the labor force rather than taking jobs. But this view is a drastic oversimplification that overlooks high rates of turnover among activities in the working-age population. In the typical month of 2013, 2.5 million people left the labor force while unemployed, more than the 2.2 million who took jobs. But 3.7 million people who were previously out of the labor force took jobs without intervening unemployment and another 2.6 million started to search for work. Many people counted as out of the labor force will move back into the labor force quite soon.

Though many discussions of labor-market dynamics refer to a population that is always in the labor force and move between employment and unemployment, the two-activity model cannot possibly describe the U.S. labor market. On the other hand, a three-activity model—not in the labor force (N), unemployed (U), and employed (E)—is a useful way to understand the basics of the turnover process. The model has 6 transition rates, designated NE, NU, UE, UN, EN, and EU, in an obvious notation. The fraction of people in an activity who remain in that activity in the following month are residuals—for example, NN = 1 - NE - NU.

When turnover is in its stochastic equilibrium, the vector $A = [\mathrm{N}, \mathrm{U}, \mathrm{E}]$ replicates itself; that is

$$A = A\Pi, \tag{15}$$

where Π is the 3×3 matrix of transition rates, with each row corresponding to one origin activity. One can calculate A by matrix inversion while ensuring that its elements sum to 1.

Because the stationary vector A omits the dynamics of the turnover process, it differs from the actual distribution across activities. But high rates of turnover imply that convergence to the stationary distribution is fairly rapid. Figure 18 shows the stationary and actual values of the fraction of the population out of the labor force. The two track each other well except that the stationary distribution responds immediately to shocks that are not fully incorporated in the actual distribution until the following year. A second reason for the discrepancies is that only three-quarters of the respondents in the CPS contribute to the transition rates whereas all of them contribute to the measurement of N—on this, see Hall and Schulhofer-Wohl (2013).

Table 5 shows, on the left, the 6 transition rates for the average month in 2013 and the average month in the pre-crisis years 2005 through 2007. The data come from the Current Population Survey. The corresponding stationary distributions across activities, A, appear in the upper-right-hand corner of the table. Note that U is the fraction of the population that is unemployed, not the standard unemployment rate stated as a fraction of the labor force, which is U/(U+E). In 2013, U was 1.4 percentage points higher than in 2005-2007,

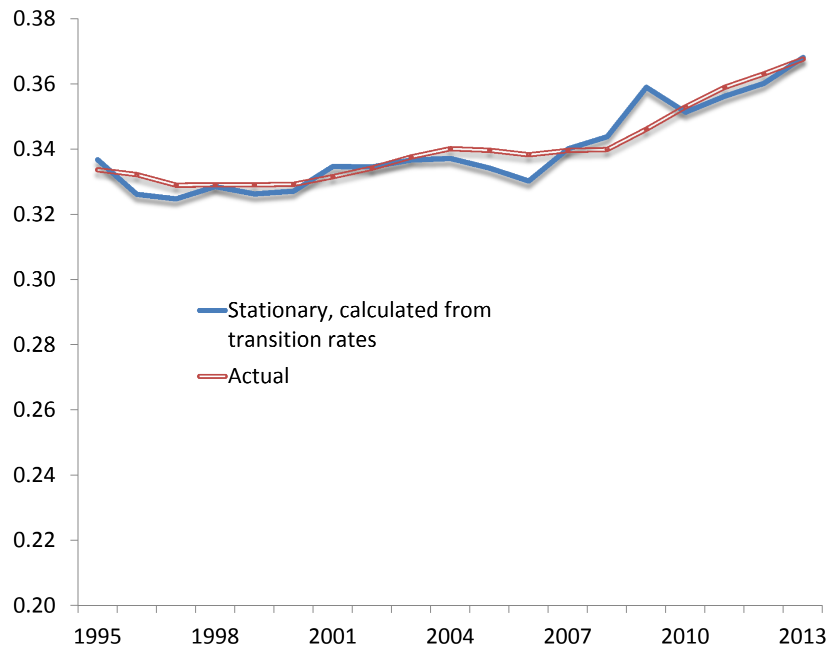


Figure 18: Calculated Stationary Fraction out of the Labor Force and Actual Fraction

but N was 3.3 percentage points higher. The reduction in participation was more than twice as large as the increase in unemployment.

The lower right-hand block in Table 5 shows the separate influences of each of the 6 transition rates. Each row shows the implied distribution across activities if all but one of the transition rates had its pre-crisis value and the one named at the left had its 2013 value. Thus the figures in the block would be the same as in the line above for 2005 through 2007 except for the role of the single transition rate for the line, shown at the left.

In the top line of the lower right-hand block of the figure, for the NE job-finding transition, lowering the rate to 4.1 percent per month from its pre-crisis level of 5.1 percent boosts the non-participating N fraction from 33.5 percent to 37.0 percent, just above its actual 2013 level. In other words, the decline in participation as of 2013 was entirely the result of the one-percentage-point decline in the job-finding rate of non-participants. It's not that more people were dropping out of unemployment and leaving the labor force permanently—in fact, the UN transition rate was a bit lower in 2013 than before the crisis. Rather, the rate of job-finding among non-participants, NE, was lower. This finding coincides with the general belief that a fraction of people classified as out of the labor force are actually job-seekers and, in normal times, succeed in finding jobs in large volumes despite exerting search efforts insufficient to meet the survey's criteria for classification as unemployed. In 2006, more than

	Transition rates		*Implied distribution of activities*		
	Actual 2013	*Actual 2005-2007*	*N*	*U*	*E*
Actual 2013			36.8	4.5	58.7
Actual 2005-2007			33.5	3.1	63.4
NE	4.1	5.1	37.0	3.2	59.8
NU	2.9	2.4	32.4	3.4	64.2
UE	19.3	27.5	34.7	3.7	61.6
UN	22.3	23.5	33.2	3.2	63.6
EN	2.7	2.8	33.0	3.1	63.9
EU	1.3	1.2	33.8	3.3	63.0

Table 5: Transition Rates and Implied Stationary Distributions among Activities

twice as many non-participants found jobs in the typical month as did those classified as unemployed.

Most of the other lines in Table 5 are similar to the actual figures for the pre-crisis years, 2005 through 2007. One exception is an obvious one—the job-finding rate for the unemployed, UE, at 19.3 percent per month, was substantially below its pre-crisis level of 27.5 percent, which accounts for a good part of the elevation of the unemployment rate in 2013 (4.5 percent of the population) over its pre-crisis level (3.1 percent). The other contributor was the elevation of the transition rate NU, from out of the labor force to unemployed. In the slacker labor market of 2013, it was more likely that a person out of the labor force who decided to seek work would go through a period of active search and be counted as unemployed, rather than finding a job without intervening unemployment.

This examination of labor-market dynamics suggests that some part, perhaps fairly large, of the decline in measured participation is actually the result of the slowing down of the process of finding work among people who are interested in working but whose search efforts do not place them among the unemployed, as defined in the CPS.

4.2 The extended labor force

The standard measure of the labor force that underlies the measurement of participation excludes many people who have a demonstrated interest in working, but do not satisfy the

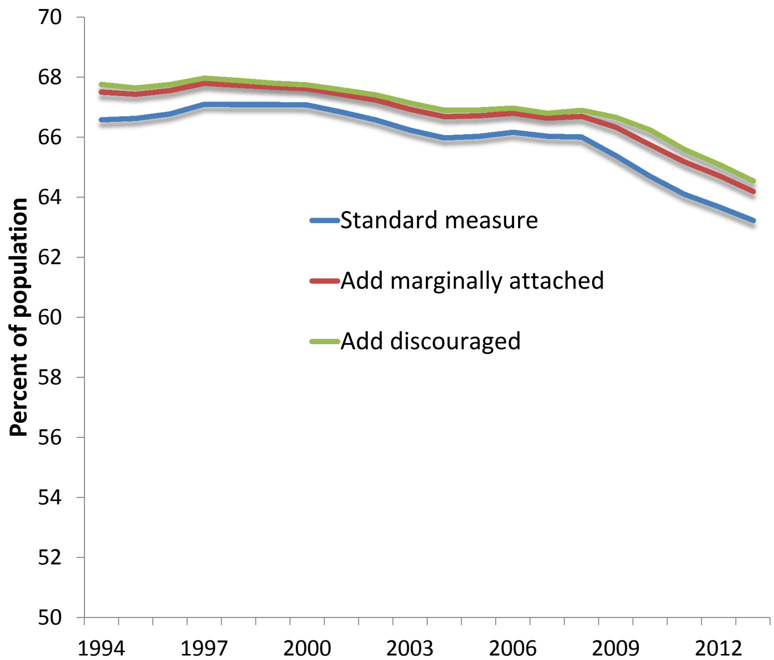


Figure 19: Conventional and Extended Measures of the Labor Force

survey's definition of active search. The definition calls for explicit job-seeking actions in the four weeks prior to the survey. For example, Hall and Schulhofer-Wohl (2013) show that the number of people who take new jobs, having been out of the labor force in the prior month, is larger than the number who were counted as unemployed. The BLS tabulates additional candidates from among those classified as out of the labor force. One is called *marginally attached*. It brings in people who want to work and are available to work, but who have not searched actively in the past four weeks. The other, rather smaller, is called *discouraged*—its members want to work but believe no jobs are available.

An obvious question is how measures of participation are affected by adding these groups to those in the conventional labor force who worked in the survey week or were actively searching in the prior four weeks. Figure 19 graphs the data. It seems fair to say that the same factors influence the extended labor force. It displays the same downward trend as the conventional measure starting in 2008 and continuing to decline at the same rate even after unemployment and other measures of slack turned around.

Table 6 shows the increments, in fractions of percentage points, to the participation rate if either or both of the additional groups were included in the labor force. In 2013, including both would raise the participation rate by half a percentage point. This amount

Year	*Marginal*	*Discouraged*	*Both*
2008	0.05	0.02	0.08
2009	0.30	0.16	0.46
2010	0.41	0.32	0.73
2011	0.43	0.24	0.67
2012	0.39	0.20	0.60
2013	0.32	0.18	0.50

Table 6: Increments to the Labor-Force Participation Rate, in Percentage Points, from Inclusion of Marginal and Discouraged Individuals

is a non-trivial component of the roughly two percentage point decline in the mix-adjusted participation rate.

4.3 Modeling the participation decision

A potential worker formulates a reservation wage, whose log is r, that governs the decision to search for work and to accept a job that she encounters. In the simplest model, the individual has a known value in the labor market, a wage whose log is w, so, at the individual level, everyone with a reservation wage below the market value declines to participate, and everyone else, with a market wage at least as good as the reservation wage, looks for work and eventually finds it, and is classified as a participant in the labor force.

A question of interest is: How much can be learned about this model from data on wages and participation? Given a distribution of the reservation wage and the market wage, one can infer the labor-force participation rate and the distribution of wages among workers. The question is how to invert the problem and find the distribution of the reservation wage and market wage from data on participation and wages of the employed. Because the unknown joint distribution of r and w is a much richer object than the observed distribution of w among workers, inversion at the most general level is impossible. The data do not identify the unknown joint distribution.

Wage-related variables tend to be distributed log-normally, so it is interesting to explore the inversion problem under the hypothesis that the unknown distribution is bivariate log-normal. The question is then reduced to determining 5 parameters of that distribution (two means, two variances, and a correlation).

The participation rate is

$$\begin{aligned}\pi &= \text{Prob}[w \geq r] \\ &= \int_{-\infty}^{\infty}\int_{r}^{\infty} \phi(r,w) dw\, dr. \end{aligned} \quad (16)$$

Here ϕ is the bivariate normal density with means μ_r and μ_w, standard deviations σ_r and σ_w, and correlation ρ.

The cdf of the wage of employed workers is

$$\begin{aligned}F(W) &= \text{Prob}[w \leq W | w \geq r] \\ &= \frac{1}{\pi}\int_{-\infty}^{W}\int_{r}^{W} \phi(r,w) dw\, dr \end{aligned} \quad (17)$$

Evaluating π and points on $F(W)$ requires numerical integration, which I accomplish using standard quadrature. The results are essentially exact.

4.4 Data

For men and women separately and by year since 2000, the BLS compiles five points on the cdfs of the normal weekly earnings of full-time workers. The points are the 10th percentile (series LEU0252911600 and LEU0252912000), the 25th percentile (series LEU0252911700 and LEU0252912100), the 50th percentile (series LEU0252881800 and LEU0252882700), the 75th percentile (series LEU0252911800 and LEU0252912200), and the 90th percentile (series LEU0252911900 and LEU0252912300). The comparable participation rates are series LNS11300001 and LNS11300002.

There are two mismatches between the theory and the data. First is the restriction to full-time workers. Though this restriction makes weekly earnings a meaningful measure of the wage rate, it results in the omission of part-time workers, who are counted as labor-force participants. Second is the omission of the unemployed, another group counted as participants.

Figure 20 shows the labor-force participation rates of men and women for the years 2000 through 2012. In both cases, participation has a pronounced downward trend and a fairly small procyclical component. Though low current rates of participation are often blamed on the soft labor market, it appears that the downward trend is by far the more important feature of participation in recent years.

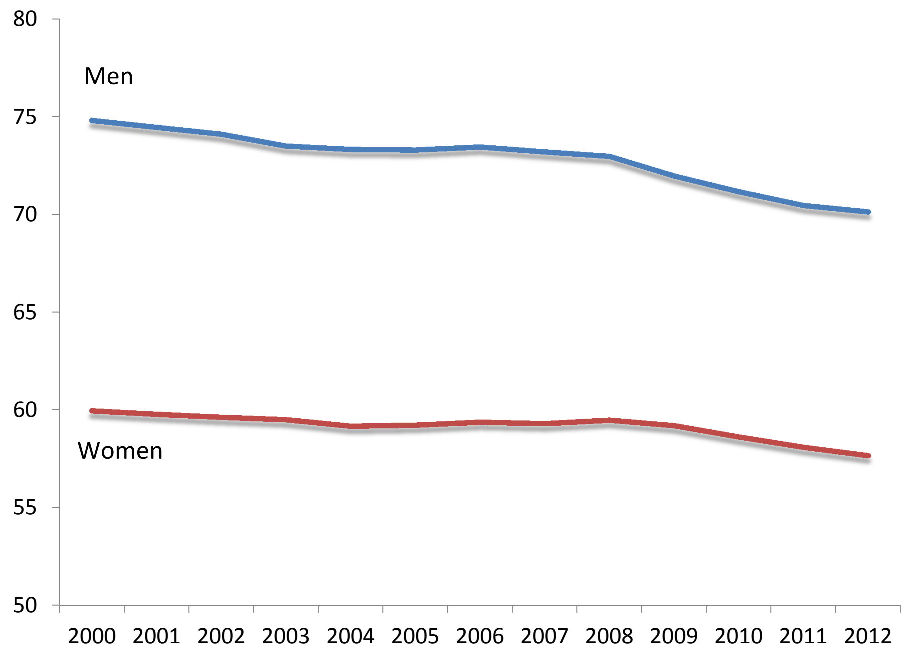
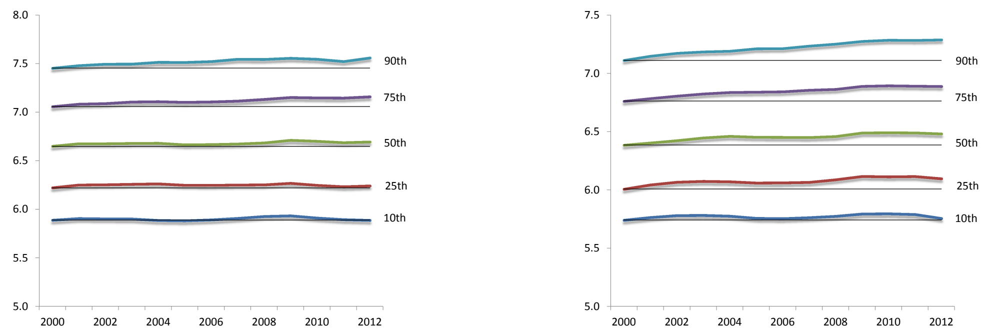


Figure 20: Labor-Force Participation Rates for Men and Women, 2000 through 2012

Figure 21 describes the distributions of real weekly earnings in terms of the earnings level at the 10th, 25th, 50th, 75th, and 90th percentiles of the distribution, for the years 2000 through 2012. The thin black lines show the levels in each quantile in 2000, to make the movements by year easier to spot. The figure confirms widely reported facts about earnings in recent decades—the dispersion of earnings rose, with earnings at the bottom of the distributions remaining constant in real terms and those at the top growing moderately. The distribution in the figure overstates the earnings opportunities of the population because it includes only those who have found jobs. One of the goals of this paper is to infer the underlying distribution of market wages for the entire population. Note that earnings growth is generally substantially higher for women than for men.

4.5 Econometrics

I estimate four unknown parameters, μ_r , σ_r, μ_w, and σ_w,, and ρ, by minimizing the sum of squared deviations of the fitted values from the model (one instance of equation (16) and five of equation (17)) from the six observed moments (the labor-force participation rate and the five quantiles). The model is overidentified by two dimensions when estimated separately for each year. Nonetheless, the observed moments do not identify the parameters with any great precision.



(a) Men

(b) Women

Figure 21: Five Quantiles of the Distributions of Real Weekly Earnings, 2000 through 2012

The parameter ρ controls the response of participation to shifts in the mean of the distribution of the market wage w, holding the reservation wage distribution constant. I pick a value, $\rho = 0.65$, that generates a mildly upward-sloping relation.

4.6 Results

Table 7 shows the estimated parameters of the participation model in the left panel. Both reservation wages and market wages have substantial dispersion among both men and women. The dispersion of the reservation wage is greater than the dispersion of market wages for both men and women. The mean of the market wage distribution is higher than the mean of the reservation wage for both men and women, to match participation rates above 50 percent, but the margin is higher for men than for women, to match the higher participation rate of men.

The right-hand panel of the table shows the derivatives of the participation rate with respect to the parameters. Higher dispersion of the reservation wage results in lower participation. Larger upper and lower tails have asymmetric effects—more lower reservation wages has little positive effect because these people already have high rates. More higher reservation wages cuts through groups at the margin of participation and has a significant negative effect. For a similar reason, higher dispersion of the market wage has a positive effect on participation. Not surprisingly, a higher mean of the reservation wage distribution results in lower participation and a higher mean of the market wage distribution results in higher participation. The derivatives with respect to μ_w and μ_r are the same in magnitude

		Average value		Derivative of labor-force participation	
Parameter	Role	Men	Women	Men	Women
σ_r	Standard deviation of log reservation wage	0.51	0.44	-0.02	0.01
μ_r	Mean of log reservation wage	-0.80	-0.94	-0.59	-0.71
σ_w	Standard deviation of log market wage	0.74	0.72	-0.26	-0.13
μ_w	Mean of log market wage	-0.46	-0.81	0.59	0.71
ρ	Correlation of reservation and market wages	0.65	0.65		

Table 7: Estimated Parameters and Derivatives

and opposite in sign—only the log-difference $w - r$ matters for participation, not the levels of the two variables.

Figure 22 illustrates the results for men in a graph. It shows 1000 random draws of the reservation wage and the market wage from the joint distribution described by the parameter values in Table 7. The heavy line separates the region of participation, where $w \geq r$, from the region of non-participation, where the market wage falls short of the reservation wage. The mode of the distribution, at the point of the mean of the log-reservation wage, $\mu_r = -0.80$, and the mean of the market wage, $\mu_w = -0.46$, is sufficiently inside the participation region to match the observed participation rate of 73 percent.

Figure 23 shows the year-by-year estimates of μ_r, the mean of the log reservation wage. It trends upward and has a pronounced countercyclical component. The distribution of reservation wages moved upward sharply in both the recession of 2001 and the Great Recession for both men and women. The increase in the Great Recession for men was no greater than in the earlier recession, whereas it was substantially larger for women.

Figure 24 shows the estimated standard deviation of the reservation wage. As I noted earlier, the dispersion of the reservation wage tends to be higher among women than among men. Women had a much larger increase in dispersion around the 2001 recession than did men. Dispersion among both men and women increased in parallel as the labor market tightened following that recession. Dispersion among women remained high during and after the Great Recession, whereas it contracted sharply for men.

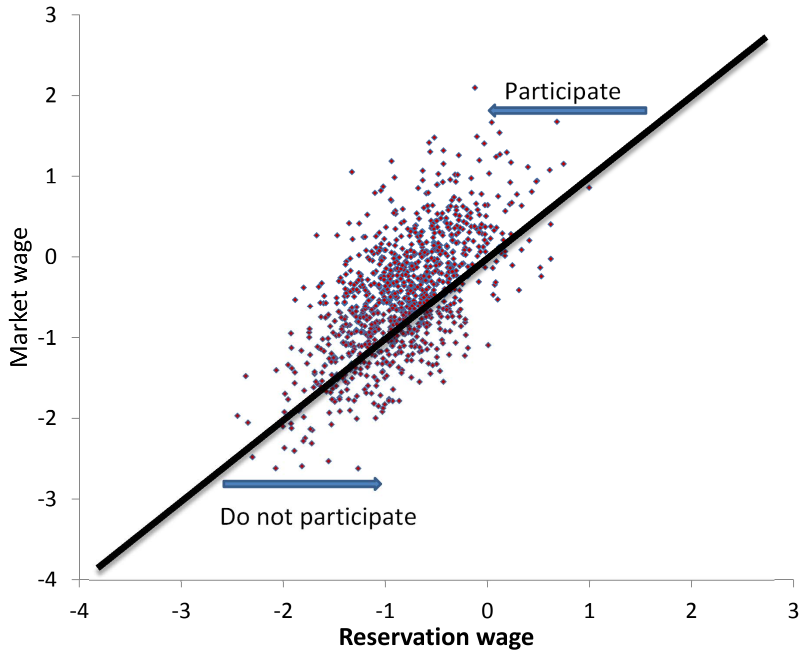


Figure 22: Joint Distribution of Market and Reservation Wages

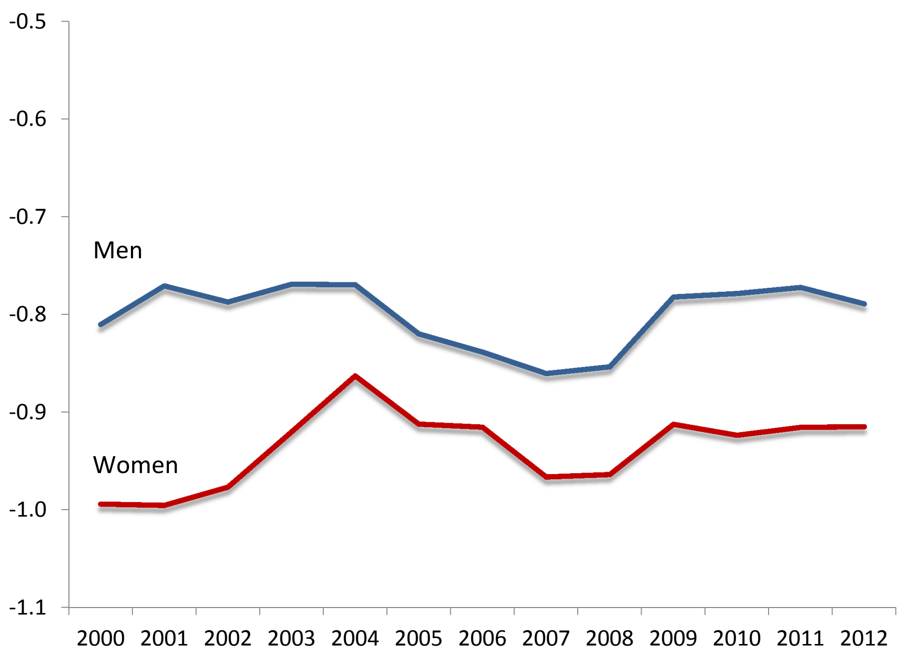


Figure 23: Mean of Log Reservation Wage, by Year

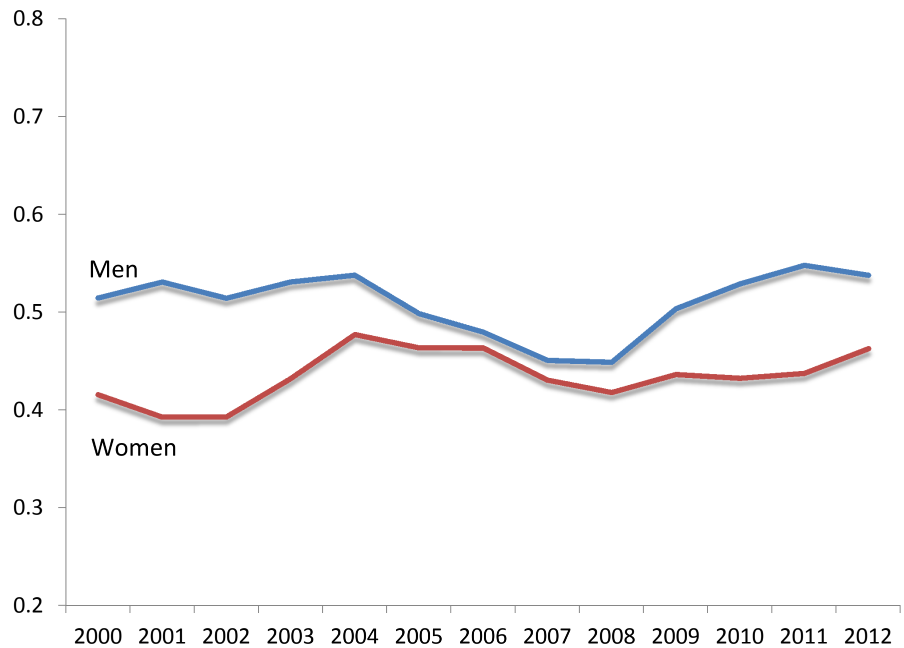


Figure 24: Standard Deviation of Log Reservation Wage, by Year

Figure 25 shows the mean of the log market wage. It has an upward trend that is more pronounced for women, reflecting the closing of the gap between the earnings of men and women. The mean is countercylical—it is higher in soft labor markets such as 2002 to 2003 and 2009 to 2011.

Finally, Figure 26 shows the estimated standard deviation of the log market wage. For both men and women, the dispersion of the market wage trends smoothly upward, tracking the rising dispersion of wages among the employed.

Figure 27 breaks down the movements of participation into two components, based on a linearization of participation with respect to the parameters. The first is the difference in the log-means of market and reservation wages. As I noted earlier, only the difference matters for participation. The second is the combined effect of the two standard deviations, σ_w and σ_r. Virtually of of the component comes from σ_r, because the movements of σ_w are small and the derivative of participation with respect to that parameter is small—see Table 7. Most of the downward trend in participation arises from the declining premium of the market wage over the reservation wage. But the large bulge in the component around 2007 is mostly offset by the decline in the dispersion component—dispersion in reservation wages rose substantially around 2007 and dispersion discourages participation. The net effect is the fairly small bulge in participation shown in the heavy line in the figure.

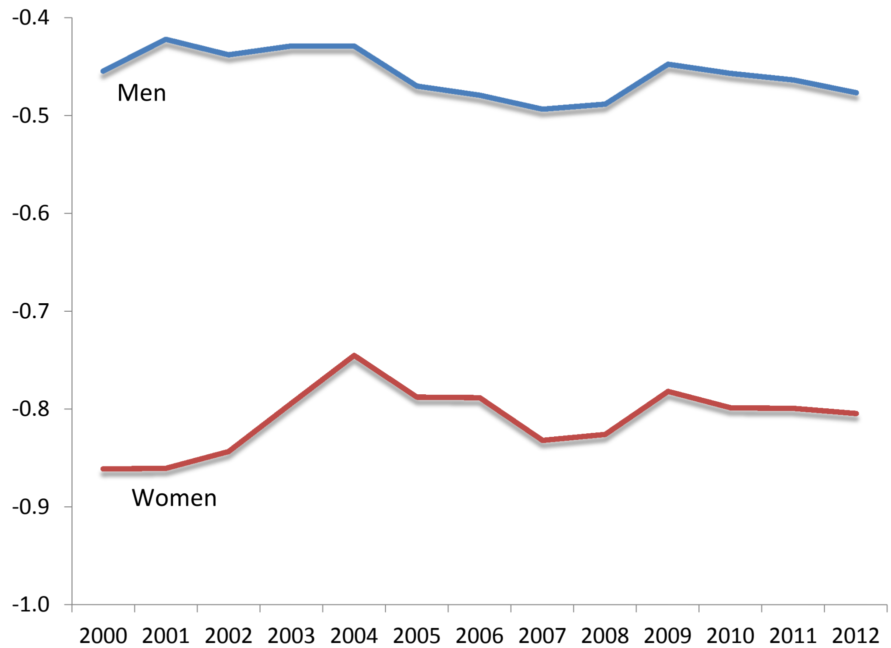


Figure 25: Mean of Log Market Wage, by Year

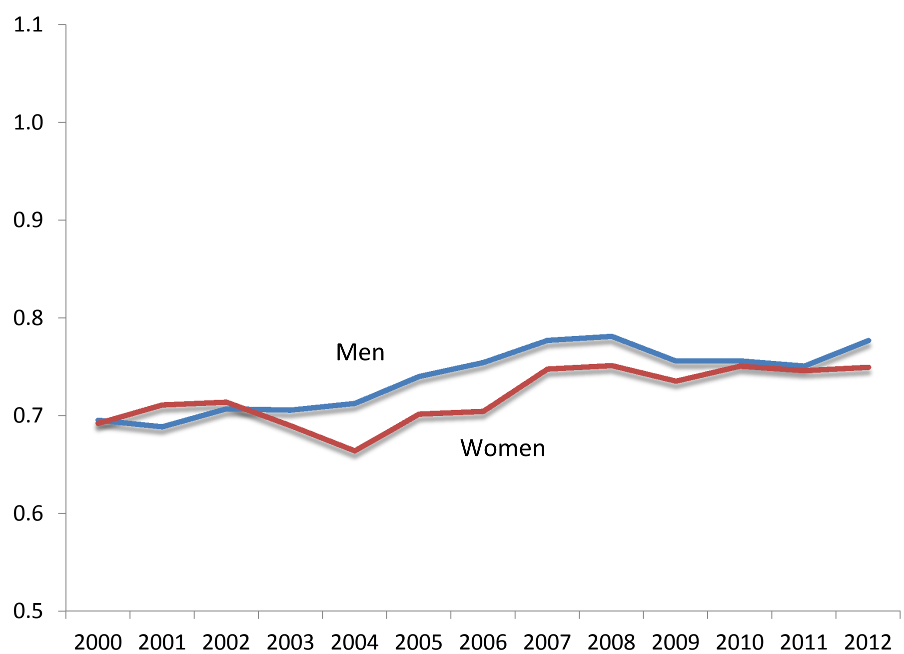


Figure 26: Standard Deviation of Log Market Wage, by Year

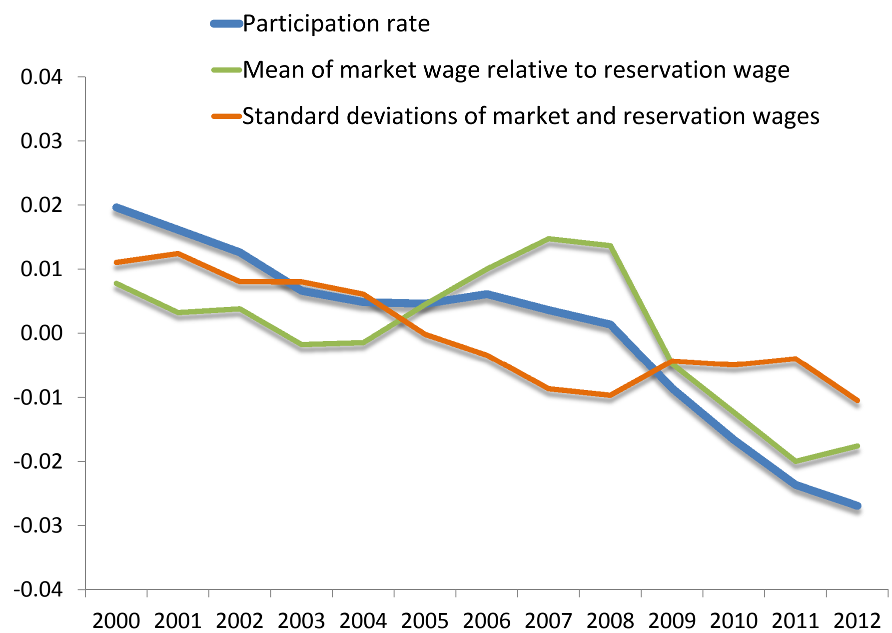


Figure 27: Decomposition of Changes in Labor-Force Participation of Men

Figure 28 breaks down the smaller decline in labor-force participation in the same way. The volatility of the two components is far less than for men. Again, most of the decline is associated with the difference in the log-means.

4.7 Conclusions from data on participation and the distribution of wages

This investigation distinguishes a shrinking gap between the means of the distributions of market and reservation wages, on the one hand, from a changing dispersion of those wages, on the other hand, as the mechanisms lying behind the downward trend in labor-force participation. The primary conclusion is that the shrinking gap in the means of the distributions accounts for most of the decline in participation for both men and women.

4.8 Tax rates and participation

The number of families receiving means-tested benefits has risen dramatically since the crisis.

Means-tested benefits have two effects within the participation model. One is the taxes implicit in means-testing. These have the effect of raising reservation wages. In log form, the reservation condition is

$$e^{-\tau} e^{w} \geq e^{r}, \tag{18}$$

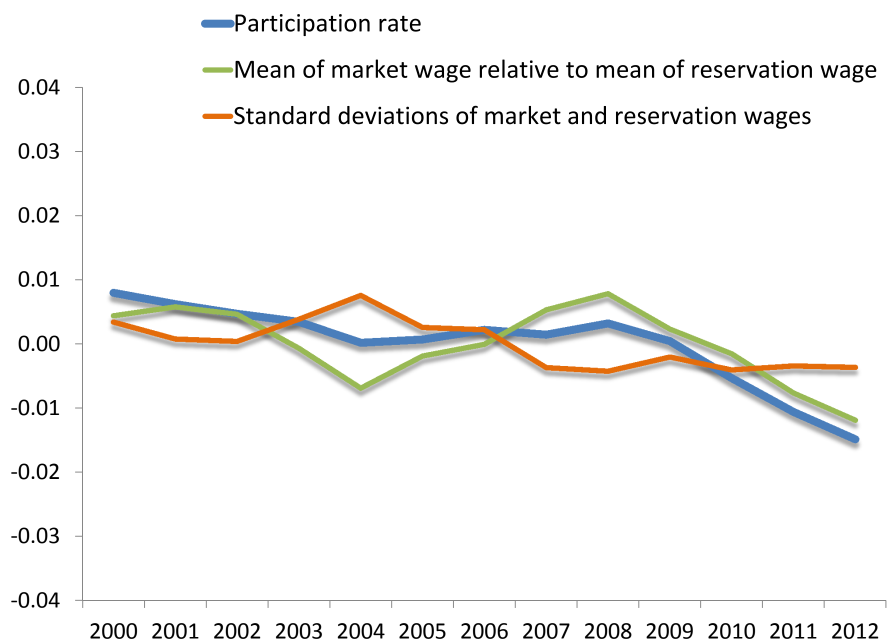


Figure 28: Decomposition of Changes in Labor-Force Participation of Women

or

$$w \geq \tau + r. \tag{19}$$

The second effect is that the benefits themselves have a wealth effect that also raises the reservation wage.

To investigate the tax effect, I consider an increase in the marginal tax rate of 11 percentage points ($\tau = 0.11$) that bears on the bottom 30 percent of the working-age population in terms of actual or potential market wages, w. The participation rate in the presence of the tax, assuming no change in the distribution of reservation wages, is

$$\pi = \int_{w=-\infty}^{w^*} \int_{r=-\infty}^{w-\tau} \phi(r, w) dr\, dw + \int_{w=w^*}^{\infty} \int_{r=-\infty}^{w} \phi(r, w) dr\, dw. \tag{20}$$

Here $w^* = \mu_w - 0.52\sigma_w$, the wage at the 30th percentile of the market wage distribution.

Table 8 shows the results of the calculation. The tax causes reductions of 2.8 percentage points in participation rates for men and 1.9 points for women. The actual declines over the period 2007 through 2012 were 3.0 and 1.6 percentage points. Extensions of benefits and rising takeup rates for programs including food stamps (SNAP), Medicaid, Social Security Disability, the Earned Income Tax Credit, and means-tested mortgage relief may have raised low-wage tax rates by 11 percentage points. Note that the safety-net program with by far the largest increase in benefits and with the highest tax rates, unemployment insurance, is not a

Participation rate, percent of population	*Men*	*Women*
Base parameters	72.9	59.2
With tax	70.1	57.2
Decline, based on model	2.8	1.9
Actual, 2007	73.2	59.3
Actual, 2012	70.2	57.7
Actual decline	3.0	1.6

Table 8: Participation Reductions from 11-percent Tax on Low-Wage Workers Compared to Actual Declines in Participation

disincentive to participation. On the contrary, to the extent that potential entrants foresee periods of unemployment with insurance coverage should they decide to participate, UI extensions encourage participation. I understand that participation dropped discontinuously when North Carolina stopped providing extended benefits partway through 2013.

4.9 Job-finding rates and participation

A low job-finding rate discourages labor-force participation by raising the difficulty of finding market employment. Historically, the effect was quite small. Participation hardly declined in recessions prior to the crisis.

In a survey of UI benefits recipients with detailed weekly recording of search effort, Krueger and Mueller (2011) found that search time is about 100 minutes per day or 1.7 hours per day or 12 hours per week. This figure is somewhat higher than found in time-use studies. Search time is close to constant across all the duration categories in the survey. From the same survey, Mueller and Hall (2014) find a weekly frequency of job offers of 5.8 percent with an acceptance rate of 72 percent. After adjustment for offers not yet accepted or rejected (21 percent), we calculate a job-finding rate of 4.8 percent per week. Thus the expected duration of search to find a job is $1/0.048 = 21$ weeks. Expected search time to find a job is $21 \times 7 \times 1.7 = 244$ hours. Job-finding rates fell approximately to half their normal levels in 2009 and 2010. Thus the extra search time was 122 hours.

A typical job lasts about 3 years, or 6,000 hours at 2,000 hours per year. To state search cost as a tax on work effort, one needs the value of time diverted from other non-work activities stated as a ratio to the earnings from work. Research on this ratio, often called z, has been active recently, but without achieving a consensus. One source of information is reported reservation wages. These tend to be close to actual wages. Krueger and Mueller (2013), Figure 2b, report that the average ratio of reservation wages to prior actual wages in their survey is 0.92. The optimal reservation wage can be higher than the opportunity cost of work, if taking a job forecloses the option of finding a higher wage. But the reservation wage can never be below the opportunity cost. The finding of high stated reservation wages is inconclusive. Further, Mueller and Hall (2014) show a substantial upward bias in stated reservation wages in the Krueger-Mueller survey—respondents frequently take jobs paying less than their earlier reported reservation wage but more rarely decline jobs paying more.

As Hornstein, Krusell and Violante (2011) point out, the opportunity cost inferred from data on search behavior is generally low, even negative. Jobseekers accept jobs with such a high frequency that they must impute a low benefit to remaining unemployed.

The research discussed above deals with the opportunity cost of moving from no work to a fulltime work schedule, which presumably drives up the marginal value of non-search time spent at home, as it declines by a substantial amount, say 40 hours per week. The opportunity cost of about 12 hours of weekly search should logically be lower. Aguiar, Hurst and Karabarbounis (2013) show that the displaced activities are mainly socializing, watching TV, and sleeping.

If the opportunity cost of search is 0.5 times the wage of the subsequent job, the tax arising from the increase in search time is $0.5 \times 122/6000$ or 1.0 percent. According to Table 7, a one-percentage-point increase in the reservation wage relative to the market wage lowers participation by 0.6 percentage points, a non-trivial effect.

4.10 Disability benefits under Social Security

Two programs under Social Security pay benefits to disabled individuals. Recipients lose some or all of the benefits if they work, so the programs discourage participation in the labor force by recipients who are capable of work, a group thought to be a growing fraction. The Old Age, Survivors, and Disability program covers those meeting certain criteria based on prior contributions to Social Security, and Supplemental Security Income covers additional recipients, almost all disabled. Some receive benefits from both programs.

Figure 29 shows the number of recipients of benefits from the two programs, without double counting. The data also exclude people aged 65 and over. The straight line shows the trend, fitted to the years 1996 through 2007. The recipient count tracks the trend quite

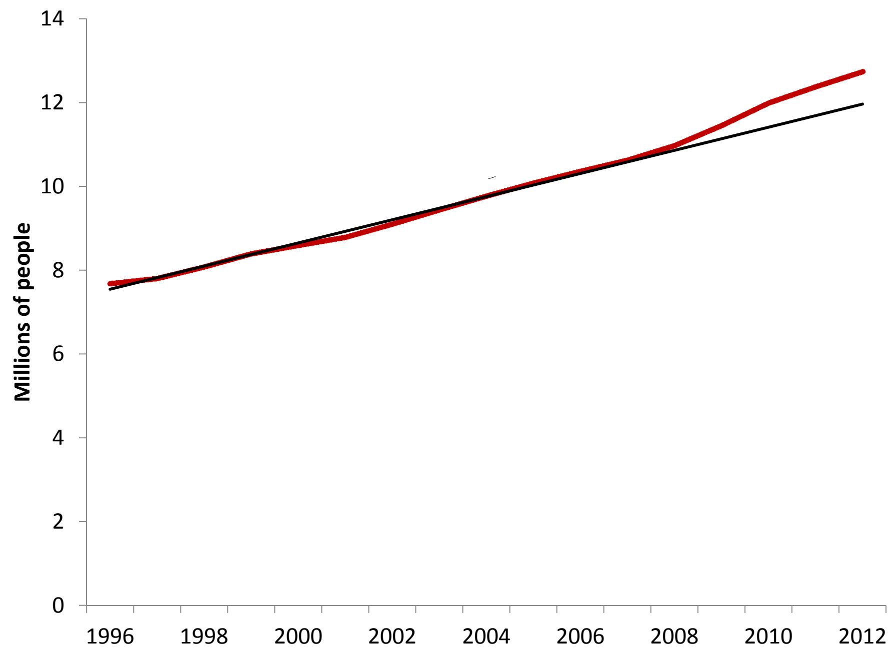


Figure 29: Number of Recipients of Social Security Disability Benefits Aged 18 through 64, in Millions

closely until the crisis, and then jumps upward. There is no sign of a return toward the trend line in recent years as the labor market has approached normal conditions.

A full analysis of the role of disability benefits in the post-crisis years would encounter the challenging issue of what fraction of the beneficiaries would be in the labor force but for the benefit programs. An upper-bound calculation of the role is available on the hypothesis that all of the added recipients would have been in the labor force. The gap between the trend line and the actual recipient count in 2013 was 770,000 people, which was 0.4 percent of the population aged 18 through 64. This amount is a potentially important fraction of the 1.9 percentage points of the post-crisis shortfall of labor-force participation calculated earlier in this section.

4.11 Other safety-net benefits

Two other components of the U.S. social safety net are large enough to be candidates for effects on participation. First is Medicaid, which provides medical care mainly to families with children. Figure 30 shows the number of people receiving Medicaid benefits in the standard format of this paper, with a trend fitted to data from 1990 through 2007, projected to 2013. Beneficiaries are on a steep upward trajectory, but the bulge in the post-crisis years

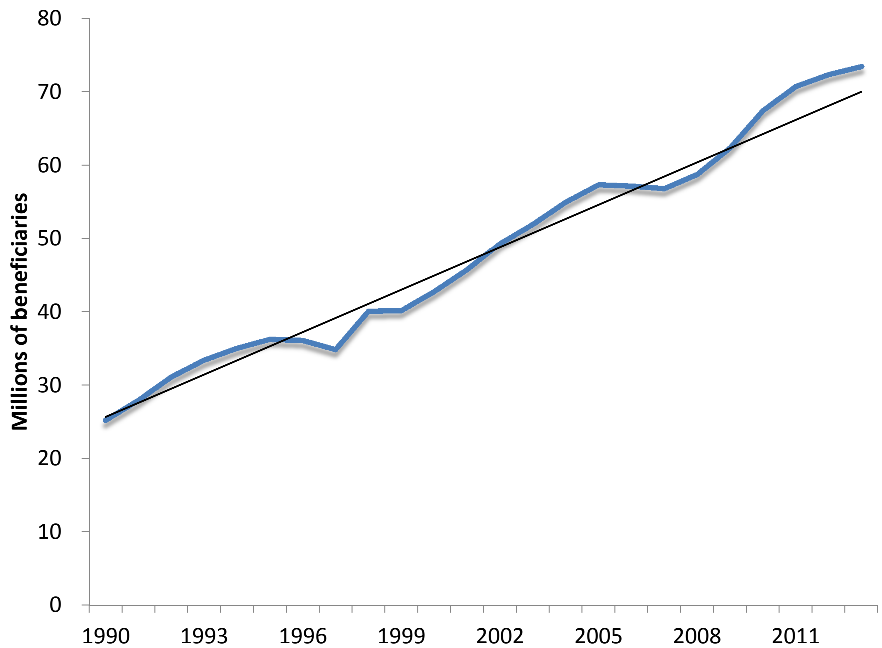


Figure 30: Medicaid Recipients

appears to be in line with those that occurred after the two previous recessions. Note that the bulge appeared to shrink in 2012 and 2013—as the labor market recovered, beneficiaries reverted toward the previous growth path. It seems unlikely that anything like a significant permanent shift in the path occurred as a result of the crisis.

The other major program is food stamps, now called SNAP. This program pays a large number of families fairly small benefits, averaging $281 per month in 2011. Figure 31 shows the number of beneficiaries, again in the standard format. Growth in beneficiaries was zero during the pre-crisis period from 1990 through 2007. In 2013, 22 million more people received food stamps than would have received them based on the pre-crisis level. In 2011, with 44.1 million beneficiaries, 20.8 million households received benefits, so the average household had just over two members. 10.1 million beneficiaries were single. Among the 20.4 million beneficiaries aged 18 through 59, 6.4 million faced work requirements. 5.7 million were employed and 5.8 million were looking for work, for an unemployment rate of 50.1 percent and a labor-force participation rate of 55.9 percent.

The rules of the food-stamp program discourage work among those electing to enroll and, on the other hand, discourage enrollment in the program for those with any significant earning power. Eligibility currently requires that gross monthly income not exceed $1,681 per month for the typical household of one adult and one child. Earnings reduce benefits

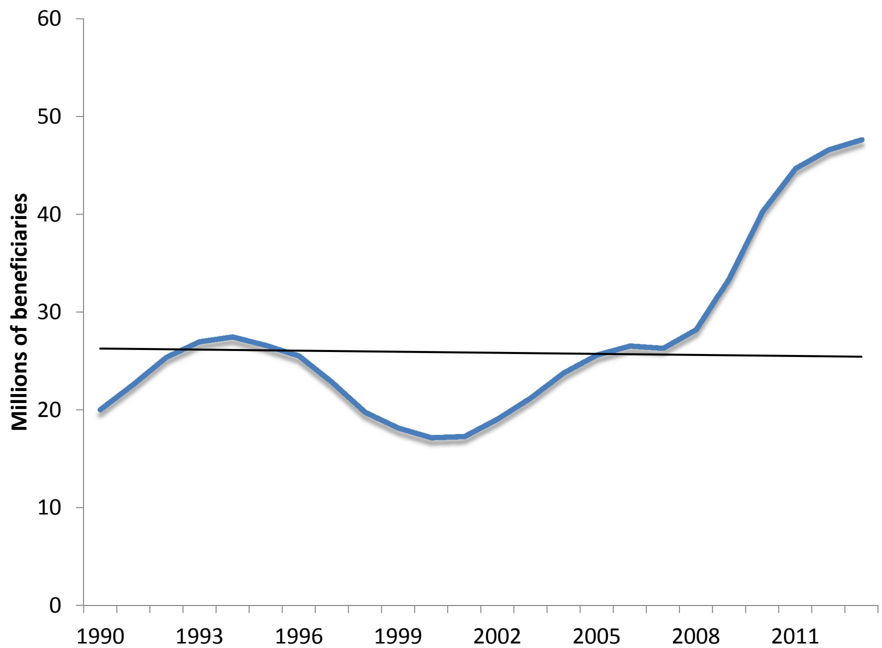


Figure 31: Beneficiaries Receiving Food Stamps

at a tax rate of 30 percent. The earnings level sufficient to reduce benefits to zero, for a household with no other source of reportable gross income, is $281/0.30 = $938 per month, about half a month's pay at $10 per hour. Actual average earned income was $312 per month in 2011, four days of work at $10 per hour.

Under the assumption that the age mix of food-stamp beneficiaries was the same in 2013 as in 2011, the increase in food-stamp beneficiaries in the age group of potential labor-force participation was 10.3 million. Of these, 6.4 million were women and 3.9 million were men. Food stamps may be part of the explanation for the higher shortfall in participation among women compared to men, shown earlier in Table 4. The 10.3 million increment was 4.2 percent of the labor force aged 16 and higher.

The expansion of food stamps resulted from some crisis-related extensions of eligibility. Mulligan (2012b) describes these in detail. These effectively removed the asset-conditioning of benefits and suspended work requirements. Higher job-finding frictions made food stamps more attractive as well. Dependence on food stamps seems to have substantial inertia, because the beneficiary population has continued to rise despite the partial return to normal conditions in the labor market.

Total decline in participation relative to trend	3.0
Sex-age mix effect	1.1
Marginal and discouraged individuals	0.5
Increase in disability benefit recipients over trend	0.4
Residual (rising primary wages, rising tax rates)	1.0
Sum of components	3.0

Table 9: Summary of Sources of Decline in the Labor-Force Participation Rate, Percentage Points of Population

4.12 Rising earnings of higher-wage primary workers

Figure 21 showed that upper-quantile real wages, especially for women, grew after the crisis at higher rates than before. These earnings tend to account for a large fraction of the total income of households, and so have a negative income effect on the participation decisions of low-wage family members, notably teenagers and young adults. Figure 16 shows that these groups had large declines in participation around the time of the crisis. This effect of the widening of the earnings distribution may be some part of the explanation of the post-crisis decline in overall participation, though it is not obviously a result of the crisis.

4.13 Conclusions about the decline in participation

Table 9 pulls together the results of the analysis of labor-force participation. The starting point is the decline relative to trend of 3.0 percent of the population, shown in Figure 15. The same figure also shows the sex-age mix effect of 1.1 percentage points. Table 6 describes the 0.5 percentage point effect of increases in marginal and discouraged individuals, who appear likely to find jobs or enter unemployment even though the CPS classifies them as out of the labor force. Figure 29 and its explanation in the text suggest that rising dependence on Social-Security disability benefits may account for as much as 0.4 percentage points of the decline in labor-force participation. Rising earnings of primary family earners may result in lower participation of other family members. Table 8 shows that a modest increase in implicit taxes from food stamps could cause important declines in participation. The last two, along with other influences, may explain the residual of 1.0 percentage points of participation decline.

Comnponent	*Contribution to shortfall*	*Immediately*	*Within a few years*	*Ultimately*
Productivity	3.4	No	No	Possibly
Capital	5.0	No	A little	Yes
Unemployment	0.9	Partly	Mostly	Yes
Participation	2.5	Partly	Partly	Partly

Table 10: Effects of Boost to Product Demand

5 Concluding Remarks

Table 10 pulls together the findings of the paper. There is no reason to expect that the cumulative shortfall in productivity growth of 3.4 percentage points of output could be reversed by a sudden increase in product demand. That shortfall seems to be the result of a period of reduced innovation, possibly the result of the crisis. The level of technology is a state variable, and thus not moveable by immediate policy. These statements are not intended as a forecast about productivity growth, however. Productivity forecasts have had no success historically. Productivity growth is a noisy process. Whether the return to a normal economy will result in a catchup in productivity growth in the longer term is an unsettled question of growth economics.

The conclusions for the capital stock are the most focused in the paper. It is unambiguous that the capital stock is an important state variable of the economy. It is responsible for the largest part of the output shortfall, 5.0 percentage points. It can't respond immediately to a boost to product demand, but a boost would probably trigger an accelerator response that would close some part of the shortfall. In the longer run, the strong mean reversion in the historical capita/output ratio should work to close the entire gap.

Employment was held back in the post-crisis period by high unemployment, which can be seen as a reduction in labor supply. Unemployment dropped slowly to 1.3 percentage points above normal in 2013, contributing 0.9 percentage points to the shortfall in output in that year. The return to normal has been slower than in previous post-recession episodes because the crisis shifted the composition of jobseekers toward those with low job-finding rates and low exit rates from unemployment. An increase in product demand would accelerate the remaining move back to normal. Mean reversion of unemployment is a well-established feature of the U.S. economy and there seems little reason to think that the crisis would affect the unemployment rate in any highly persistent way.

Labor-force participation fell substantially after the crisis, contributing 2.5 percentage points to the shortfall in output. The decline showed no sign of reverting as of 2013. Part is demographic and will stabilize, and part reflects low job-finding rates, which should return to normal slowly. But an important part may be related to the large growth in beneficiaries of disability and food-stamp programs. Bulges in their enrollments appear to be highly persistent. Both programs place high taxes on earnings and so discourage labor-force participation among beneficiaries. The bulge in program dependence is a state variable arguably resulting from the crisis that may impede output and employment growth for some years into the future.

References

Aguiar, Mark, Erik Hurst, and Loukas Karabarbounis, "Time Use during the Great Recession," *American Economic Review*, 2013, *103*, 1664–96.

Autor, David H., "The Unsustainable Rise of the Disability Rolls in the United States: Causes, Consequences, and Policy Options," Working Paper 17697, National Bureau of Economic Research December 2011.

Baicker, Katherine, Amy Finkelstein, Jae Song, and Sarah Taubman, "The Impact of Medicaid on Labor Force Activity and Program Participation: Evidence from the Oregon Health Insurance Experiment," Working Paper 19547, National Bureau of Economic Research October 2013.

Basu, Susanto, John G. Fernald, and Miles S. Kimball, "Are Technology Improvements Contractionary?," *American Economic Review*, 2006, *96* (5), pp. 1418–1448.

Bitler, Marianne and Hilary Hoynes, "The More Things Change, the More They Stay the Same: The Safety Net, Living Arrangements, and Poverty in the Great Recession," September 2013. Department of Economics, UC Berkeley.

Chari, V. V., Patrick J. Kehoe, and Ellen R. McGrattan, "Business Cycle Accounting," *Econometrica*, May 2007, *75* (3), 781–836.

Chodorow-Reich, Gabriel and Loukas Karabarbounis, "The Cyclicality of the Opportunity Cost of Employment," Working Paper 19678, National Bureau of Economic Research, November 2013.

Cochrane, John H., "Presidential Address: Discount Rates," *Journal of Finance*, 2011, *66* (4), 1047 – 1108.

Congressional Budget Office, "The Supplemental Nutrition Assistance Program," April 2012.

——, "Revisions to CBO's Projection of Potential Output since 2007," February 2014.

Daly, Mary, Bart Hobijn, Ayşegül Şahin, and Rob Valletta, "A Rising Natural Rate of Unemployment: Transitory or Permanent?," Working Paper 2011-05, Federal Reserve Bank of San Francisco, September 2011.

Elsby, Michael W.L., Bart Hobijn, and Ayşegül Şahin, "On the Importance of the Participation Margin for Market Fluctuations," Working Paper 2013-05, Federal Reserve Bank of San Francisco February 2013.

Erceg, Christopher J. and Andrew T. Levin, "Labor Force Participation and Monetary Policy in the Wake of the Great Recession," Working Paper 13/245, International Monetary Fund, July 2013.

Farber, Henry S. and Robert G. Valletta, "Do Extended Unemployment Benefits Lengthen Unemployment Spells? Evidence from Recent Cycles in the U.S. Labor Market," Working Paper 19048, National Bureau of Economic Research, May 2013.

Fernald, John, "Productivity and Potential Output Before, During, and After the Great Recession," *NBER Macroeconomics Annual*, 2014.

Fernald, John G., "A Quarterly, Utilization-Adjusted Series on Total Factor Productivity," September 2012. 2012-19, Federal Reserve Bank of San Francisco. Updated regularly on Fernald's FRBSF website.

Fujita, Shigeru, "Effects of Extended Unemployment Insurance Benefits: Evidence from the Monthly CPS," January 2011. Federal Reserve Bank of Philadelphia.

Ganong, Peter and Jeffrey B. Liebman, "The Decline, Rebound, and Further Rise in SNAP Enrollment: Disentangling Business Cycle Fluctuations and Policy Changes," Working Paper 19363, National Bureau of Economic Research, August 2013.

Hagedorn, Marcus, Fatih Karahan, Iourii Manovskii, and Kurt Mitman, "Unemployment Benefits and Unemployment in the Great Recession: The Role of Macro Effects," October 2013. National Bureau of Economic Research Working Paper 19499.

____ , ____ , ____ , and ____ , "Case Study of Unemployment Insurance Reform in North Carolina," January 2014. University of Pensylvania.

Hall, Robert E., "Measuring Factor Adjustment Costs," *Quarterly Journal of Economics*, August 2004, *119* (3), 899–927.

____ , "The High Sensitivity of Economic Activity to Financial Frictions," *Economic Journal*, May 2011, *121*, 351–378.

——, "The Routes into and out of the Zero Lower Bound," *Proceedings of the Jackson Hole Symposium, Federal Reserve Bank of Kansas City*, 2013. Forthcoming.

——, "High Discounts and High Unemployment," January 2014. Hoover Institution, Stanford University.

—— and Sam Schulhofer-Wohl, "Measuring Matching Effciency with Heterogeneous Jobseekers," November 2013.

Hanel, Barbara, "The effect of disability pension incentives on early retirement decisions," *Labour Economics*, 2012, *19* (4), 595 – 607. European Association of Labour Economists 23rd annual conference, Paphos, Cyprus, 22-24th September 2011.

Hornstein, Andreas, Per Krusell, and Giovanni L. Violante, "Frictional Wage Dispersion in Search Models: A Quantitative Assessment," *American Economic Review*, 2011, *101* (7), 2873–98.

Hotchkiss, Julie L., M. Melinda Pitts, and Fernando Rios-Avila, "A Closer Look at Nonparticipants During and After the Great Recession," Technical Report Working Paper 2012-10, Federal Reserve Bank of Atlanta August 2012.

Krueger, Alan B. and Andreas I. Mueller, "Job Search, Emotional Well-Being, and Job Finding in a Period of Mass Unemployment: Evidence from High-Frequency Longitudinal Data," *Brookings Papers on Economic Activity*, Spring 2011, (1), 1–70.

—— and ——, "A Contribution to the Empirics of Reservation Wages," November 2013.

Krusell, Per, Toshihiko Mukoyama, Richard Rogerson, and Ayşegül Şahin, "Gross Worker Flows over the Business Cycle," November 2012.

Mortensen, Dale T. and Christopher Pissarides, "Job Creation and Job Destruction in the Theory of Unemployment," *Review of Economic Studies*, 1994, *61*, 397–415.

Mueller, Andreas and Robert E. Hall, "Wage Dispersion and Search Behavior," 2014. In preparation.

Mueller, Andreas I., Jesse Rothstein, and Till M. von Wachter, "Unemployment Insurance and Disability Insurance in the Great Recession," Working Paper 19672, National Bureau of Economic Research November 2013.

Mulligan, Casey B., "Do Welfare Policies Matter for Labor Market Aggregates? Quantifying Safety Net Work Incentives since 2007," Working Paper 18088, National Bureau of Economic Research, May 2012.

——, *The Redistribution Recession: How Labor Market Distortions Contracted the Economy*, New York: Oxford University Press, 2012.

Nakajima, Makoto, "A Quantitative Analysis of Unemployment Benefit Extensions," *Journal of Monetary Economics*, 2012, *59* (7), 686 – 702.

Petrongolo, Barbara and Christopher A. Pissarides, "Looking into the Black Box: A Survey of the Matching Function," *Journal of Economic Literature*, 2001, *39* (2), 390–431.

Ravn, Morten O. and Vincent Sterk, "Job Uncertainty and Deep Recessions," December 2012. University College London.

Valletta, Rob and Katherine Kuang, "Extended Unemployment and UI Benefits," *Federal Reserve Bank of San Francisco Economic Letter*, April 2010, pp. 1–4.

Appendix

A Calculations in Table 1

The calculations embody the basic identity:

$$\text{Output growth} = \text{productivity growth} + \text{capital contribution} + \text{labor contribution.}$$

In turn,

$$\text{capital contribution} = \text{capital share} \times \text{change in log per capita input}$$

and

$$\text{labor contribution} = \text{labor share} \times \text{change in log labor input.}$$

Finally,

$$\begin{gathered}\text{Change in log labor input} = \text{change in log population} \\ + \text{ change in log participation rate} + \text{change in log employment rate} \\ + \text{ change in log hours per week} + \text{change in log labor quality} \\ + \text{ change in log of business fraction of labor input.}\end{gathered}$$

I do these calculations first for a counterfactual situation where the growth rates are equal to pre-crisis trends and second for the actual experience. The table shows the differences between the two calculations, interpreted as the post-crisis shortfall. I use the actual shares for the counterfactual calculations. Data sources and details of the calculations appear in a spreadsheet in the backup materials for the paper at stanford.edu/∼rehall .

The unemployment rate in 2007, at 4.6 percent, was 1.2 percentage points below the value I use as normal, 5.8 percent (the average from 1948 through 2013). The calculations in the table treat the counterfactual unemployment rates in 2010 and 2013 as 4.6 percent, although unemployment is mean-reverting to its normal level.

B Related Research

Congressional Budget Office (2014) describes the agency's updates of its estimates of potential output since 2007. Although the focus of the study is on all changes, the document gives some indications of the CBO's views about the effect of the crisis on potential output. In

2007, the last year of the estimate was 2017. As a result of all changes, the CBO's 2014 estimate of potential GDP in 2017, adjusted for intervening changes in the NIPAs, is 7.3 percent below its estimate for the same year, made in 2007. The CBO breaks down the 7.3 percent into four categories, of which two, *recession and weak recovery* and *reassessment of trends* account for the bulk, 1.8 and 4.8 percentage points, respectively. The CBO explains that severe recessions following financial crises "...dampen investment, raise the rate and average duration of unemployment, and reduce the number of hours that people work," and thus cut potential output. The CBO concludes that the unemployment rate will be 0.5 percentage points higher than normal and the labor-force participation rate 0.4 percentage points lower than normal in 2017 because of lingering effects of the crisis in the labor market. The effect on potential output is 0.7 percentage points. The estimated reduction in 2017 potential output from lost investment on account of the crisis and recession is 0.6 percent and the reduction from lost productivity growth (taken to be a permanent effect) is 0.5 percentage points.

All of these effects of the crisis as of 2017 are smaller—especially the effect of lost investment—than those in this paper, in Table 1, for 2013. The combined loss of output from investment, labor-force participation, and TFP is 10.9 percentage points. Though the effects of investment and participation will decline somewhat over four years, the total in this paper is obviously much larger than the CBO estimates.

The second major category in the CBO study is reassessment of trends, which accounts for 4.8 percentage points of decline in 2017 potential output. The CBO explains "...although already in progress before the business cycle peaked in 2007, did not become apparent until after that peak had been identified." With the NBER's determination of a peak at the end of 2007 and other changes in CBO's trend-measurement techniques, the rapid growth of the 1990s became less influential and the slower growth from 2000 through 2007 correspondingly more influential in later CBO projections. The change in the CBO's projections of total labor input to the business sector accounted for a decline of 3.0 percentage points in 2017 potential output. Lower investment and lower TFP growth each accounted for 0.7 percentage points of decline in 2017 potential output.

By far the most important difference between CBO's analysis and mine is the tiny role CBO assigns to the shortfall in capital, which I find accounts for 5.0 percentage points of output shortfall in 2013 while the CBO assigns it 1.3 percentage points in 2016. The CBO splits this into 0.6 percentage points from the crisis and 0.7 points from their reassessment of trends. For other components of the shortfall, the CBO's estimates are roughly in agreement with mine. For TFP, the CBO has a total effect of 1.2 percentage points compared to my 3.4 points, but I do not take much of a stand on how much of the 3.4 point shortfall resulted from the crisis. For labor input, CBO assigns 0.7 percentage points to the crisis, mostly in reduced labor-force participation, but 3.0 percentage points to a declining trend that began before the crisis. The total is comparable to my findings, but I assign somewhat more to the crisis.

B.1 Unemployment

Ravn and Sterk (2012) develop a model with two types of unemployment and a changing mix depending on driving forces. In normal times, much of the flow into unemployment comprises workers whose terminations lead to easy placement in new jobs, but, following a major uncertainty shock, the mix shifts towards those who are much harder to place. These shocks result in large increases in unemployment. The model accounts for the declining measured matching efficiency.

B.2 Labor-force Participation

Erceg and Levin (2013) conclude that the shortfall of labor-force participation from its pre-crisis trend was about two percentage points, in line with the findings here. They measure the trend as the BLS's forecast made in November 2007. They make the case that the shortfall was the result of a slack labor market. They use a regression of state-level changes in the LFPR between 2007 and 2012 on the changes in the unemployment rate between 2007 and 2010. They use the longer span for the LFPR based on evidence that historically the rate has had inertia relative to the unemployment rate. A variety of specifications agree that the coefficient is -0.3 with a standard error of 0.1. Given a 5-percentage point increase in the unemployment rate post-crisis, the coefficient implies a decline in the LFPR of 1.5 percentage points. The authors conclude, "...the state-level data indicates that the aggregate decline in prime-age LFPR since 2007 can be *fully* explained by the persistent shortfall in labor demand." (emphasis in original, p. 15). They do not take a stand on the size of the decline in the trend-adjusted prime-age LFPR other than calling it "nearly two percentage points" (p. 12).

The standard error of the estimate of 5 times the coefficient is 0.5 percentage points, so the 95-percent confidence interval for the part of the decline attributable to rising unemployment is $[1.5 - 2 \times 0.5, 1.5 - 2 \times 0.5] = [0.5, 2.5]$, so the evidence is consistent with a rather smaller role of unemployment and with a role so large as to over-explain the decline in the LFPR.

In Table 9, the line for marginal and discouraged individuals, at 0.5 percentage points of reduction in the LFPR, is explicitly a result of a slack labor market. Some part of the last line, the residual, may also be a result of slack. Thus the results in this paper are within the confidence interval, but probably near its lower boundary and therefore inconsistent the Erceg and Levin's estimate at a lower confidence level.

The authors also estimate that the rise Social-Security disability dependence above its trend is 0.4 percentage points, the same as in Table 9.

With respect to the prime-age individuals whom the authors believe withdrew from the labor market for reasons other than disability, the authors write, "Evidently, the remainder represents roughly a million individuals who have given up searching for a job and instead are engaged in other activities such as child care, home renovation projects, etc." (p. 19) I believe this statement is mistaken for two reasons. First, there is evidence that the rise in non-participation has added mostly to the groups who are engaging in job search at a low level, but will ultimately find jobs, or will begin search fairly soon. Their number is swollen by low current success rates for search. Second, the evidence on time use shows little increase in home production in slack labor markets—leisure activities tend to absorb the extra time.

Autor (2011) is a recent and complete discussion of Social-Security disability and the reasons for the expansion of dependence relative to the health of the labor force. Hanel (2012) finds substantial reductions in labor supply from the implicit taxation of earnings in the German disability program.

Congressional Budget Office (2012) is an extensive discussion of the economics of food stamps, including forecasts of gradually declining dependence after 2012. Ganong and Liebman (2013) decompose the recent growth of food-stamp beneficiaries into a large component associated with slack labor market and a smaller component associated with expanded eligibility.

Baicker, Finkelstein, Song and Taubman (2013) rule out the possibility that access to Medicaid depresses labor-force participation by more than a small amount and show that zero effect is consistent with the results of a random-assignment experiment.

Mulligan (2012a), Figure 2, describes his calculations of eligibility for three major safety-net programs: During the period from 2007 through 2011, he finds no change in eligibility standards for Medicaid and large extensions for food stamps and UI benefits.

Bitler and Hoynes (2013) present evidence that the expansion of safety-net dependence after 2007 was comparable to expansions in previous slumps, given adjustments for the magnitudes of the slumps.

Mueller, Rothstein and von Wachter (2013) study the relation between UI benefits and Social-Security disability claims. They reject the possibility that individuals move in meaningful numbers from UI to disability programs when UI benefits expire.

Hotchkiss, Pitts and Rios-Avila (2012) finds non-work activities identified as "school" and "other" grew during the period of decline in labor-force participation. They conclude that these are probably temporary and, as they return to normal, participation will rise.

Elsby, Hobijn and Şahin (2013) show the importance of studying the gross flows of individuals among employment, search, and out-of-labor-force, in understanding fluctuations in participation. They present evidence of the heterogeneity of those classified as out of the labor force—the distribution of the job-finding hazard ranges from zero to levels similar to those classified as unemployed. Krusell, Mukoyama, Rogerson and Şahin (2012) construct a model with explicit treatment of the flows among the three activities.