Explaining the Wage Growth Mystery

BY ADAM OZIMEK

A wage "mystery" has puzzled economics commentators for several years: If unemployment is so low, why has wage growth not picked up? This article will argue that there is no puzzle when the right measures are used. The problem with how wages are measured is that the most commonly used measure is biased over the business cycle. The problem with how labor slack is measured is that the magnitude and depth of the Great Recession led many workers who could and would work again to exit the labor force entirely. As a result, many workers relevant to labor market slack were no longer being counted as unemployed, making the unemployment rate a poor gauge of labor market slack.

With wage growth biased and poorly measured slack making labor markets appear tighter than they are, it is no surprise that wage growth and the unemployment rate have had a weak relationship over the recession and recovery. However, if wage growth is measured using the Employment Cost Index (ECI), which controls for the labor market composition, and if wage slack is measured using the prime employment-to-population rate, or EPOP, which is the share of those age 25 to 54 who are employed, then wage growth and labor market slack are very closely related. Measured properly, there is no wage growth mystery. Wages are exactly where one would expect them to be given the slack in the labor market.

Picking best measure of wage growth

One source of confusion surrounding the state of the labor market is that there are a variety of measures available for U.S. wage growth, and some of them are less useful than others. However, there are good reasons to favor the Employment Cost Index, and this measure paints a pretty clear story about U.S. wages: They have steadily and consistently been accelerating, but are not rising very fast yet.

To understand why the ECI is crucial, it is important to understand exactly why other measures of wage growth can be misleading or present an incomplete picture of the labor market.

The problem with average hourly earnings

One key shortcoming of many wage data sources, including average hourly earnings, or AHE, from the Bureau of Labor Statistics, is that they do not control for changes in the composition of the jobs or workforce. This becomes a problem for measuring cyclical fluctuations in wage growth because firms lay off more low-wage workers at the onset of a recession. This biases wage growth upward. As the economy recovers and employers start hiring the lowest-paid workers again, wage growth is biased downward. For example, if all workers at a firm receive a pay cut of 5%, but the lowest-paid 20% of workers are laid off, average hourly earnings at this firm could easily show positive wage growth despite wage cuts and layoffs. Then, as the recovery takes hold, if the firm raises wages but also hires more low-paid workers, average hourly earnings could fall despite across-the-board raises.

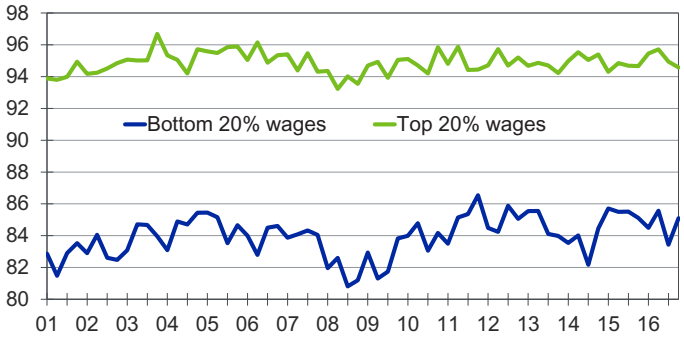
A simple empirical analysis can illustrate how large this effect could be. First, it is clear that the lowest-paid workers experienced more layoffs during the recession. Using Current Population Survey data, we can look at people who held jobs in one month and see how many of them were employed a year later. Using the outgoing rotation group sample, a subset of CPS respondents who are asked about earnings, we can also group these workers by wages in the starting period. The analysis shows that the probability of having a job a year later declined most for the lowest-paid workers during the Great Recession (see Chart 1).

To illustrate the magnitude of the composition bias, we can look at how the odds of being employed a year later changed for those who were employed in the third quarter of 2007 versus those who were employed in the third quarter of 2008, and also how the change in these odds was related to their initial pay. This allows us to estimate how composition affects average hourly earnings for continuously employed workers during the onset of the Great Recession. For the lowest-paid group, the odds of being employed a year later fell from 84.3% to 80.8% from 2007Q3 to 2008Q3, compared with a smaller decline for the highest-paid group, from 95.5% to 94%.

Although the probability of job loss increased for all wage groups during the recession, greater losses among the lowest-paid meant that the workforce became more highly skilled and highly paid than it was prior to the recession. The

Chart 1: Greater Job Loss for Lowest Paid

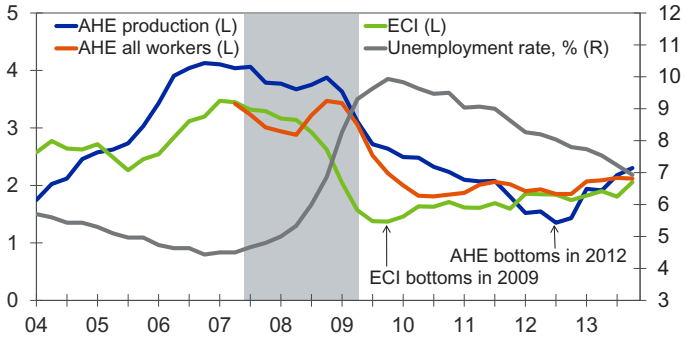
Odds of being employed a yr later by wage quintile, %



Sources: BLS, Moody's Analytics

Chart 2: Bias Slows AHE Cyclicality

Alternative wage growth measures, % change yr ago



Sources: BLS, Moody's Analytics

change in relative job loss rates from 2007Q3 to 2008Q3 implies average hourly earnings for continuously employed workers would go up by 0.4% even with no change in wages.

It is easy to see how overall AHE can be biased upward when earnings for continuing workers are biased up by 0.4% from one year to the next. After all, this analysis captures only part of the composition bias. During a recession, lower-skilled workers are not only more likely to go from employed to not working, but also less likely to transition back into employment than higher-skilled workers.

Finally, it is worth noting that the composition bias also works in the opposite direction when lower-skilled workers transition back into employment during the recovery and AHE is biased downward.

In addition to this exercise with microdata, the aggregate data clearly illustrate the problem of composition bias when AHE growth is compared with the unemployment rate over the Great Recession and recovery (see Chart 2). Overall, AHE is not very cyclical. The growth rate in AHE for production and nonsupervisory workers remained elevated even as unemployment was increasing quickly in 2008 and 2009.[1] In addition, AHE growth did not bottom until 2012, three years after the recession ended and unemployment had already come down significantly from its peak. From the start of the recession until the end, AHE fell only 1 percentage point. After the recession ended, AHE growth fell 1.5 percentage points.

AHE for all workers, which is available only starting in 2006, performs slightly better than AHE for production and nonsupervisory workers in some ways, and worse in other ways. It reaches a bottom in 2010, which is still after the recession has ended but sooner than AHE for production and supervisory workers. However, this measure of wage growth did not decelerate at all during the recession and, in fact, peaks in the fourth quarter of 2008.

Other measures

In contrast to the two measures of AHE, the ECI minimizes the risk of composition bias by focusing on wage growth within narrowly defined jobs. Importantly, these narrow definitions include job experience. This means that when the least-experienced workers are laid off, this will not necessarily affect wage growth as measured by the ECI. It is true that lowest-paid, lowest-skilled and least-experienced are not entirely synonymous concepts. However, the success of the ECI's approach in measuring wage growth is visible in the aggregate data, as the ECI showed a much more plausible cyclicality of wage growth over the recession. ECI growth decelerated almost 2 percentage points from the start of the recession to the end and bottomed two quarters after the end of the recession.

Looking beyond the Great Recession, in recent decades, wage growth as measured by the ECI is clearly more timely and cyclical than when measured by AHE. Over the past 20 years, the correlation between AHE growth and the unemployment rate is -0.54, while ECI growth and the unemployment rate are much more inversely correlated at -0.78. Given the higher cyclicality, the ECI is therefore more useful for gauging cyclical slack.

The Atlanta Fed Median Wage Growth Tracker, or WGT, is a third alternative with some desirable features. This measure follows the same workers over time and calculates the median wage growth rate among all workers in the Current Population Survey for whom wage data are available. This approach helps control for composition bias somewhat by focusing on the same worker over time. However, the WGT conflates wage growth due to promotions and experience with wage growth due to labor market tightness. For example, wage growth due to a promotion to a higher position would not be counted as wage growth in the ECI, because the individual would be moved to a higher experience group, but it would be counted as wage growth in the WGT.[2] Despite this bias, the

1 Average hourly earnings are reported as part of the monthly Current Employment Situation report. It is available for production and nonsupervisory workers back to 1964, and for all workers back to 2006. Production and nonsupervisory workers, about 80% of all workersv vary by industry. In service-providing industries, they exclude owners and those primarily employed to direct, supervise or plan the work of others. In goods-producing industries, they include working supervisors or group leaders who may be "in charge" of some employees, but whose supervisory functions are only incidental to their regular work. They exclude managers, sales or accounting personnel.

2 Alternatively, if promotions are pro-cyclical, then to some degree promotion-driven wage growth may be reflective of the business cycle. However, given the life cycle of earnings growth for individuals, most promotions are not due to cyclicality and therefore it is unlikely most of the time series variance in promotions are cyclical either.

WGT has plausible cyclicality that makes it a useful measure of wages at a first glance. It fell sharply during the Great Recession, bottomed shortly after it ended, and is strongly correlated over the last 20 years with the unemployment rate.

However, over the last two years the WGT has not performed as well as the ECI at tracking the cyclicality of the labor market. Starting in 2015, the WGT began to flatline between 3% and 3.5%, sending a signal that the labor market was at full employment. Over this time period, the unemployment rate fell by 1.5 percentage points. As a result, the four-year rolling correlation between the WGT and unemployment has fallen from -0.8 at the end of 2014 to -0.43 in the first quarter of 2018.

Looking over a longer period suggests the WGT is useful, and it is certainly better than the AHE for gauging cyclicality. However, while short-term volatility and divergences are to be expected for any wage measure, because the WGT sent a misleading signal about the labor market for two years, any confidence that its current trends reflect the cyclical reality is undermined.

Though the ECI is the most preferable measure available, it is not without imperfections. The end of 2014 and beginning of 2015 an acceleration in wage growth was followed by a rapid drop in growth. This could be statistical noise, but it also coincides with significant deflation pressures from the energy bust, which caused the headline CPI to fall by 2.5% at an annualized pace in the first quarter of 2015.

Whether the drop in the ECI reflected underlying deflation pressures or statistical noise during this period, looking at the WGT in this period provides a useful counterbalance that reflects the actual underlying labor market tightness. This illustrates that even the best wage growth measures can send misleading signals, and it is therefore useful to look at multiple measures. However, as a whole the ECI is the most reliable indicator with the most robust controls and the clearest cyclicality.

Nominal wages vs. real wage growth

An additional source of confusion surrounding the state of the labor market is whether real or nominal wages matter for gauging how far we are from full employment. As with the choice of wage measures discussed above, the choice of nominal versus real depends on context.

For example, because real wage growth subtracts inflation from nominal wage growth, it is useful for comparing wage gains between different inflation regimes. The rapid pace of inflation in the late 1960s to early 1980s compared with the last 20 years is why there is no correlation between nominal growth in average hourly earnings and the U.S. unemployment rate from 1965 to 2017. However, real average hourly earnings, deflated by core CPI, have a strong and statistically significant relationship to the unemployment rate over this long time series. This shows that for comparison across different inflation regimes, real wages are more appropriate.

However, to understand current labor market conditions, it is more useful to consider the last two decades of data rather than the very long run. Before this period, high inflation was still being wrung out of the system, and the participation of women in the workforce was still undergoing structural upward growth, making the comparison less useful.

And for the last 20 years, nominal wages have a better relationship to labor market slack than real wages do, regardless of how either is measured (see Table 1). Deflating wage growth by core PCE (excluding volatile food and energy prices) reduces its correlation with prime non-EPOP (1 minus prime EPOP, converted for comparability to the unemployment rate) from -0.93 to -0.79. Using the unemployment rate shows similar results, with the unemployment rate correlation falling from -0.79 to -0.63. Deflating wages by headline PCE weakens the relationship with labor slack further, reducing the correlation with prime non-EPOP to -0.48 and with the unemployment rate to -0.41. These results show that nominal wages have been more cyclical than real wages over the last two decades regardless of how wages or slack are measured.

The superiority of nominal wage growth is also clear in the volatile path of real wages in the last few years. Even core inflation, which is supposed to measure only the more stable components of inflation, has been buffeted by factors such as the energy boom and bust. This volatility has made real wage growth fluctuate in ways that are clearly not related to labor slack. Nominal wage growth, in contrast, falls after the recession, stays flat for a few years, and has smoothly and gradually risen. In contrast to real wage growth, this is consistent with a sharp increase in slack that has slowly and steadily been declining.

Finally, those who argued beginning in 2015 that strong real wage growth indicated full employment must also reconcile full employment with years of weak inflation.[3] One can argue that inflation was below target for transitory and measurement problems starting in 2015, but one cannot point to that same fast real wage growth as evidence that labor markets have been tight. Fast real wage growth in this case must also be transitory or driven by mismeasurement. Fast real wage growth driven by a falling inflation as evidence of full employment is a tough circle to square given that full employment should generate accelerating inflation.

Table 1: Nominal Wages More Closely Related to Labor Slack

Correlation coefficient, 1995Q1 to 2018Q1, quarterly

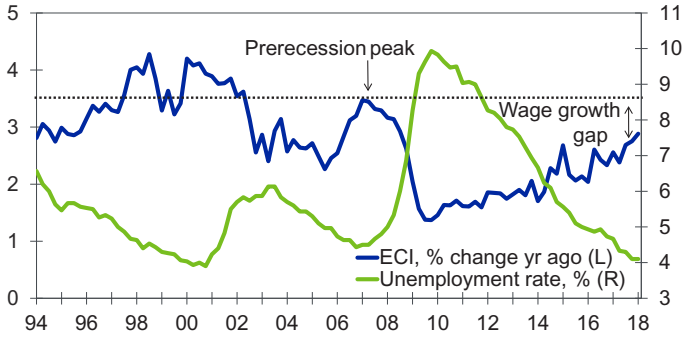
	Nominal wage growth	Real wage growth, core*	Real wage growth, headline
Unemployment rate	-0.79	-0.63	-0.41
Prime non-EPOP	-0.93	-0.79	-0.48

*Ex food and energy

Sources: BLS, BEA, Moody's Analytics

3 See, for example, Krueger, Alan B., "How Tight Is the Labor Market?" NBER Reporter 3 (2015): 1-10.

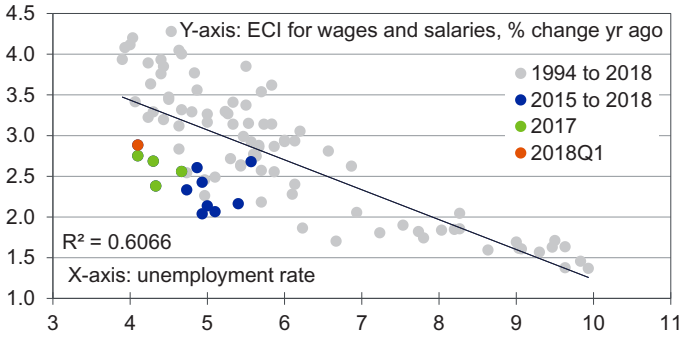
Chart 3: Wage Gains Short of Prerecession



Sources: BLS, Moody's Analytics

Chart 4: Wage Gain Low for Unemployment

Wage growth Phillips curve, quarterly 1994Q1 to 2017Q1



Sources: BLS, Moody's Analytics

Wage growth right where expected

As the most reliable measure of wage growth, the ECI is useful for gauging how much slack remains in the labor market and how far we are in the expansion. First quarter 2018 ECI clearly indicates that wage growth has not returned to prerecession peaks of 3% to 3.5%, and instead remains around 2.9% (see Chart 3). Even the prerecession peak for wage growth was still short of the 4% to 4.5% from the tight labor market of the 1990s.

Yet while wage growth is below levels that would suggest full employment, the unemployment rate has fallen below prerecession levels. This has some understandably wondering whether wage growth should be faster given that labor market slack, as measured by the unemployment rate, looks back to normal.

The wage Phillips curve is a useful economic tool for answering the question of whether wage growth is lower than it should be. This curve compares year-to-year wage growth with the unemployment rate using data from 1994 and forward, with the time period chosen to focus on a consistent inflation era. Any point below the line of best fit implies wage growth is lower than where the unemployment rate predicts it would be; any point above the line predicts the opposite. It is clear that for the last two years, wage growth is somewhat lower than expected given the unemployment rate (see Chart 4).

One explanation sometimes offered for the "wage growth mystery" is that low unemployment is no longer capable of generating wage growth. This theory suggests the economy is at full employment, but because of low productivity, monopsony power, or some other headwind, wages will not improve more.

However, an alternative theory is that there is slack in the labor market that is weighing on wage growth. This theory is consistent with continued job growth and trend inflation, which is still below its target, while the full-employment theory would predict above-target and accelerating inflation alongside slow job gains.

Looking at job growth does not suggest that we have arrived at full employment. So far in 2018, job growth has averaged 1.53% year to year (see Table 2). This is better than the 1.22% in 2011, which was well into the recovery, and is not a notable slowdown from 1.58% in 2017, or even the 1.69% in 2012 and 1.64% in 2013. Indeed, 2018 looks slow only compared with growth in 2015 and 2014. However, these two years look more like outliers than 2018, which is closer to an average recovery year.

The wage data support the wider labor slack theory. The importance of wider slack can be seen using a wage Phillips curve that replaces the unemployment rate with the prime-aged employment-to-population ratio (prime EPOP).

This measure differs from the unemployment rate in two important ways. First, it focuses only on those aged 25 to 54, considered the prime working years. This abstracts from any aging effects. Second, it does not just focus on active job seekers, the BLS definition of unemployment, but includes anyone without a job.

One important piece of evidence that prime EPOP is the most relevant measure of labor slack is that it does a better job of explaining the last two decades of wage data. Prime non-EPOP can explain 86% of the variation in the ECI for private wages and salaries from 1994 to 2018Q1, which can be seen in the r-squared of the Phillips curve (see Chart 5). In contrast, the unemployment rate explains only 61% of wage growth in this period (see Chart 4).

The prime EPOP rate also does a better job of explaining the last two years of mild-to-modest wage growth. The point for 2018Q1 falls almost exactly on the line, meaning that if one were to guess what

Table 2: Job Growth Has Not Slowed Much

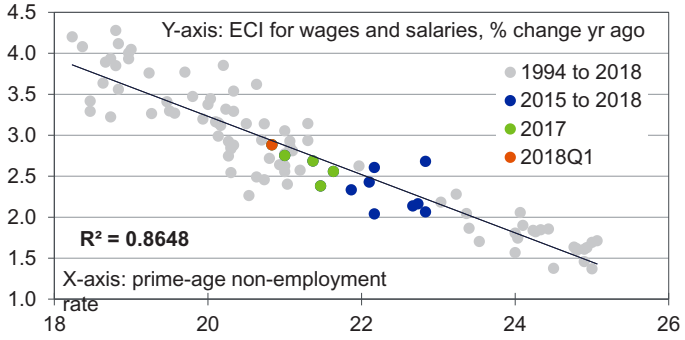
Yr	Avg monthly y/y job growth
2010	-0.71
2011	1.22
2012	1.69
2013	1.64
2014	1.88
2015	2.08
2016	1.78
2017	1.58
2018*	1.53
Post-recession avg	1.07

*YTD

Sources: BLS, Moody's Analytics

Chart 5: Wage Growth on Target for EPOP

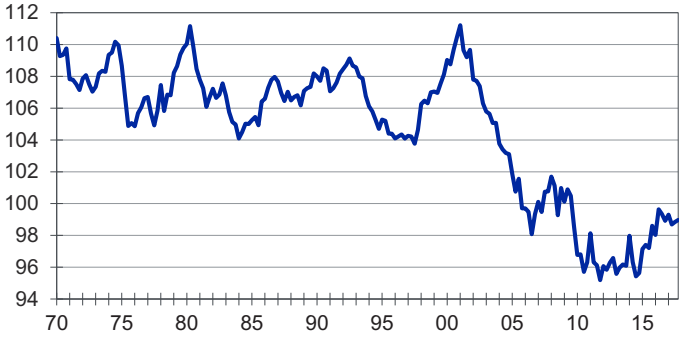
Wage growth Phillips curve, quarterly 1994Q1 to 2018Q1



Sources: BLS, Moody's Analytics

Chart 6: Labor Share Improving Again

Labor share of nonfinancial corporations, 2009=100



Sources: BLS, Moody's Analytics

wage growth would be today based on the current prime EPOP rate and the historical relationship between prime EPOP and wages, it would be almost exactly where we are today.

In short, broader measures of labor slack do a good job of explaining wage growth over the last two decades, and based on this relationship wage growth is right where it should be: modest, but indicating significant room for improvement.

Why wage growth can improve

One potential headwind for wage growth is weak labor productivity. In the long run and in equilibrium, wages should be equal to the marginal product of labor. This implies that labor productivity must increase above its current lackluster pace to achieve sustained wages growth in the long run. However, this does not mean that productivity is a binding constraint.

To understand how wages can increase despite low current productivity growth, it is useful to consider the identity that total wage income (W) equals output (O) times the labor share of output (S).

W = S*O

S = W/O

Dividing both sides by total employment, E, illustrates that average wages (w) equal labor productivity (p) times the labor share (S)

w = W/E

p = O/E

w = S*p

Using a log linearization, wage growth equals the percentage change in productivity plus the percentage change in the labor share.

dln(w) = dln(S) + dln(p)

% change w = % change S + % change p

Therefore, an increase in wage growth can come from either a change in the labor share of output or growth in productivity.

It is useful to note in this context that over the last 30 years, the share of national income going to labor has declined.

While there is an open question about whether the decline may be exaggerated by measurement issues, there is consensus that the labor share has declined since the 1980s. Whatever the cause and magnitude, the result has been that wages have risen more slowly than productivity. This leaves the possibility that wage growth could for a time outpace productivity growth, returning the labor share to historically normal levels. If the declining labor share has been due to weak labor demand from outsourcing, globalization and automation, then tighter relative labor demand from low labor slack may undo some of this. Indeed, the tight labor markets of the late 1990s also coincided with a rising labor share.

The case for a rising labor share is bolstered by looking at the last 15 years as being affected by a series of demand shocks. While the U.S. economy technically had two recessions and subsequent recoveries since 2000, an alternative view is that for a decade and a half, labor, in particular low-skilled labor, has faced weak demand due to the decline of manufacturing employment. And the Great Recession followed this period. The apparent recovery between the two recessions was temporary and masked manufacturing job losses with a housing bubble that fueled demand for construction labor. In this telling, labor markets have not been tight since the late 1990s. Thus, a declining labor share of income during this time period is not a surprising result.

If this view of the last decade and a half is correct, and if the majority of the structural adjustments to globalization have passed, then workers who have experienced a decade and a half of lackluster labor demand may soon be entering the first tight labor market since the late 1990s. An increasing labor share of income under these conditions is at the very least plausible. Indeed, for nonfinancial corporations, the labor share has already begun rising again over the last few years (see Chart 6).

An increasing labor share is not the only way for wages to grow. That could also come through a rebound in labor productivity. Historically, labor productivity has been viewed as a pro-cyclical phenomenon: Labor productivity rises during booms and falls during recessions. However, since the mid-1980s this has changed, and labor productivity is now generally countercyclical.

One reason for the changing cyclicality is that labor productivity faces countervailing forces over the business cycle. On the one hand, during a recession the least-skilled workers are fired, leaving the most-skilled and a higher ratio of labor to capital. This would generate countercyclical productivity that rises during a recession and falls dur-

Table 3: Wage Phillips Curves

Dependent variable is ECI for wages and salaries of private workers

	Model 1 Yr-to-yr level	Model 2 Yr-to-yr first difference	Model 3 Annnualized quarterly	Model 4 Yr-to-yr level with cubic trend
Prime EPOP	0.36***	0.21**	0.36***	0.32***
Trend				0.00
Trend squared				-0.00
Trend cubed				0.00
Constant	-0.25	0.00	0.75***	-0.23***
Adjusted R-squared	0.86	0.05	0.53	0.86
Sample	96	95	96	96

*** p<0.01, ** p<0.05, * p<0.1

Sources: BLS, Moody's Analytics

ing the recovery. On the other hand, labor hoarding and endogenous labor-saving technology would lead to pro-cyclicality of productivity. Labor hoarding is when during a recession firms do not fire as many workers as they could, leaving them with more workers than they need in order to avoid the cost of rehiring them later. Endogenous labor-saving technology is the theory that during a strong economy, when labor is scarce, firms may also search harder for and invest more in labor-saving technology and processes. Both labor hoarding and endogenous labor-saving technology make productivity lower during a recession and higher during a recovery.

Whether labor productivity will rise to accommodate additional wage growth resulting from the tight labor market is an open question that depends on the strength of these countervailing forces. But it is at least plausible.

What is more, aggregate labor productivity measurements are subject to many of the same measurement issues that plague aggregate wage growth measures. For example, when firms fire the least productive workers in a recession, this can raise measured average productivity but not change productivity for any given employed worker. It is possible that controlling for workforce composition in similarly rigorous manner as done for the ECI would show labor productivity growth already rebounding.

A third possible mechanism for faster nominal wage growth—in addition to increasing labor share and labor productivity—is that it will come from accelerating inflation. Inflation is below the Fed's 2% target and has been so for almost a decade. Although accelerating real wage growth remains the most likely outcome over the next two years, it cannot be ruled out that real wage growth will remain lackluster and nominal wage growth will come from higher inflation. Given the possibility of hysteresis and the stubbornness of inflation in reaching the Fed's target, this would not be unwelcome. Faster nominal wage growth even absent real wage growth can be positive if it helps workers on the margins of the labor force find a job above their nominally anchored reservation wage.

Overall, there are a variety of ways for the economy to deliver the forecast acceleration in nominal wages: a growing labor share, a rebound in labor productivity, and accelerating inflation. Real wage growth would have the greatest salutary effect on economic welfare, and is the most likely outcome in the near term.

Two scenarios for the wage recovery

The preceding analysis strongly suggests that this expansion has room to run. How much room there is remains an open question. Assuming the Phillips curve holds, it is useful to consider two scenarios. 1) What will wage growth look like if prime EPOP returns to 2007 levels? 2) What will wage growth look like if prime EPOP returns to 2000 levels?

To create these scenarios, an econometric wage Phillips curve model is used to estimate a precise coefficient relating ECI growth to prime EPOP. This is a numerical version of the line-of-best-fit in the Phillips curve chart above. Table 3 lists four models with different specifications and controls: levels, first difference, quarterly annualized instead of year to year, and levels with cubic trend.

The results are consistent across the four models. Using an average of the four models suggests a 1-percentage point increase in prime EPOP is associated with a 0.3-percentage point increase in wages. Using this coefficient, we can estimate the path of wages that would be consistent with the two scenarios for prime EPOP.

In 2007, prime EPOP peaked at 80.2%, which is 1 percentage point above the current rate (see Table 4, Scenario 1). This implies wage growth will accelerate by 0.3 percentage point (1*0.3 = 0.3), from 2.9% today to 3.2%. Over the last three years, the prime EPOP has generally improved by 0.5 to 1 percentage point per year, suggesting this could take one to two years. This is consistent with the Moody's Analytics U.S. macro model forecast of wage growth, which is expected to peak at 3.1% by the fourth quarter of 2019.

A second scenario to consider is what the labor market would look like if prime EPOP returned to its 2000Q1 peak (see Table 4,

Table 4: Labor Market Outcomes Under Two Scenarios

	Current: 2018Q1	Scenario 1: 2007 prime EPOP	Scenario 2: 2000 prime EPOP
Wage growth, %	2.9	3.2	3.7
Prime EPOP, %	79.2	80.2	81.8
Job gains, mil		1.3	3.3

Sources: BLS, Moody's Analytics

Scenario 2). This would require the prime EPOP rate to increase by 2.6 percentage points, which implies wage growth in this scenario would increase by 0.8 percentage point above current rates, pushing wage growth to 3.7%. If prime EPOP improves between 0.5 and 1 percentage point per year, this implies recovery could take 2.6 to 5 years.

Under both scenarios we can estimate how many additional jobs would be required to increase prime EPOP to these rates. To get back to 2007 rates would require 1.3 million more jobs for prime-age workers above and beyond what is needed for population growth. If we assume that this takes two years, then this is an additional 650,000 workers per year above that due to population growth. To get prime EPOP back to 2000 levels would require 3.3 million additional prime-age workers, which is consistent with five years of 660,000 job gains or 2½ years of 1.3 million.

Importantly, each scenario suggests that if wage growth does approach or exceed 3.2%, the labor market will absorb an additional 1.3 to 3.3 million jobs for prime-age workers above and beyond what is required for prime population growth, and above and beyond job growth for those older or younger than the 25 to 54 age group. These scenarios also imply that the labor market could take one to five years to fully heal. Although there is tremendous uncertainty around these scenarios, they are hard to rule out, especially in light of inflation that runs below target, job growth that remains surprisingly robust, and year after year of dropping estimates of the non-accelerating inflation rate of unemployment, which is the rate of unemployment consistent with a full-employment economy, below which inflation will begin accelerating above the target rate.

Alternative theories

One possible criticism of the prime EPOP Phillips curve theory is that it is simply an empirical correlation that has held in recent years but cannot explain the full time series of data before 1994. Yet this observation is true of the original Phillips curve, about which Greg Mankiw and Ricardo Reis observed: "As a scatter plot, it has shifted so often that no one takes it to be anything other than a transitory, reduced-form empirical relation[4]." If a failure to explain the full history of data is a mark against the prime EPOP curve because it explains only the last 25 years of data, then this places it on equal if not better footing than the standard wage Phillips curve, which can explain everything except the last 25 years of data.

Instead of an iron-clad and long-run relationship, the prime EPOP Phillips curve should be thought of, as Mankiw and Reis describe the original Phillips curve: "as a synonym for nominal rigidities, in the sense of a structural two-way causal relation between nominal and real variables in the short run."

It is of course correct that real wages in the long run will largely be determined by productivity growth. In addition, structural changes in the share of prime workers who are employed have happened in the past, are happening now in countries such as Japan, and could happen again in the U.S. For these reasons, like the original wage Phillips curve, the prime EPOP Phillips curve could break down.

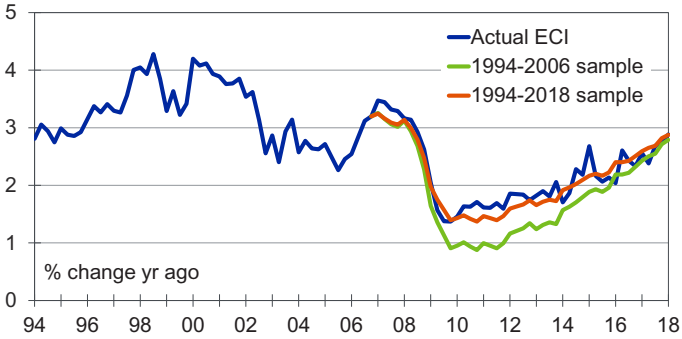
However, there are no signs yet that it is breaking down. If the prime EPOP Phillips curve was going to break down, we would begin to see it drift off the line; as of the most recent quarter, this is not the case.

Indeed, using a Phillips curve coefficient estimated on quarterly data from 1994 to 2006 and the actual path for prime EPOP, actual wage growth can be predicted out of sample very well over the entirety of the recession and recovery (see Chart 7). That model predicts that wage growth currently would be 2.8% compared with the actual 2.9%. If we use the coefficient estimated over all of the data, wage growth has followed the prediction even better.

In addition, if 2000 or 2007 levels of prime EPOP were no longer attainable in today's labor market because of a structural decline in prime working-age employment, then the curve would be shifting as well because any given level of prime EPOP would not be closer to full employment and, therefore, consistent with higher wages than in the past. The stability of the curve from 1994 through 2018 is evidence that either full employment consistent prime EPOP has not changed, or it has changed but that equilibrium nominal

Chart 7: Wage Growth Matches the Model

Employment Cost Index, private wages and salaries



Sources: BLS, Moody's Analytics

4 Mankiw, N. Gregory, and Ricardo Reis, "Friedman's Presidential Address in the Evolution of Macroeconomic Thought," Journal of Economic Perspectives 32.1 (2018): 81-96.

wage growth has also fallen by a precisely offsetting amount that keeps this curve fitting impressively tight and linear. Perhaps the latter is true, but it would be quite a coincidence to produce such a strong out-of-sample fit.

Policy conclusions

The Federal Reserve has for years overestimated how far the economy is from full employment, necessitating drops in its projection of NAIRU year after year. This analysis suggests one reason for the error: The standard Phillips curve, which relates wage growth to unemployment, is no longer a good representation of the labor market. Although there is a large amount of uncertainty in any full-employment forecast, the prime EPOP and ECI Phillips curve has performed better over the Great Recession and since. This suggests that it would be prudent for the Fed to lean more on this model.

Doing so suggests that wage growth is not mysteriously low, but simply consistent with the remaining slack in the labor market. Thus we may be further from full employment than many believe, and interest rates should rise more slowly than they are planned to be by the Fed.

About Moody's Analytics

Moody's Analytics provides financial intelligence and analytical tools supporting our clients' growth, efficiency and risk management objectives. The combination of our unparalleled expertise in risk, expansive information resources, and innovative application of technology helps today's business leaders confidently navigate an evolving marketplace. We are recognized for our industry-leading solutions, comprising research, data, software and professional services, assembled to deliver a seamless customer experience. Thousands of organizations worldwide have made us their trusted partner because of our uncompromising commitment to quality, client service, and integrity.

Concise and timely economic research by Moody's Analytics supports firms and policymakers in strategic planning, product and sales forecasting, credit risk and sensitivity management, and investment research. Our economic research publications provide in-depth analysis of the global economy, including the U.S. and all of its state and metropolitan areas, all European countries and their subnational areas, Asia, and the Americas. We track and forecast economic growth and cover specialized topics such as labor markets, housing, consumer spending and credit, output and income, mortgage activity, demographics, central bank behavior, and prices. We also provide real-time monitoring of macroeconomic indicators and analysis on timely topics such as monetary policy and sovereign risk. Our clients include multinational corporations, governments at all levels, central banks, financial regulators, retailers, mutual funds, financial institutions, utilities, residential and commercial real estate firms, insurance companies, and professional investors.

Moody's Analytics added the economic forecasting firm Economy.com to its portfolio in 2005. This unit is based in West Chester PA, a suburb of Philadelphia, with offices in London, Prague and Sydney. More information is available at www.economy.com.

Moody's Analytics is a subsidiary of Moody's Corporation (NYSE: MCO). Further information is available at www.moodysanalytics.com.

DISCLAIMER: Moody's Analytics, a unit of Moody's Corporation, provides economic analysis, credit risk data and insight, as well as risk management solutions. Research authored by Moody's Analytics does not reflect the opinions of Moody's Investors Service, the credit rating agency. To avoid confusion, please use the full company name "Moody's Analytics", when citing views from Moody's Analytics.

About Moody's Corporation

Moody's Analytics is a subsidiary of Moody's Corporation (NYSE: MCO). MCO reported revenue of $4.2 billion in 2017, employs approximately 11,900 people worldwide and maintains a presence in 41 countries. Further information about Moody's Analytics is available at www.moodysanalytics.com.

CREDIT RATINGS ISSUED BY MOODY'S INVESTORS SERVICE, INC. AND ITS RATINGS AFFILIATES ("MIS") ARE MOODY'S CURRENT OPINIONS OF THE RELATIVE FUTURE CREDIT RISK OF ENTITIES, CREDIT COMMITMENTS, OR DEBT OR DEBT-LIKE SECURITIES, AND MOODY'S PUBLICATIONS MAY INCLUDE MOODY'S CURRENT OPINIONS OF THE RELATIVE FUTURE CREDIT RISK OF ENTITIES, CREDIT COMMITMENTS, OR DEBT OR DEBT-LIKE SECURITIES. MOODY'S DEFINES CREDIT RISK AS THE RISK THAT AN ENTITY MAY NOT MEET ITS CONTRACTUAL, FINANCIAL OBLIGATIONS AS THEY COME DUE AND ANY ESTIMATED FINANCIAL LOSS IN THE EVENT OF DEFAULT. CREDIT RATINGS DO NOT ADDRESS ANY OTHER RISK, INCLUDING BUT NOT LIMITED TO: LIQUIDITY RISK, MARKET VALUE RISK, OR PRICE VOLATILITY. CREDIT RATINGS AND MOODY'S OPINIONS INCLUDED IN MOODY'S PUBLICATIONS ARE NOT STATEMENTS OF CURRENT OR HISTORICAL FACT. MOODY'S PUBLICATIONS MAY ALSO INCLUDE QUANTITATIVE MODEL-BASED ESTIMATES OF CREDIT RISK AND RELATED OPINIONS OR COMMENTARY PUBLISHED BY MOODY'S ANALYTICS, INC. CREDIT RATINGS AND MOODY'S PUBLICATIONS DO NOT CONSTITUTE OR PROVIDE INVESTMENT OR FINANCIAL ADVICE, AND CREDIT RATINGS AND MOODY'S PUBLICATIONS ARE NOT AND DO NOT PROVIDE RECOMMENDATIONS TO PURCHASE, SELL, OR HOLD PARTICULAR SECURITIES. NEITHER CREDIT RATINGS NOR MOODY'S PUBLICATIONS COMMENT ON THE SUITABILITY OF AN INVESTMENT FOR ANY PARTICULAR INVESTOR. MOODY'S ISSUES ITS CREDIT RATINGS AND PUBLISHES MOODY'S PUBLICATIONS WITH THE EXPECTATION AND UNDERSTANDING THAT EACH INVESTOR WILL, WITH DUE CARE, MAKE ITS OWN STUDY AND EVALUATION OF EACH SECURITY THAT IS UNDER CONSIDERATION FOR PURCHASE, HOLDING, OR SALE.

MOODY'S CREDIT RATINGS AND MOODY'S PUBLICATIONS ARE NOT INTENDED FOR USE BY RETAIL INVESTORS AND IT WOULD BE RECKLESS AND INAPPROPRIATE FOR RETAIL INVESTORS TO USE MOODY'S CREDIT RATINGS OR MOODY'S PUBLICATIONS WHEN MAKING AN INVESTMENT DECISION. IF IN DOUBT YOU SHOULD CONTACT YOUR FINANCIAL OR OTHER PROFESSIONAL ADVISER.

ALL INFORMATION CONTAINED HEREIN IS PROTECTED BY LAW, INCLUDING BUT NOT LIMITED TO, COPYRIGHT LAW, AND NONE OF SUCH INFORMATION MAY BE COPIED OR OTHERWISE REPRODUCED, REPACKAGED, FURTHER TRANSMITTED, TRANSFERRED, DISSEMINATED, REDISTRIBUTED OR RESOLD, OR STORED FOR SUBSEQUENT USE FOR ANY SUCH PURPOSE, IN WHOLE OR IN PART, IN ANY FORM OR MANNER OR BY ANY MEANS WHATSOEVER, BY ANY PERSON WITHOUT MOODY'S PRIOR WRITTEN CONSENT.

All information contained herein is obtained by MOODY'S from sources believed by it to be accurate and reliable. Because of the possibility of human or mechanical error as well as other factors, however, all information contained herein is provided "AS IS" without warranty of any kind. MOODY'S adopts all necessary measures so that the information it uses in assigning a credit rating is of sufficient quality and from sources MOODY'S considers to be reliable including, when appropriate, independent third-party sources. However, MOODY'S is not an auditor and cannot in every instance independently verify or validate information received in the rating process or in preparing the Moody's publications.

To the extent permitted by law, MOODY'S and its directors, officers, employees, agents, representatives, licensors and suppliers disclaim liability to any person or entity for any indirect, special, consequential, or incidental losses or damages whatsoever arising from or in connection with the information contained herein or the use of or inability to use any such information, even if MOODY'S or any of its directors, officers, employees, agents, representatives, licensors or suppliers is advised in advance of the possibility of such losses or damages, including but not limited to: (a) any loss of present or prospective profits or (b) any loss or damage arising where the relevant financial instrument is not the subject of a particular credit rating assigned by MOODY'S.

To the extent permitted by law, MOODY'S and its directors, officers, employees, agents, representatives, licensors and suppliers disclaim liability for any direct or compensatory losses or damages caused to any person or entity, including but not limited to by any negligence (but excluding fraud, willful misconduct or any other type of liability that, for the avoidance of doubt, by law cannot be excluded) on the part of, or any contingency within or beyond the control of, MOODY'S or any of its directors, officers, employees, agents, representatives, licensors or suppliers, arising from or in connection with the information contained herein or the use of or inability to use any such information.

NO WARRANTY, EXPRESS OR IMPLIED, AS TO THE ACCURACY, TIMELINESS, COMPLETENESS, MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE OF ANY SUCH RATING OR OTHER OPINION OR INFORMATION IS GIVEN OR MADE BY MOODY'S IN ANY FORM OR MANNER WHATSOEVER.

Moody's Investors Service, Inc., a wholly-owned credit rating agency subsidiary of Moody's Corporation ("MCO"), hereby discloses that most issuers of debt securities (including corporate and municipal bonds, debentures, notes and commercial paper) and preferred stock rated by Moody's Investors Service, Inc. have, prior to assignment of any rating, agreed to pay to Moody's Investors Service, Inc. for appraisal and rating services rendered by it fees ranging from $1,500 to approximately $2,500,000. MCO and MIS also maintain policies and procedures to address the independence of MIS's ratings and rating processes. Information regarding certain affiliations that may exist between directors of MCO and rated entities, and between entities who hold ratings from MIS and have also publicly reported to the SEC an ownership interest in MCO of more than 5%, is posted annually at www.moodys.com under the heading "Investor Relations — Corporate Governance — Director and Shareholder Affiliation Policy."

Additional terms for Australia only: Any publication into Australia of this document is pursuant to the Australian Financial Services License of MOODY'S affiliate, Moody's Investors Service Pty Limited ABN 61 003 399 657AFSL 336969 and/or Moody's Analytics Australia Pty Ltd ABN 94 105 136 972 AFSL 383569 (as applicable). This document is intended to be provided only to "wholesale clients" within the meaning of section 761G of the Corporations Act 2001. By continuing to access this document from within Australia, you represent to MOODY'S that you are, or are accessing the document as a representative of, a "wholesale client" and that neither you nor the entity you represent will directly or indirectly disseminate this document or its contents to "retail clients" within the meaning of section 761G of the Corporations Act 2001. MOODY'S credit rating is an opinion as to the creditworthiness of a debt obligation of the issuer, not on the equity securities of the issuer or any form of security that is available to retail investors. It would be reckless and inappropriate for retail investors to use MOODY'S credit ratings or publications when making an investment decision. If in doubt you should contact your financial or other professional adviser.

Additional terms for Japan only: Moody's Japan K.K. ("MJKK") is a wholly-owned credit rating agency subsidiary of Moody's Group Japan G.K., which is wholly-owned by Moody's Overseas Holdings Inc., a wholly-owned subsidiary of MCO. Moody's SF Japan K.K. ("MSFJ") is a wholly-owned credit rating agency subsidiary of MJKK. MSFJ is not a Nationally Recognized Statistical Rating Organization ("NRSRO"). Therefore, credit ratings assigned by MSFJ are Non-NRSRO Credit Ratings. Non-NRSRO Credit Ratings are assigned by an entity that is not a NRSRO and, consequently, the rated obligation will not qualify for certain types of treatment under U.S. laws. MJKK and MSFJ are credit rating agencies registered with the Japan Financial Services Agency and their registration numbers are FSA Commissioner (Ratings) No. 2 and 3 respectively.

MJKK or MSFJ (as applicable) hereby disclose that most issuers of debt securities (including corporate and municipal bonds, debentures, notes and commercial paper) and preferred stock rated by MJKK or MSFJ (as applicable) have, prior to assignment of any rating, agreed to pay to MJKK or MSFJ (as applicable) for appraisal and rating services rendered by it fees ranging from JPY200,000 to approximately JPY350,000,000.

MJKK and MSFJ also maintain policies and procedures to address Japanese regulatory requirements.