The Passthrough of Labor Costs to Price Inflation

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1. Introduction

Many formal and informal descriptions of inflation dynamics assign an important explicit or implicit role to labor costs. Intuitively, labor compensation is likely to be an important determinant of firms’ pricing behavior as, in the aggregate, it represents about two-thirds of firms’ total costs of production. More formally, economic theory suggests that increases in labor costs in excess of productivity gains should put upward pressure on prices; hence, many older theoretical and empirical models (including the large-scale econometric models of the 1970s and 1980s) assumed that prices were determined as a markup over trend unit labor costs. More recently, many empirical implementations of the new-Keynesian Phillips curve use real unit labor costs as a proxy for real marginal costs, which are the theoretical driver of inflation in these models.

Wage-based explanations of inflation dynamics have seen increased prominence recently, as many observers have attempted to use developments in the labor market to explain the supposedly puzzling behavior of inflation following the 2007–2009 recession. Specifically, these observers argue that inflation did not fall by as much as would have been expected after the previous recession, in the sense that conventional models of inflation dynamics would have predicted a larger decline in inflation than was actually observed given the shortfall of economic activity seen after the financial crisis. For example, Ball and Mazumder (2011) estimate a relatively standard empirical Phillips curve model over 1960–2007 and use it to produce out-of-sample dynamic simulations of core inflation. Given the actual path of real activity (as summarized by the unemployment rate), their model predicts that the four-quarter moving average of core inflation should have fallen to negative 4.3 percent by the end of 2010 (by contrast, the current estimate of the four-quarter moving average of core PCE inflation through the fourth quarter of 2010 is positive 1 percent).² A less-parametric description of recent inflation behavior is provided by Watson (2014), who compares the changes in inflation in the six years following the start of the most recent recession with the corresponding changes in inflation following the back-to-back recessions of 1980–1982. Watson shows that, despite the similar increase in the unemployment rate seen during the two episodes, inflation fell only

² The 2014 Economic Report of the President performs a similar exercise.
1 percentage point following the 2007–2009 recession, compared to a decline of 4.6 percentage points following the 1980–1982 episode.

To explain this so-called “missing deflation” puzzle, a number of analysts have adduced explanations that are ultimately based on labor-market developments that have in turn influenced recent wage dynamics. First, some observers have argued that the presence of downward nominal wage rigidity has propped up aggregate wage inflation to an unusual degree in recent years, which has in turn led price inflation to decline by less than would be expected given the magnitude and persistence of the shortfall in real activity that resulted from the Great Recession.3 Second, some researchers (most notably Gordon, 2013) have argued that recent inflation behavior can be better explained if real activity is measured in terms of the short-term unemployment rate (that is, the share of the labor force unemployed for 26 weeks or less), because the long-term unemployed seem to put less (or no) downward pressure on inflation.

Of course, the preceding only make sense as explanations of price inflation if there is an economically significant influence of compensation costs on prices. Regarding the former explanation, it is clear that downward nominal wage rigidity can have an important effect on inflation dynamics only if price setting is closely connected to labor costs. Regarding the latter explanation, we would not expect the long-term unemployed to make a smaller contribution to aggregate demand than the short-term unemployed: Presumably, the long-term unemployed—who have suffered a relatively larger and more persistent shock to their permanent income—would reduce their contribution to aggregate demand to a larger degree than would the short-term unemployed. Hence, it seems difficult to invoke the idea that the short-term unemployment rate provides a better gauge of the level of real activity that is relevant for price inflation without simultaneously arguing that the ultimate source of this relation is the differential effect that the short- and long-term unemployed have on wage inflation (and, again, that wages are an important determinant of prices).

In this paper, we explore whether there is a tight—and stable—link between wage and price inflation. Overall, we find it difficult to discern much of an effect of changes in average labor costs on aggregate price inflation in recent periods. In particular, we find evidence either

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3 Paul Krugman has made this type of argument, for instance. Formal modelling suggests that the effects of downward nominal wage rigidity could be more complicated: In Daly and Hobijn’s (2014) theoretical analysis, downward nominal wage rigidity props up wage inflation in a recession; as the economy recovers, however, the existence of “pent-up” wage cuts puts downward pressure on wages even as the unemployment rate is falling.
that the passthrough of labor costs to price inflation has fallen over the past several decades, or—
for compensation measures where there is still evidence of passthrough—that wage
developments have had essentially no material effect on price inflation in recent years.
Relatedly, we uncover little evidence that it is possible to improve forecasts of price inflation by
conditioning on measures of labor compensation.

Our findings do beg the question of how to explain recent inflation developments. We
argue that an alternative explanation for the “missing deflation”—as well as for the reduced role
of wages in driving price inflation dynamics—is that expectations of inflation have become
much better anchored over time, which has resulted in a less-persistent response of price
inflation to changes in real activity or costs.

2. Analytical background
To help motivate the empirical work, consider a stylized wage-price Phillips curve of the form
\[ \Delta w_t = \beta (U_t - U^*_t) + A(L) \Delta x_t + B(L) \Delta p_{t-1}, \]  
(1)
in which wage inflation \( \Delta w \) is related to the gap between the unemployment rate \( U \) and its
natural rate \( U^* \), a moving average of lagged trend productivity growth \( \Delta x \), and a distributed lag
of price inflation, \( \Delta p \). Typically, a wage-price specification imposes that \( A(1) \) and \( B(1) \) are equal
to one, which implies that real wages will tend to rise with productivity in the long run.4

Under the assumption that firms set prices as a constant markup over trend unit labor
costs, price inflation is given by
\[ \Delta p_t = \Delta w_t - \Delta x_t, \]  
(2)
where equation (2) can be made more realistic by allowing for additional lags of unit labor costs
or lags of price inflation, markups that adjust to some long-run level over time (or that depend on
the state of the business cycle), and supply-shock terms such as changes in relative energy or
import prices. Combining the wage and markup equations yields a price-price Phillips curve:
\[ \Delta p_t = \beta (U_t - U^*_t) + \left[ A(L) - 1 \right] \Delta x_t + B(L) \Delta p_{t-1}, \]  
(3)
where the assumed restrictions on \( A(1) \) and \( B(1) \) imply that the long-run Phillips curve is vertical
(this follows from \( B(1) = 1 \)) and that one-time changes in trend productivity growth have no

4 Equation (1) is often modified to include lagged wage inflation, in which case the restriction \( A(1) = B(1) = 1 \) is
suitably altered to ensure the equality of long-run growth in real wages and productivity.
long-term effect on price inflation (this follows from \( A(1) = 1 \)). Importantly, under this derivation the price-price model implicitly incorporates the effect of labor costs by conditioning on the determinants of compensation growth.\(^5\)

Equation (3) can be thought of as the foundation underlying different empirical price models used in various papers. Of course, the particular specifications used by different authors can vary; we ourselves consider three variations on this basic framework. First, in some models we include a survey measure of long-term inflation expectations: In equation (1), the lagged inflation terms are sometimes interpreted as proxying in part for (adaptive) expectations of inflation; one of the models we use in the paper tries to capture this more explicitly by directly adding a survey measure of expected inflation. Second, in fitting a model like equation (3), we omit the trend productivity term, as it is often difficult to get such a term to enter empirical price equations with statistically significant—or even correctly signed—coefficients.\(^6\) Third, we typically include supply-shock terms.

We then use these models to assess the passthrough of labor costs to prices. We start by fitting small time-varying parameter/stochastic volatility VAR models in price inflation, relative import price inflation, the unemployment gap, and a labor cost measure to determine whether the effect of lagged labor costs on price inflation has changed over time. The price equation from this VAR system is similar to a markup model like equation (2), albeit with more complicated dynamics and a separate role for labor market slack.

We next examine whether the fit of a price-price Phillips curve like equation (3) can be improved by explicitly adding various measures of labor costs. As we noted, the price-price model derived above implicitly captures the influence of labor costs on prices; that said, neither equation (1) nor equation (2) is structural, so there is no guarantee that the price-price model (3) correctly or fully captures the influence of wage changes on price inflation. We therefore view these exercises as providing a convenient way to assess whether there is additional information

\(^5\) While combining equations (1) and (2) can justify the specification of a price-price Phillips curve, one can also view the price-price model as a reduced-form aggregate supply curve without explicitly deriving it from a wage-price Phillips curve and a markup equation.

\(^6\) One of the first researchers to explicitly consider the role of such a productivity term was Braun (1984). More recently, Ball and Moffitt (2001) argued that a similar term could improve the fit of a price-price Phillips curve. Finally, Dew-Becker and Gordon (2005) examine a price-price model in which trend productivity is allowed to enter in a somewhat different fashion. Note that because we will use an unemployment gap that is based on a time-varying estimate of the natural rate, an effect of productivity on price inflation will in principle be captured by movements in \( U^* \).
in labor costs that could be missed by our price-price framework and thus used to forecast price changes.

Finally, we consider whether a correlation between labor costs and price inflation can be discerned by focusing on a subcomponent of consumer prices. Specifically, building on research by Brauer (1997) and Peneva (2011) we examine whether prices for consumer services—whose costs of production are more heavily weighted to labor inputs—are more closely related to labor cost changes than are broader price measures.

3. Results from other studies
A number of authors have examined whether movements in labor costs lead changes in price inflation. While the results are often specific to various methodological choices and data definitions, two broad conclusions emerge from this literature. First, there appears to be a break in the relation between labor costs and broad price measures, with changes in labor costs having little or no predictive power for price inflation after the early 1980s. For example, Mehra (2000) divides the postwar period into three subperiods and finds that wage inflation only Granger causes price inflation in the middle subperiod (1966–1983); similarly, Emery and Chang (1996) find that labor costs are only useful in forecasting core consumer price inflation in the 1970s. Second, there is some evidence that compensation measures can predict price changes for a category of consumer services that have a relatively large labor cost share (see Brauer, 1997; note, however, that Brauer does not consider the robustness of this pass-through relation over different subsets of his sample period, which starts in the early 1980s). As we will show, our results are in line with both sets of conclusions.

4. Measures of labor costs
Among the most often used measures of labor costs are: the Productivity and Cost release’s measure of compensation per hour (CPH) in the nonfarm business sector, the Employment Cost Index (ECI) for hourly compensation, average hourly earnings (AHE) of production workers, and trend unit labor costs (TULC). The ECI is calculated using fixed weights for industry and occupational groups, while the CPH and AHE measures do not control for shifts in the mix of jobs. The TULC measure is defined as either CPH or the ECI divided by trend productivity. One of the most important differences across these various measures is that AHE covers only
wages, while the ECI and CPH measures include both wages and benefits. Stock option grants and exercises, which can be responsible for large quarterly movements in compensation, are excluded from the ECI. CPH, on the other hand, includes stock option exercises once the source data from the Quarterly Census of Employment and Wages are incorporated (arguably, however, the economically relevant contribution of stock options to labor compensation costs is their market value when granted, not their value when exercised).

5. Time variation in the passthrough of labor costs to prices
We begin by using a time-varying parameter/stochastic volatility vector autoregression model (a TVP/SV VAR) to examine whether and to what degree the passthrough of labor costs to price inflation has changed over time. The baseline system we consider is a four-variable, two-lag quarterly VAR in weighted relative import price inflation, nonfarm business trend unit labor costs, core market-based PCE price inflation, and the CBO’s unemployment gap, with that causal ordering; the estimation period runs from 1965:Q1 to 2012:Q2. To gauge how the passthrough of trend unit labor costs into core inflation has changed over time, we evaluate impulse response functions for core market-based PCE inflation at different dates. Figure 1 plots the median response of market-based core inflation following a 2¾ percentage point shock to trend unit labor cost growth (expressed at an annual rate) at various times over the period 1975–2012, along with 70 percent credible sets. As can be seen from the figure, the passthrough of unit labor costs to core inflation has diminished over time; in particular, in the last year of the sample the effect of a shock to unit labor costs is negligible immediately after the quarter in which it hits.

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7 One variant of the AHE measure covers production and nonsupervisory workers only, while another covers all employees. Because the former measure has a considerably longer history, we use it in our empirical work.
8 TVP/SV VARs are recursively identified VAR models in which the VAR model coefficients and the standard deviations of the structural residuals are allowed to drift over time (they are modeled as random walks). The method improves on using rolling regression or similar techniques inasmuch as changes in coefficient estimates from rolling regressions can merely reflect sampling variability; by contrast, by explicitly modeling parameter drift and changes in the volatility of shocks—and by using data from the full sample—the TVP/SV approach can in principle provide a clearer picture of the amount and type of drift that is actually present.
9 Before the core inflation measure is used in the VAR we subtract out the estimated effects of the Nixon-era price controls, where these effects are obtained using Blinder and Newton’s (1981) methodology in a monthly Phillips curve with relative food and energy inflation and detrended unemployment (the unemployment trend is estimated using a low-pass filter).
10 A 2¾ percentage point shock is used because this is the standard deviation of trend unit labor cost growth over the full sample period.
Although the impulse response of inflation to a unit labor cost shock currently appears to be rather small, it is still possible for shocks to unit labor costs to have a nontrivial effect on inflation—even recently—because trend unit labor cost growth is quite volatile. To assess this possibility, we use the VAR system to decompose movements in core inflation from 2001 to the second quarter of 2012 into two parts: the portion attributable to the VAR’s baseline forecast (that is, a dynamic simulation of the VAR starting in 2001), and the portion that reflects the cumulative effect of the shocks to unit labor cost growth that were realized over this period. Figure 2 plots the results from this exercise. As can be seen from panel A of the figure, very little of the movement in core inflation over this period can be attributed to shocks to trend unit labor cost growth, even though these shocks account for essentially all of the actual variation in unit labor costs (not shown). For reference, panel B of the figure repeats this calculation using the shocks to the unemployment gap, which appear to have a much more material effect on core inflation over this period.¹¹

Figures 3 and 4 repeat the preceding analysis using the chain price index for nonfarm business output in place of core market-based PCE inflation.¹² Here, the responses of inflation to a unit labor cost shock appear to be more stable in recent periods, though they are still smaller than the responses obtained in the 1970s and 1980s (Figure 3). Nevertheless, trend unit labor cost shocks continue to account for only a relatively modest portion of the overall variation in nonfarm business inflation over the past decade (Figure 4).

6. Results from price-price Phillips curves

In this section, we describe the results obtained from including various measures of labor costs in several models of price inflation. In brief, we do not find evidence that the of the price-price Phillips curves we consider can be improved by adding a measure of compensation or unit labor costs: With few exceptions, the measures of compensation and unit labor costs that we consider receive statistically insignificant coefficients and yield no improvement in the models’ fit.

We employ two models of inflation for this exercise: (i) an accelerationist Phillips curve (APC) model, and (ii) an empirical implementation of the stylized expectations-augmented Phillips curve (EPC) model; in this model, we use long-run Michigan inflation expectations to

¹¹ The results are qualitatively similar if price inflation is placed before unit labor cost growth in the VAR’s causal ordering.
¹² The nonfarm business price measure is not adjusted for the effect of price controls.
proxy expected inflation. Both the accelerationist and the expectations-augmented models use a measure of labor market slack (the difference between the published unemployment rate and the Congressional Budget Office’s estimate of the short-run natural rate of unemployment) and allow for supply shocks (through import prices and energy prices). The main difference is that the accelerationist model has six lags of price inflation on the right-hand side of the regression, whereas the expectations-augmented model has four lags of price inflation and Michigan long-run inflation expectations. We consider three measures of price inflation: the core PCE price index, the core market-based PCE price index, as well as a price index that includes only market-based services that are more heavily weighted to labor inputs and whose prices are not administratively set. On the right-hand side of the regressions, we add 6 lags of changes in either nonfarm CPH, the ECI, or production-worker AHE.

Figure 5 shows how the sum of the coefficients on lagged wages evolves when 6 lags of wages are included as an additional independent variable on the RHS of the APC equation for core PCE inflation. The coefficients are from 25-year rolling regressions. In the APC model, the sums of the coefficients on AHE (top panel) is about 0.1 and nearly significant in the 25-year windows that end in 1990-1996. After that, the sum becomes zero and then enters the equation with the wrong sign. The sum of coefficients on lagged CPH also starts close to 0.1 and then is essentially zero for the years 2000-2013 (the middle panel). The bottom panel in Figure 5 shows the sum of coefficients on lagged ECI. The period shown is shorter as this measure starts later than AHE and CPH, in 1980. The sum of coefficients on the lagged ECI is the only one above zero at the end of the sample, though it is still not statistically significant. The top panel of Figure 6 shows the sum of coefficients on lagged AHE, CPH, and ECI (without the confidence intervals) in an APC model for market-based core PCE inflation. The results are very similar to those from the model for core PCE inflation, the sum of coefficients on ECI is the only one that is above zero in the 25-year regressions ending in the most recent quarters. In the expectations-augmented model for core PCE and market-based core PCE (Figure 7 and top panel of Figure 8, respectively) the sums of coefficients on lagged wages are similar and again, not statistically significant. The period shown is the same for all three measures of wages and shorter than in the APC model as Michigan long-run inflation expectations are available only starting in 1980. The sum of coefficients on ECI is again the only one that is more stable and above zero in the most recent years.
In addition to the question about the size and significance of the coefficients on lagged wages, there is another question: Would the APC and the EPC models have performed better during this last recession if a measure of labor costs has been included in them? The two panels in Figure 9 show actual four-quarter changes in core PCE inflation along with recursive (expanding window) simulations from the accelerationist and expectations-augmented models. The solid black lines are the actual four-quarter changes in core PCE prices, the blue, red, and green lines are the models’ projections when ECI, AHE, or CPH, respectively, is added on the right hand side. For the accelerationist model (the top panel), including a measure of wages on the RHS does not lead to a noticeably different projection for the four-quarter changes compared to a model that has no measure of labor compensation (the dashed black line). The same is true for the expectations-augmented Phillips Curve model (bottom panel). Table 1 summarizes the errors based on one-, four-, and eight-quarter changes, all at annual rates. As can be seen in the table, including measures of wages in the both the APC and the EPC models does not reduce the RMSEs for core PCE inflation. In short, both the APC and EPC models would not have been much affected by using any of the available measure of labor costs to explain and forecast movements in price inflation.

7. Effects of labor-cost movements on consumer services prices
Our inability to find a significant role for wages in inflation forecasting models could stem from our using overall core or market-based core PCE inflation. These price measures include both services, which are likely to be relatively labor-intensive, as well as goods, whose costs reflect the price of other inputs (such as materials) to a greater degree. We therefore create a narrow inflation measure that is subcomponent of core PCE services and includes only market-based services that are more heavily weighted to labor inputs and whose prices are not administratively set; the resulting measure therefore excludes housing, airfares, medical services, and tuition. We then use the change in this services price component as the dependent variable in our ACP and EPC inflation models. The sums of the coefficients on lagged ECI growth range are larger than in the models with broader measures of inflation, ranging from 0.1 to 0.3 in the accelerationist Phillips curve model, but most of the time are not statistically significant at the 10 percent level (see bottom panel of Figure 6). The sums of the coefficients on lagged ECI growth
in the expectations-augmented Phillips curve model are smaller and fall to zero in the rolling window regressions ending in 2012 or later. The two panels in Figure 10 repeat the recursive simulations exercise for this narrow measure of inflation from the accelerationist and expectations-augmented models. The solid black lines are the actual four-quarter changes in market-based services excluding energy, housing, medical, tuition, and airfares prices. The blue, red, and green lines are the models’ projections when either ECI, AHE, or CPH, respectively, is added on the right hand side. As can be seen from these charts and the out-of-sample RMSE for the models (shown in Table 1) including a measures of wages (whether ECI, AHE, or CPH) does not improve the forecast performance of the models.

The preceding provides some evidence (albeit weak) of passthrough of labor costs—as measured by the ECI for hourly compensation—into an important subcomponent of consumer prices. To explore the stability of this relation over time—and for comparison with the results shown in section 5—we estimated a TVP/SV VAR model in TULC growth (where TULC is defined using the ECI); the change in market-based PCE prices; and the unemployment gap (with that causal ordering). The sample period runs from 1982:Q1 to 2012:Q2. The responses of price inflation at various dates following a one standard deviation shock to TULC growth (0.8 percentage point at an annual rate) are plotted in Figure 11. In this specification, the passthrough of ECI TULC changes into core market-based PCE price inflation changes little over the past 25 years.

Given that these impulse responses are roughly stable over time, we use a VAR model with constant coefficients to compute the contribution of ECI and the unemployment gap innovations to price inflation over the past decade. These results are plotted in panel A of Figure 10. Innovations to ECI growth make a small but noticeable contribution to market-based core PCE price inflation over this period; interestingly, until the end of 2007 these contributions are about equal in magnitude—but opposite in sign—to those made by innovations to the unemployment gap.

Taken as a whole, these results point to a non-negligible degree of passthrough of one measure of labor costs into price inflation. Nevertheless, as mentioned earlier, the resulting RMSEs (1, 4 and 8 quarters ahead) when ECI is used are no better than the RMSEs obtained from a price model that omits lagged ECI growth entirely.
8. One final caveat

While the evidence that we find for significant passthrough of labor costs into price inflation in recent periods is limited—and probably cannot be exploited to meaningfully improve a projection for inflation—we would not want to argue based on these results that labor costs are not now and will never become an important determinant of price inflation. Rather, our findings likely reflect the fact that underlying or trend inflation has been relatively stable over the past couple of decades, which suggests that we have not seen persistent movements in the factors that drive price inflation—or compensation changes—over this period, let alone anything resembling a full-blown wage-price spiral. (Indeed, we view this as the most plausible explanation for the decline in the passthrough of wage inflation to price inflation that we documented in section 5.) Of course, this does not preclude the possibility that a sustained acceleration in wages would induce a pickup in price inflation—which could in turn reveal a statistical relationship between labor costs and prices that is stronger and more broadly based than the one that we have been able to uncover with our analysis.

References


Figure 1
Response of core inflation to trend unit labor cost shocks

A. 1975

B. 1985

C. 1995

D. 2005

E. 2012

Note: Core inflation defined as log difference of core market-based PCE price index. Dotted lines denote 70 percent credible set.
Figure 2
Influence of structural shocks on core inflation

A. Trend unit labor costs (based on P&C hourly compensation)

B. Unemployment gap

Note: Core inflation defined as four-quarter log difference of core market-based PCE price index.
Figure 3
Response of NFB price inflation to trend unit labor cost shocks

A. 1975

B. 1985

C. 1995

D. 2005

E. 2012

Note: Inflation defined as log difference of nonfarm business (NFB) output price index. Dotted lines denote 70 percent credible set.
Figure 4
Influence of structural shocks on NFB price inflation

A. Trend unit labor costs (based on P&C hourly compensation)

B. Unemployment gap

Note: Inflation defined as four-quarter log difference of nonfarm business (NFB) output price index.
Figure 5

Accelerationist Phillips Curve Model for core PCE inflation, 25-year rolling window regressions

**Average Hourly Earnings**

- **AHE Coefficient**
- **90% Confidence Interval**

**Compensation Per Hour**

- **CPH Coefficient**
- **90% Confidence Interval**

**Employment Cost Index**

- **ECI Coefficient**
- **90% Confidence Interval**
Figure 6

Accelerationist Phillips Curve Model, 25-year rolling window regressions

Market-based core PCE inflation

Market-based services excluding housing, energy, medical, tuition, and airfares.
Figure 7

Expectations-Augmented Phillips Curve Model for core PCE inflation, 25-year rolling window regressions

**Average Hourly Earnings**

- AHE Coefficient
- 90% Confidence Interval

**Compensation Per Hour**

- CPH Coefficient
- 90% Confidence Interval

**Employment Cost Index**

- ECI Coefficient
- 90% Confidence Interval
Figure 8

Expectations-Augmented Phillips Curve Model, 25-year rolling window regressions

Market-based core PCE inflation

Market-based services excluding housing, energy, medical, tuition, and airfares.
Figure 9

Philips curve models for core PCE inflation
Recursive estimation, starting in 1982:Q2

Accelerationist

Expectations-Augmented
Figure 10

Philips curve model for PCE services excluding energy, housing, medical, tuition, and airfares
Recursive estimation, starting in 1982:Q2

**Accelerationist**

**Expectations-Augmented**
Figure 11
Response of core inflation to ECI TULC growth shocks

A. 1985

B. 1995

C. 2005

D. 2012

Note: Core inflation defined as log difference of core market-based PCE price index. Dotted lines denote 70 percent credible set.
A. Effect of structural shocks on core inflation

1. ECI trend unit labor cost shocks

Baseline plus effect of trend unit labor cost shocks
Baseline forecast
Actual

2. Unemployment gap shocks

Baseline plus effect of unemployment gap shocks
Baseline forecast
Actual

B. Effect of structural shocks on ECI trend unit labor cost growth

3. ECI trend unit labor cost shocks

Baseline plus effect of trend unit labor cost shocks
Baseline forecast
Actual

4. Unemployment gap shocks

Baseline plus effect of unemployment gap shocks
Baseline forecast
Actual

Note: Core inflation defined as four-quarter log difference of core market-based PCE price index.
Table 1: Out-of-sample Root Mean Square Errors based on recursive (expanding window) estimation

Models are re-estimated every quarter and forecasts for the next 8 quarters are produced. The starting date is 1982:Q2. RMSE are calculated for the past 20 observations.

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<td>Market-based PCE Services excluding housing, energy, medical, tuition, and airfares.</td>
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