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Economics Research
8 October 2015

Federal Reserve Commentary

Some unpleasant dual mandate arithmetic

Update: This version corrects the core PCE numbers in the second cover bullet and on the third page.

- Declines in energy prices, dollar appreciation, and the overall tightening in financial conditions are likely to rekindle disinflationary pressures. We measure the effects of each of these shocks, applying a bottom-up approach using the Barclays indices of Domestic and Tradable CPI.
- Our results suggest that these shocks will reduce CPI ex-energy by about 0.4pp over the next 12 months, primarily through the response of tradable prices to currency and energy price movements. We now expect core CPI to slow to 1.7% y/y in H1 2016 before resuming a modest upward trend through year-end 2016. For core PCE, we foresee it bottoming at 1.4% y/y next year before rising to 1.7% y/y in December.
- Chair Yellen's recent remarks indicate to us that she sees a risk that inflation will remain below the FOMC's 2% target for some time, which could cause long-run inflation expectations to drift lower. This risk is informed by the chair's view that the U3 unemployment rate significantly underestimates the amount of slack. If accurate, then resource underutilization will continue to put downward pressure on inflation in the coming year at the same time import prices are likely to weigh on tradable prices and core inflation.
- If the chair's primary concern is drifting inflation expectations, then there is much in her – and our – analysis to suggest that monetary policy should become much more accommodative. We find evidence to suggest that long-term inflation expectations have slipped modestly and investors are placing higher probabilities on low inflation outcomes.
- Even if the Fed desires to meaningfully defer rate hikes in support of its inflation target, preventing further slippage in long-run inflation expectations is likely to prove difficult given the lasting effects of dollar and energy price movements on tradable prices and a relatively flat Phillips curve. We retain our outlook for a March 2016 lift-off, as our forecast calls for the unemployment rate to fall to a level that we believe the committee will find incompatible with zero policy rates, a large balance sheet, and its long-run policy objectives.

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The Yellen "conundrum"

> My interpretation of the historical evidence is that long-run inflation expectations become anchored at a particular level only after a central bank succeeds in keeping actual inflation near some target level for many years … Actual inflation would probably be affected only after the central bank has had sufficient time to concretely demonstrate its sustained commitment and ability to generate a new norm for the average level of inflation.
>
> -Janet Yellen, 2015, the *Philip Gamble Memorial Lecture*

Current Fed Chair Yellen may face a "conundrum": the absence of inflationary pressures despite a declining unemployment rate

In February 2005, Fed Chairman Greenspan described a stable 10y Treasury yield in the face of a substantial rise in the federal funds rate as a "conundrum." Current Fed Chair Yellen may very well face a "conundrum" of her own: the absence of inflationary pressures despite a declining unemployment rate. We read Chair Yellen's remarks on *Inflation Dynamics and Monetary Policy* as leaving her of two minds. On the one hand, she says the economy has made enough progress that a gradual rate hike cycle should begin before year-end. Moving too late or too slowly would raise undesirable medium-term stability or inflation risks. On the other hand, she says disinflationary pressures remain elevated, labor markets have not yet healed, and lost credibility on inflation is both costly and difficult to reverse. Hiking too soon or too rapidly under this scenario would be a mistake.

The chair's remarks suggest to us that she sees a risk that inflation – which has fallen short of the Fed's mandate during the recovery – will remain below the FOMC's 2% target for some time to come, causing long-run inflation expectations to drift lower. This risk, in part, is grounded in the chair's view that the U3 unemployment rate significantly underestimates the amount of labor market slack. If accurate, then resource underutilization will put downward pressure on inflation for some time, instead of modest upward pressure if the economy were at full employment. In the meantime, import prices are likely to weigh on tradable prices and core inflation through late-2016.

If the chair's primary concern is unanchored inflation expectations, the rate hike cycle should be meaningfully deferred

If the chair's primary concern is unanchored inflation expectations, there is much in her (and our) analysis to suggest that the rate hike cycle should be meaningfully deferred. We find that the pass-through effects of dollar and energy price movements on tradable prices are long-lasting, long-term inflation expectations have slipped modestly, and the Phillips curve is flat. With financial stability concerns muted at present, there is a strong case to be made that policy should become much more accommodative.

However, preventing further slippage in long-run inflation expectations may prove difficult and entails its own risks, including driving the unemployment rate to levels that many on the committee would associate with heightened financial stability risks. Consequently, we see the Fed as having to begin a modest tightening cycle without having complete confidence in its ability to hit its inflation target in order to avoid unemployment rates that could prove destabilizing. We retain our call for a March 2016 lift-off, as our forecast calls for the unemployment rate to fall to a level that we believe many on the committee will find incompatible with the FOMC's long-run policy objectives.[1]

In this report, we assess the effects of renewed dollar strength and energy price weakness on inflation, the stability of long-run inflation expectations, and the strength of the Phillips curve relationship. While the Fed speaks of these influences on headline and core inflation, we prefer to assess their effects on tradable and non-tradable prices using our recently

[1] On August 24, the combination of a weaker inflation profile and heightened volatility in domestic financial markets, which has historically weighed on activity and labor markets, caused us to change our forecast for the first Fed rate hike to March 2016, which may be conservative should external risks intensify. See *Federal Reserve: First rate hike in March 2016 as financial volatility amid EM uncertainty pushes our call*, August 24, 2015 and *US Inflation update: Lower headline CPI on both energy weakness and softer core trend*, August 24, 2015.

constructed series of Tradable CPI and Domestic CPI. In our view, these indices allow us to differentiate the portion of inflation driven by domestic supply and demand and the portion driven by the evolution of supply and demand abroad.

Our analysis suggests that the recent changes in the exchange rate and the fall in commodity prices will reduce CPI ex-energy by about 0.4pp over the next 12 months

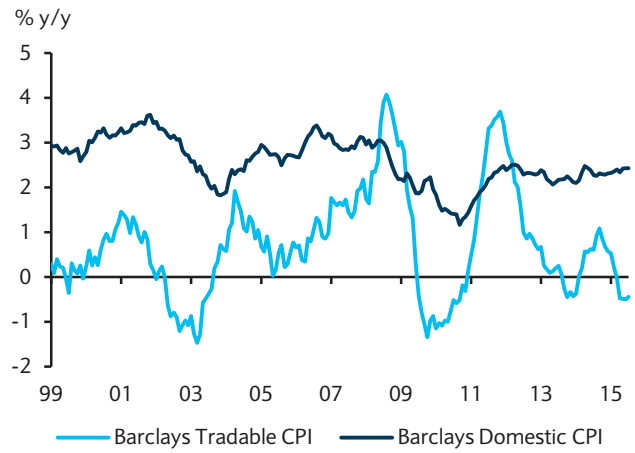
Our analysis suggests that the recent changes in the exchange rate and the fall in commodity prices will reduce CPI ex-energy by about 0.4pp over the next 12 months, primarily through the response of Tradable CPI to currency and energy price shocks. In contrast, we do not expect a meaningful effect on Domestic CPI, leaving this portion of the consumer price basket the main driver of overall inflation once again. These results are consistent with our forecast that core CPI will slow to 1.7% y/y in H1 2016 before resuming a modest upward trend through year-end 2016. Our forecast for core PCE bottoms at 1.4% y/y in H1 and then rises to 1.7% y/y by December.

Déjà vu all over again: Strong dollar, weak commodities to weigh on Tradable CPI in 2016

In its September statement, the FOMC said that "[r]ecent global economic and financial developments may restrain economic activity somewhat and are likely to put further downward pressure on inflation in the near term." In the press conference that followed, Fed Chair Yellen elaborated on why participants had lowered their median inflation projection, saying "the outlook abroad appears to have become more uncertain of late, and heightened concerns about growth in China and other emerging market economies have led to notable volatility in financial markets." Even though the Fed does not see these risks as altering the outlook for activity and labor markets, they do alter the outlook for inflation.

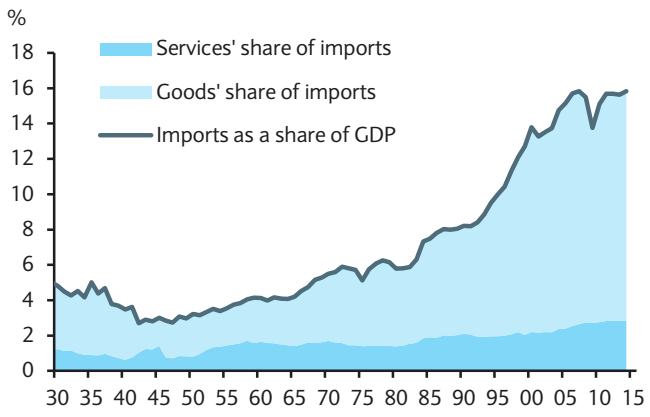
As concerns about global growth became more pronounced, the dollar strengthened (by 5.0% since the June FOMC meeting) and Brent fell further (from $50 to a low of $43 on August 24, before rebounding more recently). Our commodities research team has lowered its outlook for Brent to $52/b for H2 2015 and to $63 for 2016; the latter is $5 below the previous price target (see *The Blue Drum: Too fast, too spurious*). These renewed pressures on the dollar and energy prices will feed through to inflation at a time when past dollar appreciation and energy price declines have yet to fully pass through.

FIGURE 1
Barclays Tradable and Domestic CPI



Source: BLS, Haver Analytics, Barclays Research

FIGURE 2
Imports' share of GDP has risen significantly since the 1970s



Source: BLS, Haver Analytics, Barclays Research

As Chair Yellen made clear in her subsequent remarks on *Inflation Dynamics and Monetary Policy*, whether the committee can be "reasonably confident that inflation will return to 2.0 percent over the next few years" depends on more than assessing dollar and energy price pass-through effects. The Fed's outlook assumes that long-run inflation expectations remain stable and further labor market tightening results in faster wage appreciation.

Not headline versus core, but tradable versus non-tradable

We prefer to group inflation into its tradable and non-tradable components

While we agree that separating energy and food prices to create a series on core inflation is a reasonable way to exclude some volatile prices that are beyond the influence of monetary policy, we prefer to group inflation into its tradable and non-tradable components. To understand the effects of recent dollar and energy price movements on inflation, we apply a bottom-up approach using our in-house inflation indices: Domestic and Tradable CPI. These two series, which are constructed using components of CPI at a disaggregated level, behave differently (Figure 1) and have varying degrees of sensitivity to external and domestic inflation pressures (see *US Economic Research: Creating Domestic Inflation*).

The Domestic CPI contains mainly core services components and other series such as food consumed in restaurants, various vehicle prices, medical care commodities, and recreation related goods and services

The Domestic CPI is about three-quarters of the CPI basket and contains mainly core services components and other series such as food consumed in restaurants, various vehicle prices, medical care commodities, and recreation related goods and services. By construction, it has a lower import penetration component. We believe this series best identifies sources of inflation pressures in the US. The Tradable CPI is composed of the bulk of the remainder of the CPI basket. With high import content, the series should be responsive to movements in international prices and factors exogenous to the US economy.[2] The share of imported goods to GDP has increased significantly since the 1970s, while that of imported services has remained broadly stable at low levels (Figure 2), also suggesting that prices of goods and services should react differently to external shocks. Altogether, we believe that Domestic CPI is useful for understanding the underlying trend in inflation, while Tradable CPI is useful for following the net influence of external shocks, such as the Chinese exchange rate devaluation, on overall US inflation.[3]

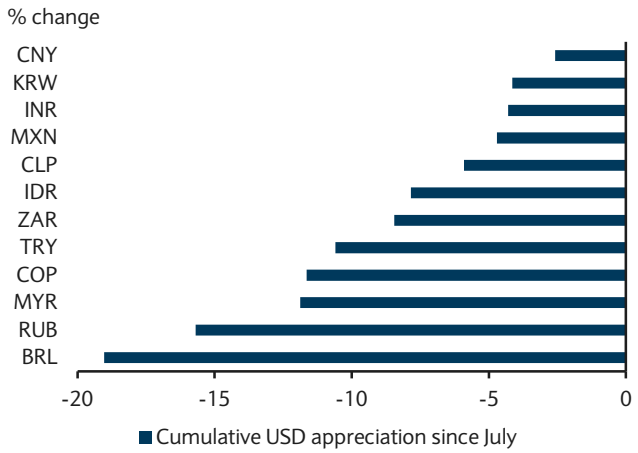
FIGURE 3

After a brief pause, the dollar resumed its rise on a trade-weighted basis

Source: Federal Reserve, Haver Analytics

FIGURE 4

The dollar appreciation has been more pronounced against currencies of EM trading partner



Source: Bloomberg

[2] We exclude energy components (energy commodities and energy services) from both indices. For a complete listing of the categories in each index, see Table 1 in the Appendix of *US Economics Research: Creating domestic inflation*.

[3] The use of tradable CPI instead of core goods increases the size of the estimated effects and the efficiency of the VAR by removing core goods that have high levels of domestic value added. In our previous work (see *Just passing through: The effect of USD appreciation on inflation, growth, and Fed policy*), we found a strong effect of the exchange rates on import prices but had more difficulty mapping those changes into inflation. By focusing attention only on those items in CPI that are actually imported, we eliminate much of the influence of domestic conditions on prices.

US dollar strength weighs on Tradable CPI, but not Domestic CPI

After a brief pause in Q2, the dollar has resumed appreciation in recent months. The nominal effective exchange rate (NEER) index, the Fed's preferred measure, has appreciated about 5.0% since the June FOMC meeting versus a basket of currencies of its major trading partners (Figure 3). The latest bout of dollar strength is mainly against its emerging markets trading partners (Figure 4), while the appreciation against developed economy currencies has been more measured. Over this time frame, the dollar has appreciated almost 3.0% against other major currencies, but 6.5% against EM currencies.

China dominates the share of non-automotive consumer goods imports, making the dollar's appreciation against the Chinese yuan particularly important for the path of Tradable CPI

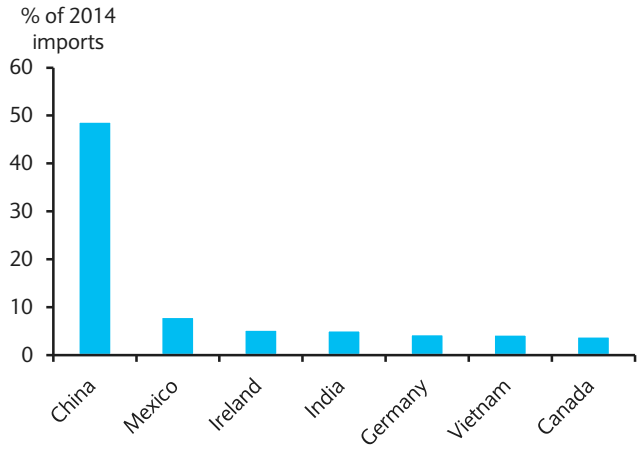
China dominates the share of non-automotive consumer goods imports (Figure 5), making the dollar's appreciation against the Chinese yuan particularly important for the path of Tradable CPI. However, yuan appreciation may not fully account for the degree of imported disinflation from China. Chinese producer prices and the prices of countries that export raw materials and intermediate inputs to Chinese firms are other important factors. That said, risks to the growth outlook in China highlight the downside risks to goods inflation from one the US's main import partners.

We use a vector autoregression (VAR) framework that allows energy and currency shocks to affect Tradable and Domestic CPI separately. We control for the business cycle by using the Barclays Indicator of Labor Market Conditions, which captures the signal from a wide range of labor market indicators and is a robust measure of the cycle (see *Assessing US labor market conditions: From many indicators, a clear signal*). In addition, we include the Barclays Financial Conditions Indicator, which tightened significantly following the market volatility during August (Figure 6). In prior analysis, we found that higher financial stress and tighter financial conditions attenuate hiring, increase the unemployment rate, and soften consumption (see *US Economics Research: Stress-testing the FOMC*). Here, we also want to investigate whether a change in these conditions has a direct effect on domestically generated inflation.

The VAR impulse response suggests a cumulative drag of 0.2pp on our index of tradable consumer prices over 12 months for a one standard deviation change in the value of the dollar.[4] The recent 5.0% dollar appreciation since mid-June would be consistent with a

FIGURE 5

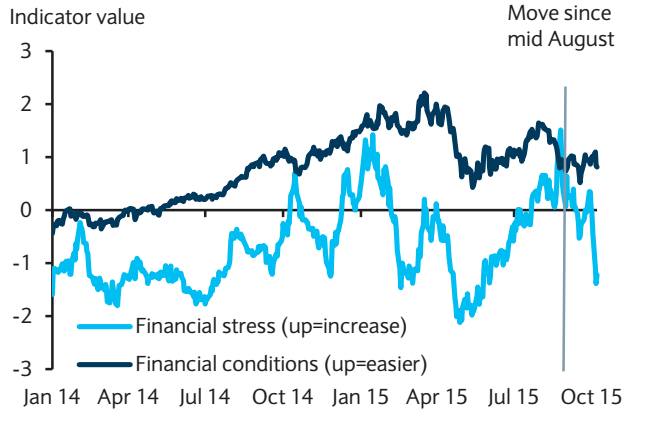
Most of non-automotive consumer goods' imports come from China



Source: International Trade Commission

FIGURE 6

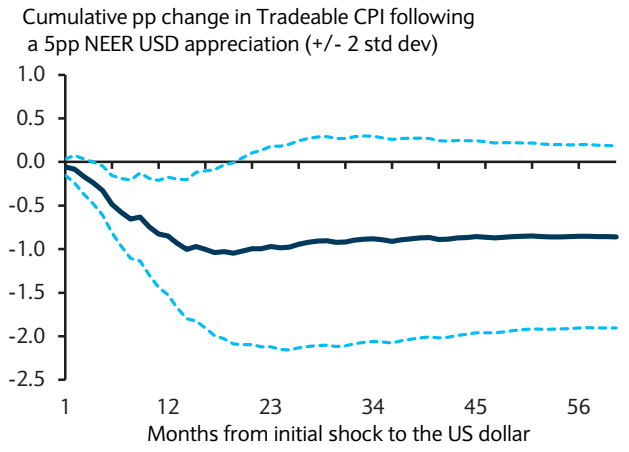
Financial conditions tightened and financial stress bounced in recent months



Source: Barclays Research

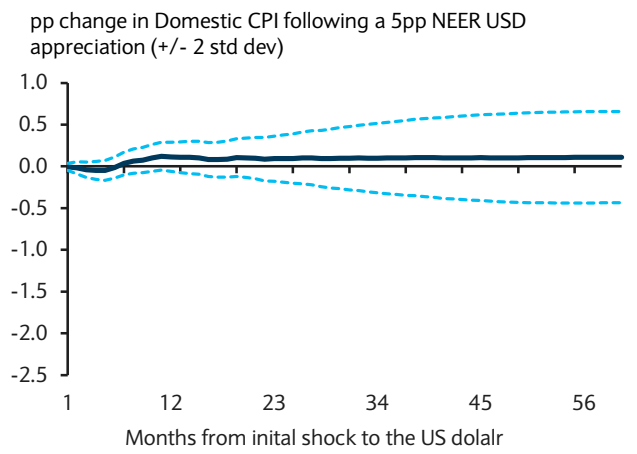
[4] For tradable CPI, our VAR estimates the pass through of energy and currency shocks to import, producer, and consumer prices in a fashion similar to the model developed in McCarthy (2006) (*J. McCarthey (2006), Pass-though if exchange rates and import prices to domestic inflation in some industrialized economies, Federal Reserve Bank of New York*). The VAR consists of six variables: oil prices, a measure of spare capacity, the exchange rate, import prices, producer prices, and the Barclays tradable CPI measure. The variables are in the order given above, the number of lags is set to 12, and the model is estimated using monthly data from 1998 to date. We estimate the impulse responses of tradable CPI from changes in the dollar value and oil prices.

FIGURE 7
Cumulative effect of dollar appreciation on Tradable CPI



Source: Barclays Research

FIGURE 8
Cumulative effect of dollar appreciation on Domestic CPI



Source: Barclays Research

1.0pp drag on Barclays Tradable CPI over four quarters (Figure 7). We also note that the results of our exercise suggest that there is a permanent effect on the level of tradable prices. Given that our Tradable CPI index is just under 20% of the CPI basket, the dollar move since mid-June would be equivalent to a 0.2pp decline in overall consumer prices.

Our model suggests a drag of 0.2pp on our tradable index over 12 months for a one standard deviation change in the value of the dollar

We find that the effect of a similar dollar appreciation shock on the index of Domestic CPI is not statistically different from zero (Figure 8).[5] Although we do find a statistically significant relationship between our output gap measure and domestic prices, we find little evidence that dollar shocks are a driver of this process. Hence, we conclude that other factors outside of US dollar appreciation/depreciation are the main drivers of domestic inflation. In our view, this seems logical given that the US is a large closed economy.

Oil price shocks have second-round effects on Tradable CPI

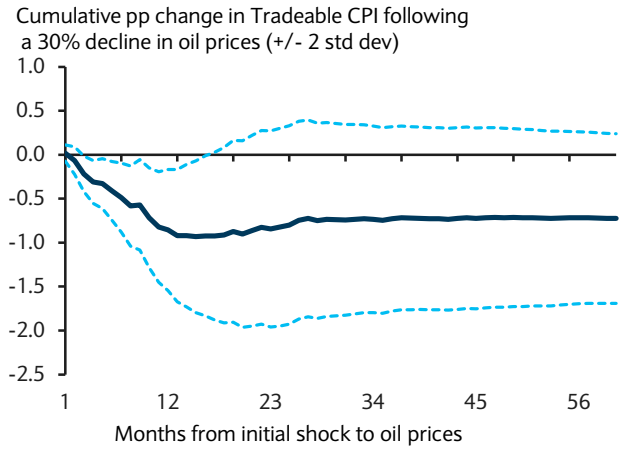
We also find significant second-round effects from oil prices

We also find significant second-round effects from a supply side shock to Tradable CPI. The impulse response of a one standard deviation change in oil prices boosts Tradable CPI by about 0.2pp over 12 months. As was the case with dollar shocks, changes in oil prices have a permanent effect on the level of Tradable CPI. The 30% decline in oil prices since the June FOMC meeting translates into a 1.0pp drag on our tradable index of prices (Figure 9). Given its weight in CPI, this is equivalent to a 0.2pp decline in overall consumer prices. The index of Domestic CPI is largely unchanged after an oil price shock (Figure 10).

Our results hold even if we control for supply-side shocks by using prices of other commodities, such as copper. This suggests that the 1.0pp drag on Tradable CPI should be interpreted as a second-round effect from a supply-side shock more generally, rather than in the narrow sense of the pass-through from lower energy prices. Declining global commodity prices could also be symptomatic of slower global demand (in particular, emerging markets, which have been large consumers of commodities in recent decades). As a result, the supply shock parameter would capture not only the effect on prices of lower input costs, but also the effect of slower global demand on globally traded goods and services prices.

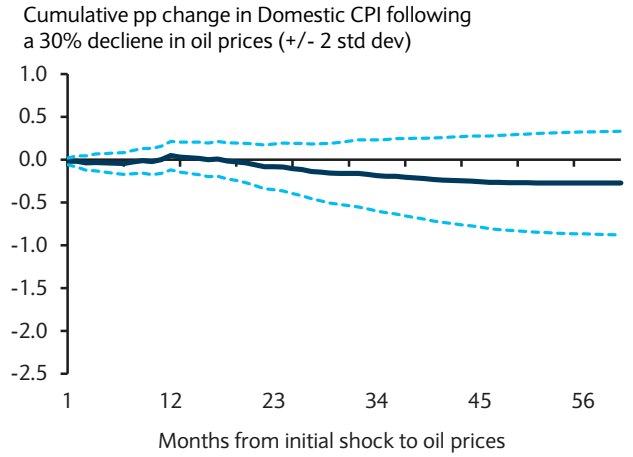
[5] Our VAR for domestic CPI includes six variables: oil prices, a measure of spare capacity, the exchange rate, a measure of financial conditions, the producer price index from the non-manufacturing ISM survey, and the Barclays domestic CPI measure. Uncertainty about our estimates is significant, as pass-through from shocks can be affected by other factors. For instance, market structures that can allow firms to maintain a larger part of profit gains from lower input costs and not pass-through the full input cost declines, which we do not control for here. Nevertheless, this framework is helpful in approximately estimating the aggregate effect of recent shocks on US consumer prices.

FIGURE 9
Energy price declines drag Tradable CPI lower over a year…



Source: Barclays Research

FIGURE 10
…while leaving Domestic CPI broadly unchanged



Source: Barclays Research

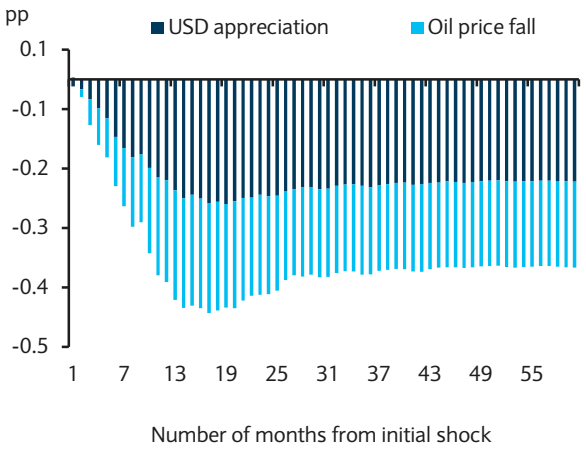
Tradable prices to weigh on CPI inflation in H1 2016

The overall effect on CPI (ex-energy) prices from the latest dollar appreciation and oil price declines adds up to 0.4pp over a 12-month horizon (Figure11), with a transmission primarily through the Tradable CPI channel. The model estimate is based on a simplification of the real world and does not control for market distortions that could limit FX pass-through. Nor does it control for the fact that invoicing of trading partners exports leads to lower pass-through of currency fluctuations to US markets. Nevertheless, our results are in line with other research that finds that the pass-through of external shocks to US consumer prices is relatively muted and confined largely to the tradable portion of the consumer price basket.[6]

These results are consistent with our forecast of more modest core inflation

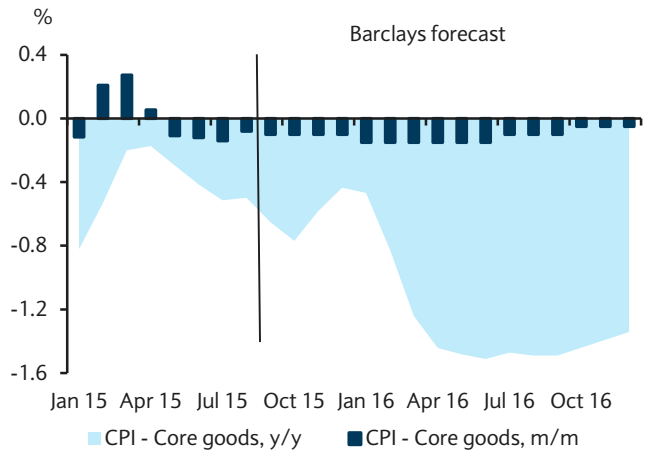
These results are consistent with our forecast of more modest core inflation in H1 2016 due to a drag from core goods prices that intensifies over the next several quarters (see *US inflation update: Lower headline CPI on both energy weakness and a softer core trend*). In addition, our finding that currency moves and external supply side shocks do not have a

FIGURE 11
Cumulative response on consumer prices from currency and oil price shocks



Source: Barclays Research

FIGURE 12
Core goods inflation profile



Source: BLS, Haver Analytics, Barclays Research

[6] See, for instance, *Gita Gopinath (2015), The international price system*.

significant effect on Domestic CPI bodes well for our expectations that consumer prices will continue to be boosted primarily by core services components, especially shelter inflation, over the remainder of the forecast horizon.

Long-run inflation expectations: Stable with some slippage

Whether recent dollar strength and energy price weakness have a transitory effect on inflation depends on the stability of long-run inflation expectations

Whether recent dollar strength and energy price weakness have a transitory effect on inflation depends on the stability of long-run inflation expectations. As Chair Yellen said in her recent speech, if inflation expectations are indeed stable, they will provide a credible anchor for inflation to return to over time as shocks to import and other prices fade. If there is no credible anchor for long-term inflation, then shocks to inflation may cause expectations to shift, and expected inflation may follow actual inflation higher, as was the case in the 1970s. The monetary policy-induced recession of the early 1980s was the Fed's attempt to restore its inflation bona fides, in part by re-anchoring long-run expectations at a lower level. While the 1970s provide evidence of an upward drift in long-run inflation trends, the risk in the current environment is that persistent disinflationary pressures may cause long-run inflation expectations to drift lower, making it difficult for the Fed to achieve its 2.0% objective over time. If inflation expectations drift lower, then inflation could settle in at a sub-2.0% rate once dollar and energy price effects on tradable prices fade.

In Chair Yellen's view and the consensus view of the committee, long-run inflation expectations can be characterized as stable.

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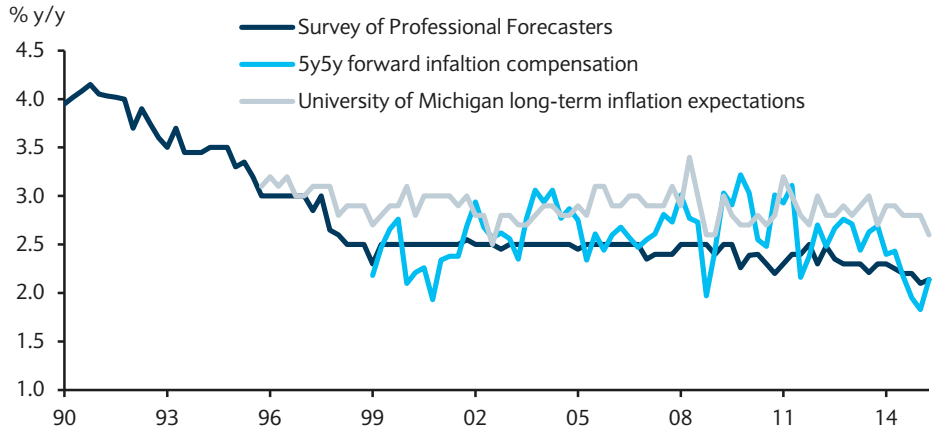
We broadly agree. FOMC participants point to the general stability of inflation expectations from surveys of professional forecasters and households, as well as market-based measures of inflation compensation, to justify this view. However, as shown in Figure 13, there is some evidence that long-run inflation expectations have started to drift modestly lower. Chair Yellen raised this risk in her recent speech and pointed to the decline in inflation compensation as a worrisome trend, but concluded that technical factors cloud the ability of policymakers to read inflation expectations from measures of breakeven inflation. Since movements in breakeven rates of inflation can come from changes in inflation expectations, the inflation risk premium, and relative liquidity conditions between nominal and real Treasury securities, decomposing changes in breakeven inflation into their component parts can be a statistical challenge.

Recently, in an interview with *The Wall Street Journal*, New York Fed President Dudley said that he believes the decline in inflation compensation is due primarily to a reduction in the

FIGURE 13

Survey and market measures of long-run inflation expectations show modest slippage



Note: Survey of Professional Forecasters is 10y expected CPI inflation, inflation compensation is a 5y5y forward estimate from TIPS based on CPI indexation, and University of Michigan is a 5-10y inflation expectation survey of households without specifying an underlying index. The wedge between CPI and PCE inflation has averaged 46bps since 1990. Source: Bloomberg, Federal Reserve, Philadelphia Fed, University of Michigan, Haver Analytics

inflation risk premium and not a decline in long-run inflation expectations. We have some sympathy for this view, but are not as dismissive of the decline in inflation risk premia, since we believe market pricing suggests that investors are becoming more confident that inflation will undershoot the Fed's 2.0% target over time.

Figures 14 and 15 show the probability of 10y CPI inflation falling within certain ranges as implied by CPI options markets at three points in time since 2013. Since year-on-year rates of CPI inflation generally exceed PCE inflation by 40-50bp on average, we view outcomes of 2.0-3.0% as indicative of the Fed's achieving its PCE inflation target. Some of the reduction in inflation risk appears to be driven by a low probability of high inflation outcomes. For example, the probability of CPI inflation exceeding 4.0% in the decade ahead has fallen substantially, from 15% to 5%. Policymakers should welcome this development, and we would look through any decline in inflation compensation driven solely from this source.

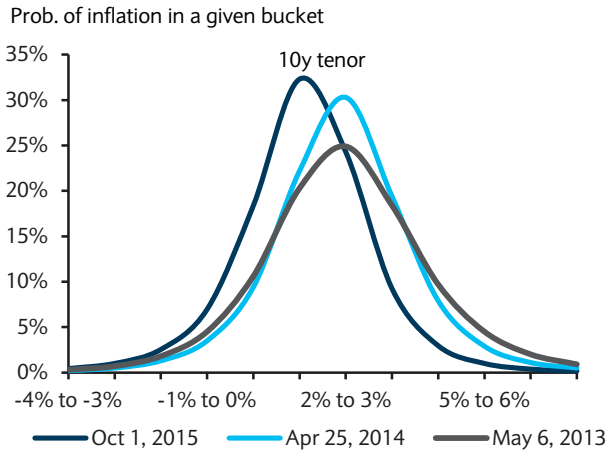
However, we also note that outcomes have become skewed in the direction of low inflation. CPI options markets now place greater weight on inflation modestly undershooting the Fed's target than on hitting the target, and market pricing implies that it is four times as likely that 10y CPI inflation will fall below 2% than rise above 3%. In previous years, options markets saw risks related to the Fed's target as more symmetric. Overall, we view trends in long-dated inflation risk as suggesting that markets may be losing faith in the Fed's ability to meet its inflation objectives. If so, the decline in inflation risk premium and inflation compensation is, in our view, a more troublesome trend and may be a signal that long-run inflation expectations are becoming unanchored and could continue to drift lower.

Labor markets provide weak support for Domestic CPI

Chair Yellen studies inflation dynamics using an expectations-augmented Phillips curve

Finally, we turn to domestic inflation and assess the relationship between labor market improvement and confidence in the inflation outlook. We begin with the model of inflation used by Chair Yellen in her recent speech on inflation and monetary policy. Her framework falls under the class of models knows as expectations-augmented Phillips curve models and assumes that core inflation is influenced mainly by inflation expectations, past inflation, resource utilization (as proxied by the unemployment rate relative to its long-run value), and the relative price of imports.[7] She uses the framework to argue that inflation will return to the FOMC's 2% inflation target once transitory shocks to energy and the dollar subside.

FIGURE 14
Inflation risk is skewed toward low inflation outcomes



Source: Barclays Research

FIGURE 15
The likelihood of sub-2.0% inflation has risen

Implied probability of 10y CPI inflation within a given range	Oct. 1, 2015	April 25, 2014	May 6, 2013
below 0%	11%	5%	7%
0% to 1%	18%	9%	11%
1% to 2%	32%	22%	20%
2% to 3%	24%	30%	25%
3% to 4%	9%	19%	18%
above 4%	5%	11%	15%

Note: Numbers may not sum to 100 due to rounding and truncation of the distribution for presentation. Source: Barclays Research

[7] The core inflation forecasting equation is:

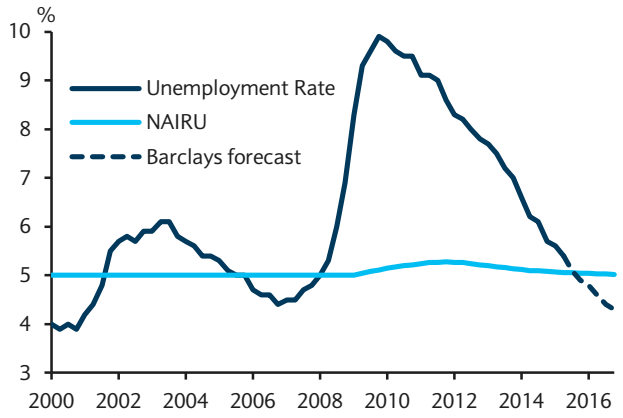
$$\pi_t^c = \pi_t^e + \pi_{t-1}^c + \pi_{t-2}^c + SLACK_t + RPIM_t + \epsilon_t,$$

FIGURE 16
The Phillips curve is relatively flat

1990Q1 to 2014Q4			
	Chair Yellen's Results	Public Data	Coefficient Restriction
Inflation Expectations	0.41	0.58	0.43
Lag(-1)	0.36	0.25	0.37
Lag(-2)	0.23	NS	0.20
UR - NAIRU	-0.08	-0.07	-0.07
Rel. Import Price	0.57	0.53	0.55
LR Inflation 1	2.00	1.55	2.00
LR Inflation 2	1.63	1.36	1.66

Note: LR inflation 1 is equilibrium value of inflation assuming that inflation expectations are stable at 2%, the UR gap is zero, and the relative price import price is zero. LR inflation 2 uses sample average of UR gap and relative price difference. NS indicates not statistically significant at 90%. Source: Federal Reserve, Barclays Research

FIGURE 17
Labor markets to provide modest support for inflation



Note: CBO long-run NAIRU estimate. Source: BLS, CBO, Haver Analytics, Barclays Research

We attempted to replicate the chair's results using publicly available data (we will spare readers most of the details of that exercise in the main text and focus our comments on the results in Figure 16).8 The first column of Figure 16 contains the results reported by the chair in her speech, the second reflects an unrestricted estimation using publicly available data, and the third shows results after imposing restrictions that allow us to closely match the chair's results.

Absent restrictions, we find long-run inflation expectations of 1.4-1.6%, consistent with our findings that inflation options markets suggest higher probabilities of low-inflation outcomes

We have three main takeaways from the model. Comparing the first two columns of Figure 16, we match the coefficient on relative import prices and the unemployment gap, but our coefficients on the lags of inflation and inflation expectations are different. We are able to match the full estimation (in the third column) only if we impose a restriction that the first three coefficients in the regression sum to one, which is an assumption that assures inflation expectations are 2.0% in the long-run dynamics of the system.[9] Absent these restrictions, we find long-run core inflation expectations of 1.4-1.6%, consistent with our findings in the previous section that inflation options markets suggest higher probabilities of low-inflation outcomes.

where core inflation (π_t^c) is modeled on long-term inflation expectations (π_t^e), lags of core inflation, economic slack ($SLACK$)in terms of the U3 unemployment rate against the CBO's measure of long-run unemployment, and the relative price of core imported goods ($RPIM$) as described in the paper.

[8] We use the median forecasts of long-run PCE or CPI inflation reported in the Survey of Professional Forecasters, with a constant adjustment of 50 basis points prior to 2007 to put the CPI forecasts on a PCE basis as a proxy for inflation expectations. For data prior to Q4 1991, we pull expectations from the public version of the FRB/US model, using the series ptr that is contained within the state space module. Core PCE inflation is BEA data. We use U3 unemployment rate minus the CBO's long run estimate of the natural rate for NAIRU for the slack variable. We construct the last term from publicly available data. The Federal Reserve's definition of "core" import prices relies on a special unpublished aggregate from the BLS that is not available to the public. The International Finance division of the Board of Governors typically excludes natural gas, computers and semiconductors from nonpetroleum goods imports when assessing underlying import price trends. This import price aggregate from the BLS is available for only a portion of the sample period over which the inflation forecasting model is estimated. The individual import price series, for nonpetroleum goods, natural gas, and computers and semiconductors are available for the sample period, however. Thus, we calculated "core" import prices on a best-efforts basis with publically available data by using t_-1 nominal goods import shares from the Census Bureau as weights and the quarterly changes in each of the individual price series. The natural gas and computers and semiconductors import prices series are available only on a quarterly basis prior to 1995. For the monthly data available since, we use the quarterly average of monthly values to arrive at continuous quarterly time series before constructing the aggregate index. Finally, we seasonally adjust this aggregate using the default X-12 settings in E-views.

[9] Notice that the chair's first three coefficients in the first column add exactly to one. We also penalize the first coefficient if it deviates too far from 0.41 to ensure convergence. The long-run dynamics of the system assume that the slack and relative import price values are zero (eg, the system is at equilibrium), and the three coefficients on inflation expectations and lagged core inflation must sum to one. Although the restriction is binding on the coefficients, the fit of the regression is falls only modestly with the restriction imposed, from an R^2 of 0.66 to 0.62. Our unrestricted estimation in the second column is consistent with long-run inflation expectations below 2.0%.

The second takeaway is the moderate influence that tightening labor markets have on core inflation. Regardless of the assumptions over long-run inflation expectations, the coefficient on labor market slack is fairly small. In other words, the Phillips curve is relatively flat. Each percentage point that U3 is above (below) NAIRU pulls down (pushes up) core inflation by about 0.1pp. If correct, the U3 unemployment rate would need to fall by several percentage points from its current 5.1% to provide counterbalance to the anticipated weakness in Tradable CPI. If policymakers are unwilling to permit this outcome – we do not believe they are – then the risk is that repeated transitory shocks to the currency and energy prices, plus a flat Phillips curve, mean that long-run inflation expectations move below 2.0%.

The level of inflation today has a strong influence on the level of inflation tomorrow

The third main takeaway from the chair's model is that, in the absence of a strong Phillips curve relationship, the level of inflation today has a strong influence on the level of inflation tomorrow (the lags are significant), implying that innovations to inflation are long lasting. Likewise, import prices pass through directly into core prices. Interpreting the response of core prices to import prices is difficult because of how the term is constructed in the chair's model. In that term, import prices are rescaled by both the lagged four-quarter change in core inflation and the share of core imports in GDP.[10] Including untransformed import prices, we find that a 10pp increase in import prices boost core prices by 0.5pp. The finding that current inflation is heavily influenced by recent inflation matches our own efforts in estimating underlying inflation (see *Core Inflation: Lower now, higher later*). Our hybrid approach places more weight on inflation momentum to estimate near-term inflation pressures and transitions to a top-down inflation expectations-augmented Phillips curve framework to inform the medium-term forecast.

[10] We believe the construction of this term is meant to measure a purchasing power parity concept. Only foreign prices, in dollar terms, that are substantially different from domestic prices should heavily influence inflation dynamics in the US. However, the inclusion of the four-quarter change of the dependent variable, even transformed, is econometrically complicated, as its inclusion influences the lag structure of inflation any time this quarter's import prices are different from last year's core inflation. We follow the chair's specification but in our own robustness tests we find that inclusion of import prices alone improves the fit of the regression, with or without coefficient restrictions.

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