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Explanations for Recent Low Inflation

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I. Introduction

PCE price inflation has been below the Fed's 2 percent objective for most of the period following the Great Recession (Chart 1). Moreover, on average the recent monthly inflation readings from March through May were especially low, and came in noticeably below the staff's expectations. This experience of low inflation has led some to question whether the FOMC is on track to achieve its inflation objective over the medium term.

In the staff's baseline view, the pattern of inflation over the past several years is broadly explainable in terms of its usual determinants, including an underlying inflation trend that is a little below 2 percent at present; in particular, we view recent months' downward surprises as transitory and have not let them affect our inflation projection beyond this year. Indeed, in the June Tealbook we continued to assess the risks around our inflation projection as balanced, not skewed to the downside; provisionally, we intend to provide the same characterization in the July Tealbook.

However, our baseline view could be mistaken. Furthermore, the fact that inflation has also been persistently low in other advanced economies contributes to the suspicion that there could be broader-based disinflationary forces at play (Chart 2).[1] In this memo, we discuss a number of alternative explanations for this low-inflation

Chart 1: Change in the price index for personal consumption expenditures

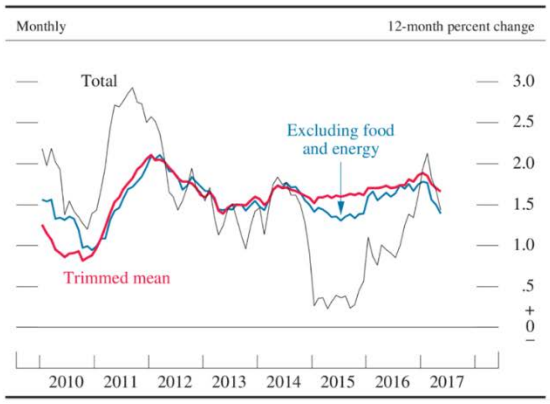
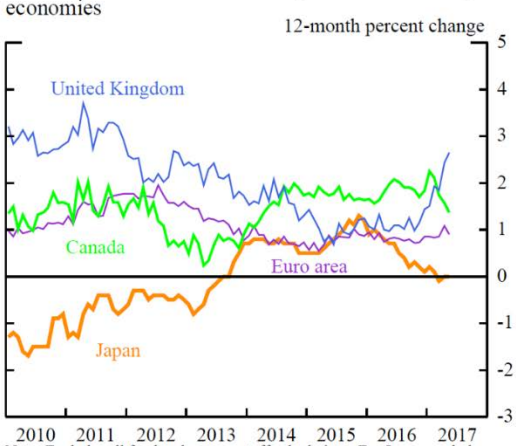


Chart 2: Core inflation in the major advanced foreign economies



Note: Excludes all food and energy; staff calculations. For Japan, excludes only fresh food and energy, and adjusts for the effect of the 2014 consumption tax hike; BOJ calculations. Source: Haver Analytics.

[1] The recent surge in U.K. inflation largely reflects the pass-through to consumer prices of the substantial depreciation of the pound following the Brexit referendum held in June 2016.

experience, both in recent years and in the past few months. These explanations—some of which we views as downside risks, and some we find not compelling—include (but are not limited to) the following:

- The natural rate of unemployment or inflation's underlying trend could be lower than we think;
- Import prices could be having larger and longer-lasting effects than we think;
- Factors specific to particular sectors of the economy, such as medical care or housing, could be holding down inflation;
- Greater competition, especially in the retail sector, could be putting downward pressure on consumer prices;
- Global factors, including foreign slack, could be holding down domestic prices; and,
- The weak published inflation could reflect changes in how the official price statistics are being measured.

II. A brief summary of the staff's baseline analysis and evidence on the recent importance of idiosyncratic shocks

1. The staff baseline

Under the staff's baseline interpretation, recent inflation dynamics reflect the interplay of a stable long-run trend (which we attribute to anchored longer-term inflation expectations), resource utilization, and supply shocks (including the pass-through of energy and import price changes to core inflation). In addition, factors that are unrelated to these "fundamental" determinants, such as unusual movements in nonmarket prices or idiosyncratic changes in other relative prices, are an important source of quarterly—and even year-to-year—variability in inflation.

Panel A of Chart 3 plots core PCE price inflation together with the staff's judgmental estimate of its underlying trend—that is, the level we expect inflation to return to absent any supply shocks and when there is no upward or downward pressure from resource utilization. In the out-years of the projection, the staff assumes that the inflation trend will eventually drift up toward the FOMC's 2 percent objective as a continued tight labor market and correspondingly higher actual inflation persistently boost households' and firms' inflation expectations. (This assumption has no real empirical basis; rather, it reflects our conviction that the economy's long-run rate of inflation is ultimately determined by the actions and communications of the monetary authority.)

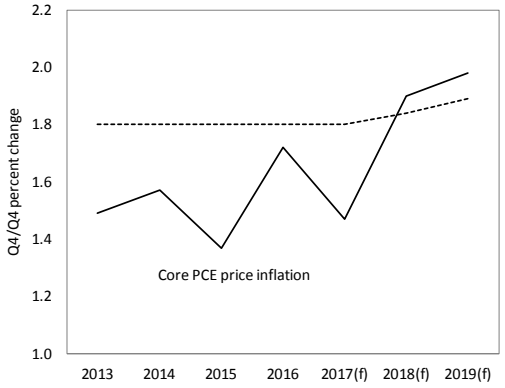
Panel B of Chart 3 provides a rough estimate of how important the other determinants of inflation have been in recent years by using the staff's judgmental rules of thumb to decompose deviations of core PCE price inflation from its trend.[2] As can be

[2] Chart 3 is based on a preliminary version of the staff's July Tealbook projection. It incorporates published price data through May.

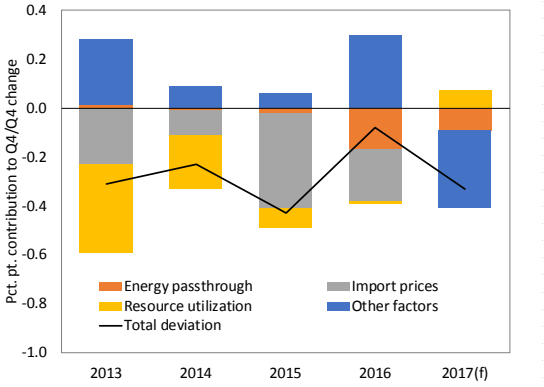
seen from the figure, "other factors" (the blue portions of the bars), which reflect influences on inflation that are not captured by slack, supply shocks, or the evolution of the trend (and which are in that sense similar to the residuals from an econometric model), can make relatively large contributions to inflation. Such a situation occurred in 2013 and 2016, when these factors pushed up inflation; likewise, based on the data so far in hand for this year, we project that 2016's positive contribution will be followed by a similarly sized negative contribution in 2017. In many cases, these factors represent "noise" in the form of idiosyncratic relative price changes that carry little signal about future inflation.[3] Nevertheless, as the figure suggests, the contribution of these other factors can often obscure the influence of more-fundamental determinants of inflation.

Chart 3: Determinants of core PCE price inflation

A. Core inflation and its underlying trend



B. Decomposition of deviations from trend



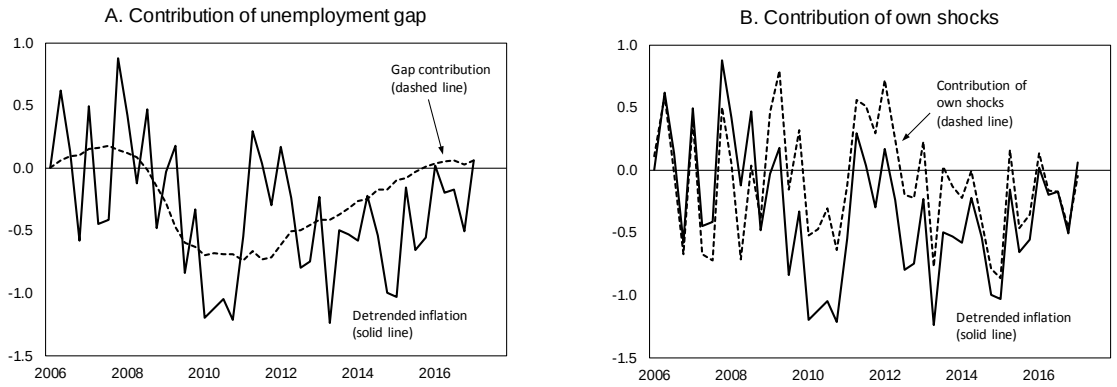
Another way of illustrating this point uses the results from a simple VAR system (Chart 4). In panel A of the chart, the estimated contribution of the staff's unemployment gap—the dashed line—is plotted against detrended core inflation (here we use market-based core PCE price inflation in order to eliminate the portion of inflation variability that reflects movements in nonmarket price inflation).[4] According to this model, over the past decade resource utilization has made an important low-frequency contribution to core inflation that has (on average) resulted in a below-trend pace of price increases. However, this contribution is difficult to discern because of inflation's quarterly variability, which—as can be seen from the dashed line in panel B—itself largely reflects uncorrelated own-shocks to inflation (that is, structural shocks to the VAR's inflation

[3] For example, 2013 saw a sharp increase in nonmarket PCE price inflation, which tends to fluctuate erratically around a relatively stable mean, while 2016 saw both a large increase in nonmarket prices and an unusual jump in prescription drug prices.

[4] The VAR system includes two lags of weighted relative core import price inflation, growth in ECI-based trend unit labor costs, market-based core PCE price inflation, and the staff unemployment gap (with that ordering). Price inflation and unit labor cost growth are expressed relative to longer-run expected inflation from the Survey of Professional Forecasters (SPF); with an SPF value of 2 percent, the model implies a level of trend inflation that is consistent with the staff's 1.8 percent assumption. (In Chart 4, actual inflation and the contributions of shocks are expressed relative to this implied trend by removing the VAR model's baseline forecast.)

equation). Similarly, the relatively high quarterly variability of inflation implies that own-shocks will tend to be a dominant source of inflation forecast errors even at relatively far horizons.[5]

Chart 4: Contributions of slack and own shocks to inflation (from VAR model)



Notes: Detrended inflation and contributions of shocks are expressed as percentage point deviations from the baseline VAR forecast. (The inflation rate is defined as the quarterly log difference in the market-based core PCE price index, expressed at an annual rate.)

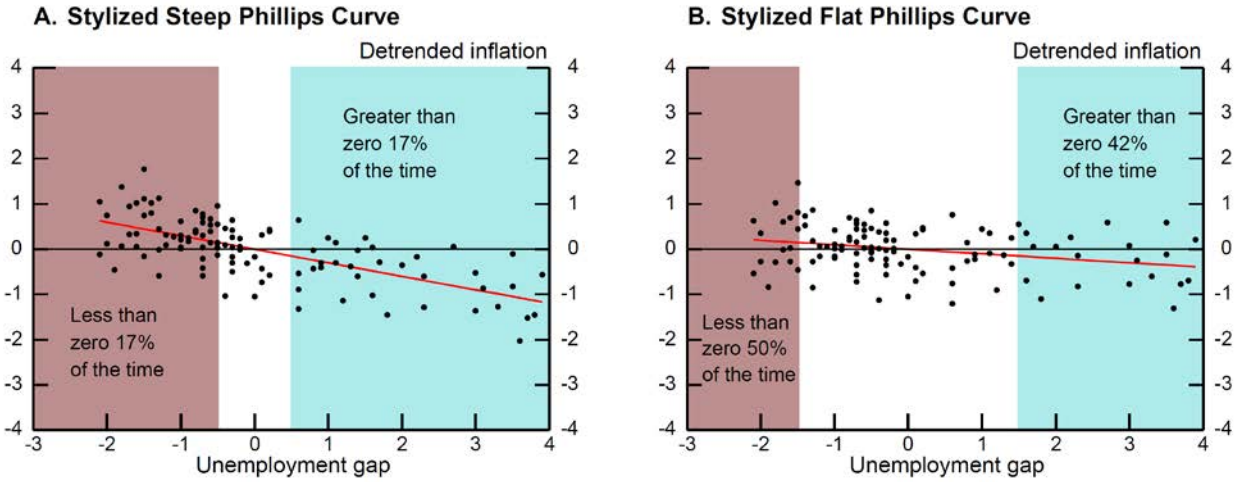
An important reason why a high degree of idiosyncratic variability in inflation hampers our ability to clearly identify the effect of resource utilization on inflation is that the Phillips curve is relatively flat at present. Chart 5 uses a stylized example to illustrate this point; specifically, the figure shows the relationships between detrended inflation and the unemployment gap that we would expect to see in a world where the Phillips curve is relatively steep (panel A) or relatively flat (panel B).[6] With a flat Phillips curve—and even when resource utilization is quite tight, with the unemployment rate more than 1½ percentage points below its natural rate (the red region in panel B)—inflation is sufficiently noisy that we are about as likely to see *below*-trend inflation as above-trend inflation in any given quarter. This problem is far less acute when the Phillips curve is steeper—panel A—in that even a small deviation of unemployment below its natural rate typically results in above-trend rates of inflation.

2. Evidence on recent inflation surprises and idiosyncratic movements

Taken together, these considerations suggest that nontrivial inflation surprises—such as the downward surprises seen in recent months—are likely to be quite common. Indeed, our ability to forecast inflation has been rather limited, even during the period of relative inflation stability that has prevailed over the past couple of decades: As indicated by the exhibit that is routinely presented in Book A of the Tealbook, the width of the 70 percent

[5] For the VAR shown here, own innovations account for more than 85 percent of the variance of the eight-quarter-ahead forecast errors for inflation, while innovations to resource utilization account for a little under 8 percent of these inflation forecast errors.
[6] The calibrations are informed by empirical Phillips curve estimates.

Chart 5: Stylized steep and flat Phillips curves



confidence interval around our June projection for the 2017 Q4 over Q4 change in core PCE prices was 0.6 percentage point; for our 2018 core inflation forecast, the width of the 70 percent confidence interval was 1.4 percentage points.[7]

Regarding the inflation surprises seen this spring, an important reason for viewing them as transitory—as we have emphasized in previous Tealbook discussions—is that we can point to particular examples of recent price movements that appear idiosyncratic. For instance, wireless telephone service prices plunged in March and prescription drug prices dropped in April.[8] Taken alone, the drop in these two items account for around half of the slowdown of the 12-month change of core PCE since January. Not surprisingly, the 12-month change in the Dallas Fed trimmed mean PCE index has shown less deceleration than total or core PCE inflation in recent months (chart 1), and suggests a similar contribution of idiosyncratic factors to the deceleration.

Another piece of evidence in favor of the preceding view comes from a model that formally decomposes inflation movements into common (to all items) versus idiosyncratic (item-specific) innovations. Chart 6 shows such a decomposition applied to one-month changes in core PCE inflation.[9] This model estimates a large negative

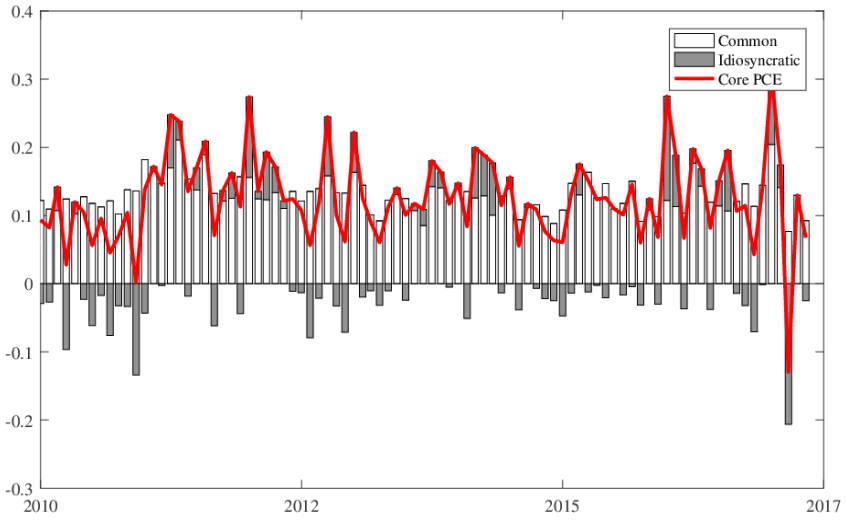
[7] See pages 80–81 of Book A of the June 5, 2017 Tealbook. Note that the forecast confidence intervals for total PCE price inflation are even wider (the corresponding figures are 1.2 percentage points for 2017 and 2.5 percentage points for 2018).

[8] In March, quality-adjusted prices of wireless telephone services, which has a weight of about 1 percent in PCE, plunged 7 percent. The drop—the largest ever in history—was triggered by the introduction of unlimited data plans by the two largest carriers (AT&T and Verizon). Also, in April prices of prescription drugs—3-1/2 percent of PCE—dropped 0.9 percent. The drop was also the largest in history, and it most likely reflects earlier patents expiration and the introduction on the market of generic drugs (which are typically priced 80 percent to 85 percent below their branded counterparts).

[9] This model was developed by Matteo Luciani of the Board's staff. It assumes that each core PCE item ($\pi_{i,t}$) can be decomposed into a common component ($\chi_{i,t}$) and an idiosyncratic part ($\varepsilon_{i,t}$)—formally, ($\pi_{i,t}$=

idiosyncratic shock in March that was not reversed in April or May. That said, the model also suggests a slowdown of the common component in the last three months, even if this deceleration does not appear unprecedented in recent history.

Chart 6: Core PCE inflation—decomposition of one-month changes



III. Structural explanations for low inflation (1): Explanations associated with the staff's Phillips curve framework

Although the staff's judgmental framework has done a reasonably good job characterizing inflation dynamics over the past several years, our analysis could be wrong in a number of ways. We begin by discussing alternative explanations for low inflation that are closely associated with the estimates and parameters from the staff's Phillips curve framework. Section IV then discusses a variety of potential explanations that are less directly tied to our framework.

1. Lower natural rate of unemployment or trend inflation

In the staff's framework, two important "free parameters" that influence our interpretation of recent inflation behavior are the natural rate of unemployment (which determines the amount of slack that is present in the economy), and the rate of underlying inflation. Different assumptions about either or both elements of our framework could allow us to better explain recent months' inflation surprises—or a persistent shortfall from the FOMC's 2 percent inflation objective.

$\chi_{i,t} + \varepsilon_{i,t}$). The common component is estimated using a principal component analysis: $\chi_{i,t} = \lambda_i f_t$. Once each disaggregate index has been decomposed, the common component is obtained by aggregating $\chi_{i,t}$ using the PCE weights.

First, persistent negative inflation surprises could signal that the natural rate is lower than the staff's assumed value of 4.9 percent. Given how flat we think the Phillips curve is at present, a relatively large change in the natural rate would be needed in order to explain a persistent deviation of actual inflation from its predicted value. For example, in our empirical models that condition on survey expectations of longer-term inflation, explaining a persistent ¼ percentage point downward surprise to inflation would require the natural rate to be 1¾ percentage points to 2¼ percentage points lower than our current assumption.[10]

Alternatively, the level of underlying inflation could be lower than our assumption of 1.8 percent (in the staff's framework, changes to this assumption would eventually feed one-for-one into currently predicted inflation). The staff's underlying inflation assumption is informed by considering the long-term trend rate of inflation that is implied by a range of univariate and multivariate time-series models, together with the long-run level of inflation implied by Phillips curve models that condition on measures of expected inflation from surveys or financial markets (see Table 1 for a representative set of estimates). As these estimates indicate, our models imply a wide range of trend inflation values; almost all are lower than the FOMC's stated 2 percent objective and five out of eight are lower than the staff's current assumption of a 1.8 percent underlying inflation rate.

Although the time-series models do not provide a structural characterization of trend inflation, the fact that both survey measures of longer-term expected inflation and the trend estimates from several time-series models have been relatively stable since the late 1990s provides some (admittedly circumstantial) evidence that the two phenomena are related, with inflation's long-term trend ultimately determined by longer-term expectations. Over the past couple of years, longer-term expected inflation from the Michigan survey and from TIPS- and swaps-based estimates have drifted lower on net; while we do not really know whether any of these developments are relevant for wage- and price-setting behavior, they could be an indication that inflation's long-term trend is currently lower than what we have assumed in the staff baseline.[11]

[10] By itself, assuming an even flatter Phillips curve would not really help us explain recent inflation errors given how close we think we are to full employment: For example, with a 2017:Q2 unemployment gap of ½ percentage point, these same Phillips curve models imply that slack is directly contributing 5 basis points or less to core inflation at present.

Of course, it is also possible that—again, contrary to the staff's current judgment—other, unmeasured margins of labor- or product-market slack beyond those captured by the unemployment gap could be affecting inflation. Such influences would likely need to work either by reducing firms' costs (labor compensation or materials prices) or by influencing demand conditions; regarding the former channel, therefore, it is noteworthy that we have not been surprised by the behavior of compensation once we take into account the weak productivity performance of recent years. (Below, we consider the broader questions of whether demand conditions or materials costs could currently be weighing on inflation to a greater degree than the staff's interpretation implies.)

[11] More benign interpretations are also possible; for example, the reduction in the Michigan survey's measure could instead reflect households' becoming better aware of the FOMC's stated inflation target and thus reporting something closer to that value in their responses to the survey.

Table 1. Estimates of the Underlying Rate of Core PCE Inflation
(Percent; 70 percent confidence interval/credible set in parentheses)

Empirical model	Estimated trend in 2007:Q4	Estimated trend in 2017:Q1
Multivariate:		
Phillips curve with Michigan expectations*	2.0	1.5
	(1.8 to 2.1)	(1.4 to 1.6)
Phillips curve with SPF expectations*	1.9	1.9
	(1.8 to 2.1)	(1.8 to 2.1)
Phillips curve with TIPS compensation*	2.3	1.5
	(2.0 to 2.6)	(1.2 to 1.8)
Time-varying parameter VAR	1.9	2.0
	(1.5 to 2.4)	(1.4 to 2.6)
Common trend with stochastic volatility	2.1	1.7
	(2.0 to 2.3)	(1.6 to 1.9)
Univariate:		
Stock–Watson UCSV	1.9	1.7
	(1.7 to 2.2)	(1.5 to 1.8)
Cogley–Sargent	1.8	1.6
	(1.5 to 2.1)	(1.4 to 1.9)
Markov switching (mean, stationary state)**	1.9	1.8
	(1.8 to 2.1)	(1.7 to 1.9)

Notes: * Evaluated at that quarter's average expectations or TIPS compensation value.
** Uses total PCE price inflation.

We note that estimates of the natural rate and the underlying inflation trend are interdependent: Distinct from whether we might wish to adjust one of these estimates down to better explain negative inflation surprises, we could adjust both estimates, in opposite directions, in such a way as to leave the overall contribution of these fundamentals to inflation unchanged. We illustrate this point by showing how estimates of the natural rate vary when different values of trend inflation are assumed in a particular empirical framework that tries to jointly describe the dynamics of unemployment and inflation. Specifically, using one of the state-space models maintained by the Board's staff, we show how the model's natural rate estimates vary when we level-adjust the model's assumed inflation trend by various increments starting in 2012.[12] The results from this exercise are shown in Table 2; as it happens, changes in the inflation trend in this model turn out to feed through one-for-one into the model's

[12] The model generates time-varying estimates of the natural rate using a Phillips curve equation together with an Okun's Law relation and a set of growth accounting relations. The model's Phillips curve conditions on a measure of trend inflation that, in recent years, is given by the median longer-term PCE price inflation projection from the SPF.

natural rate estimates. (This degree of pass-through is not imposed on the model.) We emphasize, though, that these quantitative results are model specific.[13]

Table 2. Natural Rate Estimates from State-Space Model under Alternative Trend Inflation Assumptions

	Assumed trend inflation (Percent; average level from 2012:Q1 to 2017:Q2)						
	1.5	1.8	1.9	2.0	2.1	2.2	2.5
Estimated natural rate in 2017:Q2 (percent)	5.4	5.1	5.0	4.9	4.8	4.7	4.4

Note: Alternative trend assumptions start in 2012:Q1.

2. Import prices

Another potential source of errors in the staff forecast for core PCE price inflation could involve errors in our projection of core import prices, as well as incorrect assumptions regarding the timing and the magnitude of the pass-through of these movements to core PCE prices.

As noted above, import prices have been a source of restraint on U.S. inflation in recent years. Following the substantial appreciation of the dollar and the plunge in non-energy commodity prices since mid-2014, core import prices declined noticeably, putting downward pressure on domestic core consumer prices. Moreover, because the changes in the dollar turned out to be larger and more persistent than anticipated by the staff, these import price movements led to downward surprises in the staff's projections for core PCE price inflation over this period.

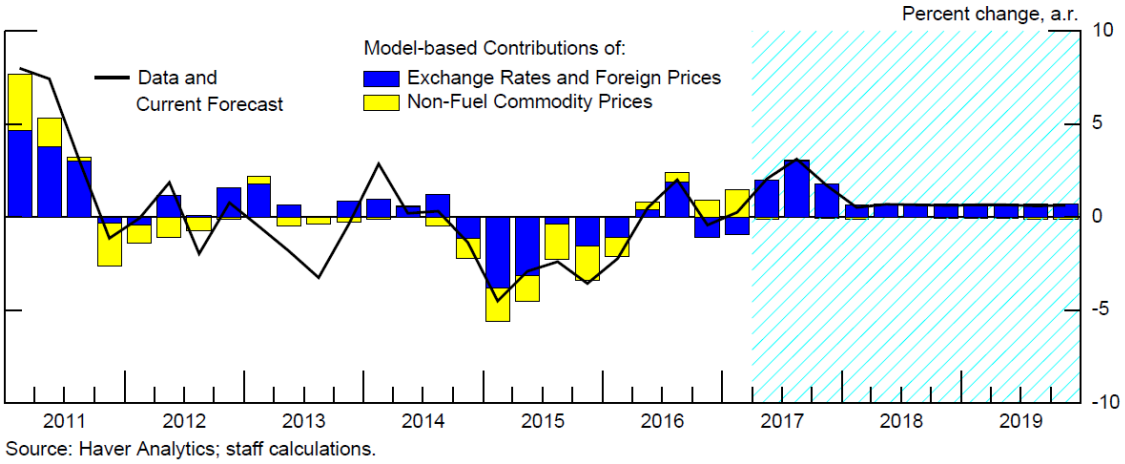
That said, with the benefit of hindsight, the staff models appear to explain well the *ex-post* evolution of core import prices and their pass-through to core PCE prices. Chart 7 illustrates that, once the path of the dollar and non-energy commodity prices is known, the staff benchmark model for core import prices does a good job tracking their recent behavior. Our models also suggest that the pass-through from actual core import prices to core PCE price inflation has been stable over time.[14] Accordingly, we estimate that the pass-through of the 2014 dollar and commodity price shocks to core import prices as well as core PCE prices should by now be largely completed. However, we cannot rule out that these shocks may still be exerting downward pressure on consumer

[13] In particular, the pass-through in the state-space model is noticeably smaller than what would be implied by simply inverting the empirical Phillips curves used to inform the judgmental projection: In addition to having a steeper Phillips curve (which in turn reflects the state-space model's use of a longer estimation period), the state-space model takes into account the extent to which its ability to explain other variables besides inflation (such as the unemployment rate, output, or labor force participation) is affected by revisions to the natural rate.

[14] The staff forecast continues to assume that a 1 percent increase in core import prices for the year translates into an increase in core PCE price inflation of around 8 basis points within a year.

prices, if the staff is wrong about the exact magnitude and/or timing of the pass-through. Indeed, ECB President Draghi (2017) in a recent speech argued that past declines in euro-area import prices, through their lasting impact on global producer price inflation, were still holding back euro-area core inflation. A similar dynamic could be at play in the United States.

Chart 7: Core Import Price Deflator



Source: Haver Analytics; staff calculations.

3. Oil prices

Similar considerations to those made in regard to import prices apply also to oil prices. Oil prices unexpectedly plunged in 2014, and since then have recovered only partially. These movements have importantly held down headline inflation, though our estimate of their effect on core inflation is small. The staff currently estimates that energy prices held down core PCE inflation 15 basis points in 2016 and will hold it down 10 basis points this year. Even so, our estimates are imprecise and could be understating the true pass-through to core inflation. Moreover, it is certainly possible that oil prices may surprise us again on the downside, exerting further downward pressure on consumer prices.

IV. Structural explanations for low inflation (2): Factors outside of the baseline staff framework

1. Greater competition

One hypothesis is that recent softness in inflation reflects an increasing degree of market competition, especially in the retail sector of the economy—either reflecting greater competition among traditional sellers or via higher competition between online

commerce and physical stores.[15] While increased competition implies a lower *level* of price markups over costs, such influences could affect inflation over a number of years as these lower markups gradually take hold.[16]

Although the staff acknowledges the possibility of this hypothesis, a number of factors lead us to doubt its importance. Maybe most important, the hypothesis seems to be at odds with evidence that the economy overall has become more concentrated in recent years. (Note that prices ought to reflect the degree of competition at all stages of production, not only in the retail sector.) The net decline in the labor share of income over the past decade is frequently attributed to increased market power; and the recent evidence for a decline of U.S. business dynamism also suggests less competition from new entrants.[17] And within the retail sector (including non-store retailers as well as traditional retailers), the data point to solid profit margins.[18] Other developments within the retail sector also seem unfriendly to this hypothesis. The share of online sales in total retail sales has gradually risen over time, but with no visible structural breaks, and it remains less than 10 percent of the total. And data from the Billion Prices Project suggest that the online-offline price gaps are small for the United States (and smaller than in other advanced economies). Finally, online sellers may have the ability to price discriminate by targeting advertisements to certain consumers, in effect boosting their market power.[19] For all these reasons, the staff has not importantly modified the inflation forecast based on this hypothesis.[20]

2. Foreign slack and other global factors

As noted in section I, the staff framework for forecasting inflation takes into account import prices, which reflect the influence of commodity prices as well as dollar fluctuations (which, in turn, are affected by foreign inflation and economic growth). But other global factors may still play a significant role in shaping domestic inflation dynamics.

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[15] See Curran and Jamrisko (2017) and Trainer (2016). Also see Duca and VanHoose (2000).
[16] One measurement issue is of particular note here. If internet sellers enter the market and charge lower prices than traditional retailers do, those lower online prices will not be registered as a price decline in the CPI. Implicitly, the BLS assumes that the lower price at one seller versus another reflects differences in quality between the sellers. However, in this example, if the traditional retailer lowers prices in response to the online competition, the BLS would pick that up as a price decline.
[17] On market concentration, see Council of Economic Advisers (2016). On the relationship with the labor share, see Autor, *et al.* (2017). On declining business dynamism, see Hathaway and Litan (2014) and Decker, *et al.* (2016).
[18] This statement is based on data on gross retail trade margins as a percentage of sales, from the Census Bureau (available here: http://www2.census.gov/retail/releases/current/arts/gmper.xls). A Goldman Sachs report (2017d, page 12) comes to the same conclusion.
[19] That said, Cavallo (2017) argues that when a firm goes online it tends to *lose* (not increase) its ability to price discriminate because it is easier for consumers to compare prices.
[20] The only exception involves food prices, following Amazon's recent purchase of Whole Foods and Aldi's (German grocer) planned expansion into the U.S. market. Although margins are already quite low in the grocery sector, the staff has assumed a small effect going forward and edged down the PCE food and beverages forecast over the course of the next two years.

A prominent view—typically associated with the BIS—is that globalization has increased the supply of labor and other inputs to production, and thus domestic inflation has become increasingly sensitive to foreign resource utilization. Borio and Filardo (2007) argued that global economic slack adds considerable explanatory power to reduced-form Phillips curve inflation equations and that its role has been growing over time. However, subsequent studies challenged those findings, showing that the original analysis was statistically flawed and that the results were not robust to plausible alternative measures of global slack.[21] Updated analyses with data after the global financial crisis have confirmed these criticisms.[22] Accordingly, we continue to find little reason to include measures of global slack into our benchmark inflation equations. In any case, foreign slack has diminished over the past several quarters, so whatever role it may have played earlier, it seems an unlikely candidate for explaining the recent weakness in U.S. inflation or to be very important in the period ahead.[23]

Nevertheless, other global factors possibly have become important drivers of U.S. inflation, though they may be difficult to identify econometrically. A prominent argument is that the integration of China and other emerging market economies into the world economy has led to increased competition from abroad, constraining wage and price increases in industries of advanced economies that are open to foreign competition. In other words, that integration could have resulted in lower costs or smaller margins.[24]

Moreover, some empirical evidence shows that inflation rates across many advanced economies have been converging, suggesting that global factors may be exerting increasing influence on domestic inflation. A principal component analysis of inflation in 22 OECD countries identifies a common factor that can account for a significant variation in inflation in those countries.[25] This finding suggests that this common factor, which is referred to in the academic literature as "global inflation," should be added to forecasting models of domestic inflation. However, a recent analysis by Goldman Sachs (2017a) found that a similar measure of global inflation is an important driver of domestic inflation in open and commodity-exporting countries, such as Canada, whereas it exerts negligible effects in the United States and other large more-closed economies. In any case, an important caveat to the importance of global inflation is that this convergence of national inflation rates may be the result of the adoption of similar monetary policies amid synchronized business cycles. Since the mid-1980s,

[21] For instance, see Ihrig, Kamin, Lindner, and Marquez (2010).
[22] Both a recent ECB Economic Bulletin article (ECB, 2017) as well as preliminary analysis by IF staff using data through early 2017 concluded that global slack does not appear to exert an appreciable direct effect on domestic inflation in the United States and most other advanced economies.
[23] More recently, Auer, Borio, and Filardo (2017) argued that the expansion of global value chains (GVCs)—that is, cross border trade in intermediate goods and services—is an important channel through which global slack influences domestic inflation. However, the Auer et al. results are also controversial, as other economists found only mixed support for augmenting traditional Phillips curves with GVC integration (ECB, 2017). Moreover, GVCs have plateaued in recent years and thus, given the already mentioned diminishing foreign slack, they do not appear to be a plausible explanation for the tepid recent inflation readings.
[24] For instance, a recent BNP Paribas article argued that the recent weakness in apparel CPI inflation reflects soft import prices from China (BNP, 2017).
[25] See Ciccarelli and Mojon (2007).

advanced economies' central banks have been focused on delivering price stability. National inflation rates have trended down in all advanced economies, and the resulting lower level and volatility of inflation also meant that more of the variation in national inflation rates is due to global price shocks, such as oil price changes. In addition, the synchronization of business cycles across advanced economies resulted in common movements of domestic measures of resource slack.

3. Demographics

The ongoing demographic transition could also be exerting downward pressure on trend inflation. The staff framework already incorporates a dampening effect of population aging on the natural rate of unemployment, and thus indirectly on inflation, over the past decade. But there may be other transmission channels, which, at least theoretically, may push inflation either up or down. For instance, retirees are sometimes considered more price conscious and so contribute to less seller power and lower markups, exerting similar forces to those discussed in the section on "greater competition" above. [26] Recent studies by the IMF and the BIS examined the empirical evidence across the advanced economies (including the United States) and concluded that the ongoing demographic transition has been a drag on inflation in these economies.[27] Other studies argued that the behavior of Japanese inflation has been influenced by demographic factors.[28]

That said, this literature is still in its infancy, and so its findings should be taken with caution. Moreover, the aging of the U.S. population is still in its early stages and much less pronounced than in other advanced economies, such as Japan. Accordingly, we maintain our view that the ongoing demographic transition has not exerted a meaningful low-frequency drag on consumer prices, and certainly cannot help explain the surprising weakness of the past few months. Even so, the demographic channel may turn out to be an important influence on inflation in the future, especially once the size and composition of the U.S. population change more noticeably.

4. Medical prices

Some of the weakness in core inflation has been concentrated in particular expenditure categories, leading some to consider whether sector-specific issues might be affecting

[26] Bullard, Garriga, and Waller (2012) proposed an additional explanation for how demographic factors may affect inflation. They developed a political economy model which emphasizes the interaction among different age cohorts and the desire for intergenerational redistribution of resources in the economy. In their model economy, changes in the population structure are interpreted as the ability of a particular cohort to influence the redistributive policy. When older cohorts have more influence on the redistributive policy, the economy has a relatively low steady-state level of capital and a relatively low steady-state rate of inflation. The opposite happens when young cohorts have more control of policy. Of course, this channel would affect U.S. inflation only if it actually influenced Federal Reserve policy.

[27] See Yoon, Kim, and Lee (2014) and Juselius and Takats (2015).

[28] For instance, Katagiri (2012) investigated the effects of changes in demand structure caused by population aging in Japan using a multi-sector new-Keynesian model and found that population aging—modeled as unexpected shocks to its demand structure—subtracted 0.3 percentage point from Japanese inflation, on average, since the early 1990s.

overall inflation. Probably the most important is medical expenditures, given their very large weight in PCE. Price increases for medical services have been subdued in recent years, and pharmaceutical prices declined this spring. These developments have had a notable influence on total and core PCE inflation.[29]

PCE includes all medical services, including those paid by Medicare and Medicaid, and those prices are in many cases essentially set by the government ("administered" prices). The formulas used to set Medicare prices were adjusted by the 2010 Affordable Care Act and the so-called Doc-Fix bill passed in 2015, and they automatically result in smaller increases in prices for the same increase in costs than would have been the case in the prior decade. Medicaid prices have probably been restrained somewhat by the budget pressures on state governments. In addition, research suggests that lower Medicare prices tend to lead to lower negotiated prices by private insurers as well (see Clemens, Gottlieb and Shapiro, 2016). The staff projection implicitly assumes that these factors are already built into our underlying inflation trend and we have not assumed that medical services will be an extra downward influence on inflation. Of course, there is a great deal of uncertainty about the path of future legislation in these areas, and this could be a source of downside risk to the staff projection.[30]

The decline in pharmaceutical prices this spring (which followed relatively large increases last year) appears related to an unusual degree of competition from generic drugs, as a number of drugs have gone off patent over the past year. We view these declines as unlikely to continue; analysis from Goldman Sachs (2017b) comes to a similar assessment.

5. Housing services

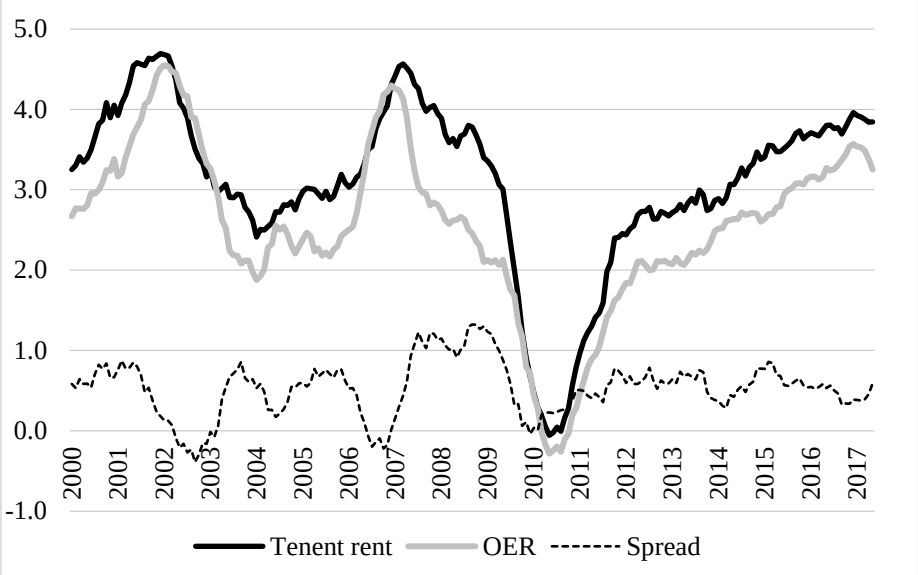
Sector-specific issues have also been hypothesized for housing prices, which have softened in the past few months. Because housing is one of the most persistent price categories, some have argued that the recent softness might continue to put downward pressure on inflation going forward (for example, see Deutsche Bank, 2017b). However, we see the recent pattern as potentially reflecting a BLS adjustment for utilities costs and do not see a persistent deceleration in the housing indexes.[31]

Chart 8 plots the 12-month changes in both tenants rents and owners' equivalent rents (OER), together with the spread between the two series. As can be seen, most of

[29] Deutsche Bank (2017a) and Goldman Sachs (2017b) provide assessments of the prospects for health care inflation.
[30] The current health care legislation before Congress does not include any changes to Medicare payments, but does includes substantial reductions in federal payments to state governments for Medicaid, which would probably put some downward pressure on reimbursement rates negotiated by states with providers.
[31] In addition to the treatment of utilities, the tenants' rent and OER measures may differ because sampled housing units get different weights in the two indexes. Most especially, rent-controlled housing units are not part of the OER index; this factor can have a large influence in areas such as New York, San Francisco, and Los Angeles. See BLS (2009).

the recent slowdown is attributable to OER (which has a larger weight than actual rents); tenants rent has marginally decelerated but appears to remain on its post-recession trend.[32] Consequently, the spread between tenants rents and OER has widened in recent months, even if not to levels that are particularly unusual. That spread often reflects utilities costs. For some rental units, utilities are included along with rent, and by construction, rent of primary residence *includes* utilities in those cases; by contrast, OER is adjusted to *exclude* all utilities. So this adjustment will hold down OER relative to tenant's rent at times when utilities costs are rising relatively rapidly.[33]

Chart 8: 12-month change in tenant rents and Owners' Equivalent Rent (OER)



While the staff has lowered the price forecast for housing in the near-term to build in a bit of persistence of the recent weakness, we see the recent deceleration in OER as fundamentally transitory. Under the assumption that the current spread reflects differences in the utility costs and given the path of expected energy prices, we anticipate that OER will start to rise faster once the pass-through of lower utilities costs is completed. This projection also is supported by the fact that vacancy rates, a useful indicator of rent pressures, remain at low levels.

4. "Disinflationary bias" and trend inflation

Theoretical work suggests a reason why inflation might fail to return to the FOMC's inflation target even after the economy has returned to its steady state. In new-Keynesian models, the possibility that the effective lower bound (ELB) on the Fed's policy rate

[32] Housing has a larger weight in the CPI (34 percent) than in PCE (16) percent. In both indexes, OER has a weight around three times higher than tenants rent.

[33] Depending on how rents themselves are adjusted with changing utility costs, one might expect higher utility costs to show up positively in rent of primary residence (if rents fully adjust) or *negatively* in OER (if rents do not adjust). The staff thinks that the latter case is more typical.

could bind in future implies that the distribution of future economic outcomes is skewed to the downside; if price setters are forward looking, the presence of this tail risk imparts a "deflationary bias" to their decisions and yields a rate of aggregate *current* inflation that will lie below the central bank's inflation target even when the effects of any previous shocks to the economy have fully played out.[34]

A lower natural rate of interest (R-star) could exacerbate this ELB issue. With a lower R-star, the ELB will bind more frequently, weighing on the ability of monetary policy to effectively respond to negative shocks and so augmenting this effect on expected inflation. This consideration could be relevant at present: A recent literature suggests that an aging population, slowing population growth, or both could considerably reduce the level of R-star.[35]

In the context of the staff's framework, such considerations would imply an underlying inflation trend that is lower than the FOMC's 2 percent objective—though whether it would also be lower than the staff's current assumption of 1.8 percent is unclear—and would further suggest that the trend will not increase to 2 percent in the future absent a significant change to how monetary policy is conducted.[36] Of course, the practical relevance of these theoretical arguments is difficult to gauge—a key assumption that is required to obtain the disinflationary bias result is that price setting is governed by a high degree of forward-looking behavior, something that is virtually impossible to assess empirically.[37]

5. Neo-Fisherian inflation dynamics

According to the so-called "neo-Fisherian" theory, the long period of near-zero interest rates, rather than being a source of stimulus as in conventional analyses, has acted to hold down inflation.[38] Extensions to this theory further suggest that inflation could initially

[34] See Hills, Nakata, and Schmidt (2016a, 2016b).
[35] For Japan, Fujita and Fujiwara (2016) developed a new-Keynesian search/matching model to study the macroeconomic implications of demographic changes. Calibrating the model using Japanese data since 1980, the paper finds that a drop in labor force entry can significantly lower per-capita consumption growth and the real interest rate, and also weigh on inflation when the monetary policy follows the standard Taylor rule, failing to recognize the time-varying nature of the natural rate of interest. Similarly, for the United States, Gagnon, Johannsen, and López-Salido (2016) calibrated an overlapping-generation model with a rich demographic structure to observed and projected changes in U.S. population, family composition, life expectancy, and labor market activity. In their model, these demographic changes account for essentially all the observed decline in the real interest rate.
[36] In the models considered by Hills, *et al.*, changing how monetary policy is conducted (for example, moving to a price-level target or using a higher inflation target in a Taylor rule) can reduce deflationary bias by lowering the likelihood and likely duration of a return to the ELB.
[37] See Mavroeidis, Plagborg-Møller, and Stock (2014).
[38] The standard Fisher relation holds that nominal interest rates equal real interest rates plus expected inflation. With real interest rates assumed to be independent of monetary policy in the long run, changes in nominal rates require a corresponding change in expected inflation in order to be consistent with the Fisher relation. Under strong rational expectations and forward-looking price setting behavior, the model therefore predicts that higher nominal interest rates (eventually) result in higher inflation, and vice-versa.

decline as the central bank starts lifting its policy rate above the ELB.[39] We view the results of this literature largely as theoretical curiosities; for example, the predictions of these models appear to be highly sensitive to assumptions about expectations formation (for example, whether some sort of adaptive learning is present). Accordingly, we do not put much weight on this explanation for low inflation.

6. Measurement issues

A final reason why measured inflation might be lower than anticipated relates to possible changes in the amount of measurement error that is present in published price indexes. Measures of consumer price inflation are widely believed to overstate true changes in the cost of living, in part because of difficulties associated with adjusting price indexes to reflect the introduction of new, higher quality goods and services.[40] However, to explain the low inflation seen in recent years (or the surprises seen this spring) it would need to be the case that whatever upward biases are present in the published price indexes had diminished over time, perhaps because of methodological improvements to the indexes. While the BLS periodically revises its quality adjustment procedures, we have no good reason to think that changes in measurement can explain the low inflation we have seen in recent years.[41]

One exception is the introduction of hedonic quality adjustment procedures for wireless telecom services implemented by the BLS in January. Informal talks with the BLS have confirmed that the new procedures likely contributed to the exceptionally low reading in March, when several carriers introduced unlimited data plans. Even so, we are treating this price decline as a one-time event, and we do not see this change in BLS procedures as measurably holding down inflation on an ongoing basis.[42]

[39] Specifically, combining the neo-Fisherian framework with the fiscal theory of the price level—an extension that proponents claim is required to explain why inflation has been stable and determinate while the economy has been at the ELB—implies that an increase in short-term interest rates will result in a one-time downward adjustment of the price level. In the presence of nominal rigidities, this price-level adjustment results in a temporary decline in inflation. See Sims (2011) and Cochrane (2017).

[40] Indeed, this likely overstatement is one reason that central banks have chosen their inflation objectives to be above zero. For recent discussions of measurement error in U.S. price statistics see Feldstein (2017) and Moulton (2017); see also Lebow and Rudd (2003) for an earlier comprehensive analysis of measurement error in the CPI.

[41] A recent Goldman Sachs report (2017c) comes to the same conclusion. The Goldman Sachs report argues that "…with the exception of healthcare and internet, for the majority of inflation categories, quality/new products adjustment are either already implemented or are unlikely to be implemented any time soon."

[42] Under BLS procedures, the decline in wireless telephone prices in the CPI was concentrated in March even though relatively few consumers switched their service plans that month and actually experienced a price change. Under an alternative "user cost" approach, the price decline would have been spread over time as people gradually switch their service plans.

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