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The Historical and Recent Behavior of Goods and Services Inflation

- Since the late 1990s, the gap between the inflation rates of services and goods has expanded to a record level as services inflation has remained relatively high while goods prices have actually been falling.
- The widening gap has led some observers to conclude that continued rapid increases in services prices will spell faster overall inflation, while others argue that the progressively steeper decline of goods prices will result in deflation.
- A study of the 1967-2002 period finds that the gap between inflation rates has a strong tendency to return to a "constant equilibrium value" in the long run.
- When the gap is above its long-run value, as it currently is, a rise in goods inflation and a decrease in services inflation should combine to restore equilibrium.

1. Introduction

An interesting and often noted feature of the current inflation experience has been the growing divergence between the rate of increase of services prices and that of goods prices. For decades, prices of services have tended to increase faster than prices of goods. But since the late 1990s, the "gap" between these two inflation rates has widened to a record level and become quite persistent as services inflation has remained relatively high while goods prices have actually been declining.

The expanding gap between goods and services inflation has led to differing opinions—many of them pessimistic—about the near-term outlook for overall inflation in the United States. Some commentators, for example, argue that the continued rapid increases in services prices will bring about faster overall inflation. Others are convinced that the progressively steeper decline of goods prices will lead to a falling overall price level, or deflation.

In this article, we model the relationship between goods inflation and services inflation from 1967:2 to 2002:4. To help inform the inflation debate, we then use our results to forecast inflation for 2003. The specific inflation series that we model is the quarterly change (at an annual rate) of the core personal consumption expenditures (PCE) deflator, or the PCE deflator excluding its food and energy components.[1]

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We find that over the past thirty-five years, core PCE goods inflation and core PCE services inflation have experienced permanent increases and reductions, but these shifts have moved roughly in tandem.[2] That is, the difference, or "gap," between the two inflation rates exhibits a strong tendency to revert back to a constant equilibrium value in the long run, a process known as mean reversion. In the short run, however, the gap displays cyclical fluctuations, tending to widen around business cycle peaks and narrow during recessions and the early stages of recovery. When the gap is above its long-run value, as it currently is, equilibrium is restored through an increase in core goods inflation and a decline in core services inflation.

These findings provide the basis for our estimation of a vector error-correction model (VECM) to forecast overall core PCE deflator inflation for 2003. The VECM is a particularly attractive model because it admits an explicit role for the gap and thereby offers a convenient framework to analyze the gap's behavior over time. This model, which assumes that the gap will revert to its long-run value in the same manner it has in the past, points to a fairly stable level of core PCE deflator inflation. Thus, we conclude that the pessimistic outcomes suggested by the current inflation debate are not likely to occur in the near future. In another result, we find that the VECM approach to forecasting core PCE deflator inflation over a one-year horizon is somewhat more accurate than a popular alternative, the random-walk model.

Our analysis proceeds as follows. We begin by providing some background on the core goods and core services price indexes used in this study and investigate their time-series properties. Next, we explore the long-run and recent behavior of the gap between core services and core goods inflation as well as discuss our VECM estimation results. The forecasting performance of the VECM is then compared with that of a random-walk model. We conclude by presenting our VECM forecast of the core PCE deflator for 2003.

2. The Behavior of Goods and Services Inflation

2.1 Background and Cyclicality

The PCE deflator, the basis for our analysis, is a chain-weight price index published monthly by the U.S. Department of Commerce's Bureau of Economic Analysis. The index is intended to measure the change in price of all the goods and services consumed by households. Accordingly, it includes items such as imputed financial services not explicitly paid for by the consumer and health care goods and services paid by third parties. Table 1 presents the 2002:4 weights for the core PCE deflator and some of its major components. Note that nonfood, nonenergy goods account for about 30 percent of the core PCE deflator, while nonenergy services account for about 70 percent.

The top panel of Chart 1 presents core goods inflation and core services inflation for the period 1968:1-2002:4, with the inflation rates measured as year-over-year changes in the underlying indexes. The bottom panel presents the measured gap in these inflation rates.[3] It shows that the rate of increase of services prices has generally been higher than that of goods prices, with an average difference of 2.6 percentage points over the period.

There are several possible reasons why the average value of the measured gap is positive: the income elasticity of demand for services is higher than it is for goods, productivity growth has been higher in goods production than in services production, and goods are more susceptible to import substitution than are services. It is important to note, however, that while neither inflation series has shown a tendency to revert back to a particular value over the sample period, the

Table 1

Major Components of the Core Goods and Core Services Indexes of the Personal Consumption Expenditures Deflator

2002:4

	Weight (Percent)	
Component	All Items	Core
All items	100.00	—
All items excluding food and energy	81.35	100.00
Nonfood, nonenergy goods	24.18	29.72
Durable goods	11.77	14.47
Motor vehicles and parts	5.06	6.22
Apparel	4.40	5.41
Other nondurable goods	8.01	9.85
Drug preparations and sundries	2.74	3.37
Nonenergy services	57.17	70.28
Housing services	14.68	18.05
Medical care services	15.85	19.48
Household operation services excluding energy	3.47	4.27
Transportation services	3.75	4.61
Recreation	3.93	4.83
Other services	15.49	19.04

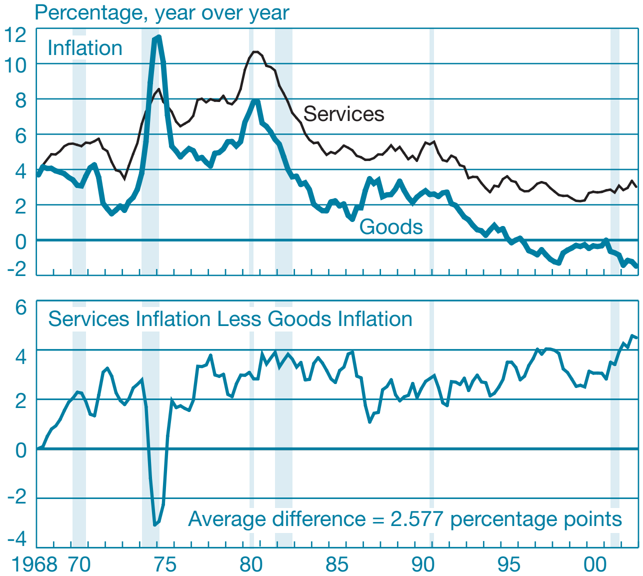
Sources: U.S. Department of Commerce, Bureau of Economic Analysis; authors' calculations.

inflation rates have typically moved in tandem. In particular, the parallel rise of the two series during the 1970s and their parallel decline through the 1980s and 1990s have translated into a measured gap that has behaved in a fairly steady manner.[4]

As shown in the bottom panel of Chart 1, the difference between the core services and core goods inflation rates from 1968 through the early 1990s tended to widen near cyclical peaks, as core services inflation accelerated more than core goods inflation. The difference then narrowed during recessions and the early stages of recovery, as the rate of increase of core services prices slowed somewhat more than the rate of increase of core goods prices. A notable exception to this general pattern was the period from 1974 to 1976, when core goods inflation first accelerated more and then decelerated more than core services inflation. This episode likely reflects the combination of two developments: the near quadrupling of oil prices from the middle of 1973 to the middle of 1974 and the April 1974 relaxation of wage and price controls enacted in August 1971. Another interesting point is that the cyclical acceleration and deceleration of core services inflation and core goods inflation appear to have become more muted over time.

Chart 1

Core PCE Goods and Core PCE Services Inflation
1968:1-2002:4



Sources: U.S. Department of Commerce, Bureau of Economic Analysis; Board of Governors of the Federal Reserve System; authors' calculations.

Notes: Core PCE is the core personal consumption expenditures deflator, or the PCE deflator excluding the food and energy components. Shaded areas indicate periods designated national recessions by the National Bureau of Economic Research.

Although the more recent behavior of core services and core goods inflation has to some extent followed the typical cyclical pattern, there have been some significant differences. Core services inflation accelerated somewhat more than core goods inflation in the later stage of the last expansion. However, the

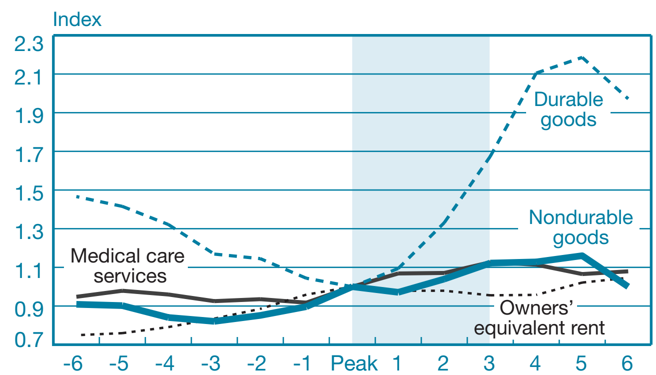
The rate of increase of services prices has generally been higher than that of goods prices, with an average difference of 2.6 percentage points over the [1968:1-2002:4] period.

gap between core services and core goods inflation continued to widen during the recession and recovery as core services inflation stabilized while core goods inflation slowed dramatically. The difference between the two inflation rates approached five percentage points in 2002:4—the largest difference over our sample period.

Chart 2 provides additional insight into the cyclical behavior of core goods and core services inflation. It presents the average inflation rates around the six recessions that occurred in the 1967-2002 period for the two major subcomponents of core goods (durable goods and non-food, nonenergy nondurable goods) and the two major subcomponents of core services (owners' equivalent rent and

Chart 2

Components of Core PCE Goods and Core PCE Services Inflation



Sources: U.S. Department of Commerce, Bureau of Economic Analysis; authors' calculations.

Notes: Core PCE is the core personal consumption expenditures deflator, or the PCE deflator excluding the food and energy components. Shading indicates length of average recession.

medical care services)—all indexed to the business cycle peak. The chart shows that durable goods price inflation tends to slow in the quarters leading up to the peak while owners' equivalent rent inflation tends to increase. Then, from the peak forward, durable goods price inflation tends to increase while owners' equivalent rent inflation tends to stabilize or even decline slightly.

The PCE or the CPI?

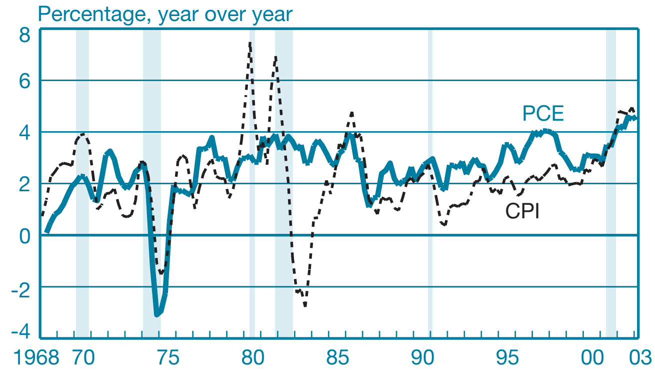
One could also analyze the behavior of core goods and core services inflation for the consumer price index (CPI). While we did in fact obtain results using the CPI, there are several reasons why we elected not to report them in favor of the PCE deflator results.[5]

For one, although the CPI is probably the price index most widely followed by the public, the PCE deflator is currently the most-watched price index from the standpoint of monetary policy. The PCE deflator also covers the entire market basket of goods and services consumed by households; by comparison, the CPI covers only the goods and services that households pay for through out-of-pocket expenditures.[6] In addition, the PCE deflator is a chain-weight index that captures the response of consumers to changes in relative prices, whereas the CPI is a fixed-weight index that fails to account for this response. Furthermore, for our purposes, the PCE deflator provides a long, methodologically consistent time series of price indexes for nonfood, nonenergy (core) goods and nonenergy (core) services. Conversely, there have been significant changes in methodology in the construction of the CPI core goods and core services indexes that limit the sample and raise concerns about the consistency of the results.

To gauge the potential relevance of these considerations, we plot in Chart 3 the measured gaps between the core services and core goods inflation series for the PCE deflator and CPI. As the chart shows, the behavior of the measured gaps is qualitatively similar: the average gap measured on a year-over-year basis is 2.59 percent for the PCE deflator and 2.16 percent for the CPI. In addition, both gaps have shown a marked increase since the late 1990s. There is, however, one notable difference: the measured CPI gap displays a more pronounced cyclical pattern, especially around the 1980 and 1981-82 recessions. This pattern likely reflects the absence of a methodologically consistent treatment of owners' equivalent rent in the CPI.[7]

Chart 3

Measured Gap between the CPI and the Core PCE



Sources: U.S. Department of Commerce, Bureau of Economic Analysis; U.S. Department of Labor, Bureau of Labor Statistics; Board of Governors of the Federal Reserve System; authors' calculations.

Notes: The CPI is the consumer price index; the core PCE is the core personal consumption expenditures deflator, or the PCE deflator excluding the food and energy components. Shaded areas indicate periods designated national recessions by the National Bureau of Economic Research.

2.2 Stationarity and Cointegration Tests

The approach adopted in our study is similar in spirit to the Freeman (1998) analysis of measures of trend inflation. Specifically, we investigate the stationarity properties of core goods and core services inflation that relate to the persistence in their movements.[8] We also consider the possibility that the series share a common stochastic trend and display a long-run equilibrium relationship. Accordingly, our empirical framework is consistent with the idea that goods inflation and services inflation are linked through the effects of monetary policy. That is, although goods inflation and services inflation may experience permanent increases (decreases) due to episodes of expansionary (contractionary) monetary policy, the changes are of the same magnitude.

Although we are ultimately concerned with characterizing the relationship between core goods inflation and core services inflation, we initially focus on the behavior of the individual series and whether they are subject to permanent changes in their level. This issue is known as the unit-root hypothesis, and it has important implications for the choice of model specification as well as for making valid inferences from our estimation and testing procedures. Drawing upon the results from a large number of studies, we proceed under the assumption that each price index is subject to permanent shifts in its level and therefore contains a unit root.[9] Consequently, the key issue for us centers on the stationarity of each inflation series. That is, does (the log of) each price index contain two unit roots so that each index needs to be differenced a second time to achieve stationarity?

To address this issue, we apply augmented Dickey-Fuller (1979) unit-root tests to the individual inflation series. The testing procedure is based on the following regression:

$$(1) \qquad \pi_t = \alpha + \rho\pi_{t-1} + \sum_i \delta_i \Delta\pi_{t-i} + \eta_t ,$$

where $\{\eta_t\}$ are mean-zero, serially uncorrelated innovations. The inflation rate π_t is assumed to contain a unit root under the null hypothesis that $\rho = 1$. The lagged first differences of the inflation rate ($\Delta\pi_{t-i} = \pi_{t-i} - \pi_{t-i-1}$) are included to control for serial correlation of the regression residuals.

Table 2 presents the results of the augmented Dickey-Fuller tests for the presence of a unit root in core PCE goods inflation and core PCE services inflation, where the inflation rates are now measured as 100 multiplied by the quarterly change in the log of the price index. The number of lagged first differences of the inflation rate was selected using the Akaike information criterion (AIC) rule. As shown, the values of the test statistic do not reject the null hypothesis of nonstationarity in the level of each inflation series, with the evidence of a unit root stronger in the case of goods inflation. However, first differences of the inflation series appear to be stationary.

The initial evidence that core goods inflation and core services inflation are nonstationary variables suggests that shocks can impart a permanent shift in their level. While nonstationary variables typically require additional differencing to induce stationarity, there are linear combinations that can be stationary. Those variables are then said to be cointegrated, reflecting an equilibrium relationship in which the series do not drift too far apart over the long run. Moreover, if there is a long-run relationship between variables, then ignoring this feature of the data for estimation purposes entails a misspecification error.

> *Although we are ultimately concerned with characterizing the relationship between core goods inflation and core services inflation, we initially focus on the behavior of the individual series and whether they are subject to permanent changes in their level.*

The notion that a long-run relationship may exist between goods inflation and services inflation is already suggested from our inspection of the measured gap depicted in the bottom panel of Chart 1. For our purposes, the issue of cointegration therefore takes on added importance because of the interpretation that we can ascribe to the results. Specifically, it informs us about the existence of a stable gap between goods inflation and services inflation. We now consider techniques that allow us to investigate this issue more formally.

Although a number of alternative tests have been proposed for cointegration, we apply the maximum-likelihood procedure developed by Johansen (1988, 1991). Because the testing procedure relies heavily on the relationship between the rank of a matrix and its characteristic roots, we do not provide a detailed discussion here.[10] However, it is useful to view the Johansen procedure as a multivariate generalization of the Dickey-Fuller test for a unit root. Specifically, if services inflation and goods inflation are cointegrated, then deviations in their estimated relationship should not be persistent. This implies that there is a linear combination, $\pi_t^{Services} - \alpha - \beta\pi_t^{Goods}$, that produces an error term that is

Table 2

Dickey-Fuller Unit-Root Tests of Nonstationarity in Level and First Difference of Inflation Measures

Panel A: $\pi_t = \alpha + \rho\pi_{t-1} + \sum_i \delta_i \Delta\pi_{t-i} + \eta_t$

Measure	π^{Goods}	$\pi^{Services}$
Sample period	1967:2-2002:4	1967:2-2002:4
ADF t^*	-0.52	-1.49
1 percent critical value	-3.48	-3.48
5 percent critical value	-2.88	-2.88

Panel B: $\Delta\pi_t = \alpha + \rho\Delta\pi_{t-1} + \sum_i \delta_i \Delta^2\pi_{t-i} + \eta_t$

Measure	π^{Goods}	$\pi^{Services}$
Sample period	1967:3-2002:4	1967:3-2002:4
ADF t^*	-5.09	-12.35
1 percent critical value (for $T = 250$)	-3.48	-3.48
5 percent critical value (for $T = 250$)	-2.88	-2.88

Source: Fuller (1976, Table 8.5.2), corrected in Fuller (1996, Table 10.A.2).

Notes: In panel A, the number of lagged differences, *i*, in the inflation rates for the regressions for core goods inflation and core services inflation is twelve and two, respectively. $H_0: \rho = 1$; $H_1: \rho < 1$.

In panel B, the number of lagged differences, *i*, in the change in the inflation rates for the regressions for core goods inflation and core services inflation is eleven and one, respectively. $H_0: \rho = 1$; $H_1: \rho < 1$.

stationary, and therefore temporary in nature. Thus, the Johansen procedure and its corresponding test statistics essentially amount to identifying the number of cointegrating equations in a system of *n* variables.

Table 3 reports the statistics for the Johansen cointegration tests. It provides very strong evidence that core PCE services inflation and core PCE goods inflation are cointegrated series. In particular, both test statistics indicate that there is one cointegrating relationship at both the 5 percent and 1 percent significance levels.[11]

The results of the cointegration tests have two important implications. First, a stable gap exists between goods inflation and services inflation. While the growth rates of goods and services prices may experience permanent changes, they tend to move together over time. Second, we can incorporate the gap into our subsequent analysis by introducing an error-correction term. The error-correction term represents short-run deviations of the gap from its long-run equilibrium value and allows us to provide a broader characterization of the dynamic relationship between goods inflation and services inflation.

Table 3

Johansen Cointegration Rank Tests

$$\pi_t^{Services} = \alpha + \beta\pi_t^{Goods} + \varepsilon_t$$

Hypothesized Number of Cointegrating Equations	Characteristic Root	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None**	0.2023	34.1400	19.96	24.60
At most one	0.0176	2.4903	9.24	12.97
		Maximum Characteristic Root Statistic		
None**	0.2023	31.6496	15.67	20.20
At most one	0.0176	2.4903	9.24	12.97

Sources: Authors' calculations; critical values are from Johansen and Juselius (1990).

Note: The number of lagged differences in the inflation series is two.

**Denotes rejection of the hypothesis at the 1 percent level.
*Denotes rejection of the hypothesis at the 5 percent level.

3. The Gap between Goods and Services Inflation

We now develop an empirical framework that features cointegrating and error-correction techniques. Specifically, we consider the following vector error-correction model for goods and services inflation:

$$(2)\quad \Delta\pi_t^{Goods} = \lambda_{10}(\pi_{t-1}^{Services} - \alpha - \beta\pi_{t-1}^{Goods}) + \sum_i \gamma_i^{11}\Delta\pi_{t-i}^{Goods} + \sum_i \gamma_i^{12}\Delta\pi_{t-i}^{Services} + \varepsilon_{1t},$$

$$\Delta\pi_t^{Services} = \lambda_{20}(\pi_{t-1}^{Services} - \alpha - \beta\pi_{t-1}^{Goods}) + \sum_i \gamma_i^{21}\Delta\pi_{t-i}^{Goods} + \sum_i \gamma_i^{22}\Delta\pi_{t-i}^{Services} + \varepsilon_{2t},$$

where ε_{1t} and ε_{2t} are mean-zero, serially uncorrelated random disturbance terms.

The VECM augments a vector autoregressive process in first differences of the inflation series with their cointegrating relationship. In addition to providing an appropriate representation for the series, this modeling framework has several attractive features for our study. First, the design of the VECM explicitly incorporates a role for the gap between services inflation and goods inflation. As specified, goods inflation and services inflation change in response to random shocks (represented by ε_{1t} and ε_{2t}) and to the term $(\pi_{t-1}^{Services} - \alpha - \beta\pi_{t-1}^{Goods})$ representing the previous period's deviation from long-run equilibrium. All else equal, if the error-correction term equaled zero, there would be no need for either inflation series to adjust from its current level.[12] Second, the estimation of the error-correction term allows for a straightforward investigation into the behavior of the gap between services inflation and goods inflation over particular historical episodes. Finally, we can examine the sign and magnitude of the coefficients λ_{10} and λ_{20} in order to analyze the adjustment process by which long-run equilibrium between the inflation series is restored. Although the recent behavior of core goods and core services inflation may be of more immediate interest, the ability to gauge near-term movements in the two series requires consideration of their long-run relationship.[13]

Panel A of Table 4 reports the results from estimation of the VECM in equation 2 using the maximum-likelihood procedure proposed by Johansen (1988, 1991), with the choice of lag length for the first differences of the inflation series again determined using the AIC. As can be seen, the error-correction term is statistically significant in each equation. Moreover, the coefficients on the error-correction term are of the opposite sign and offer very clear insight into the adjustment process for each inflation series. Specifically, a value of the gap above (below) its long-run equilibrium in one quarter will produce upward (downward) pressure on goods inflation and downward (upward) pressure on services inflation in the subsequent quarter. The coefficients on the error-correction term also indicate that the magnitude of the response for goods inflation is more than twice that for services inflation. There is additional evidence that services inflation responds to its own changes during the previous two quarters. Interestingly, however, there is no corresponding direct response of goods inflation to previous changes in either series.

The Johansen procedure also allows us to test parameter restrictions on the estimated cointegrating equation. In particular, we can examine whether the measured gap between core services inflation and core goods inflation ($\beta = 1$) is consistent with the estimated cointegrating equation. As illustrated by the value of the test statistic (Table 4, panel B), we cannot reject the hypothesis that ($\pi_t^{Services} - \pi_t^{Goods}$) is a stationary process.

Chart 4 plots the estimated gap between services inflation and goods inflation ($\pi^{Services} - \hat{\beta}\pi^{Goods}$). Because the data do not preclude us from setting $\hat{\beta} = 1$, it is not surprising that there is a correspondence between the behavior of the estimated gap and the measured gap depicted in the bottom panel of Chart 1.[14] In particular, the estimated gap displays a similar cyclical pattern with recurrent deviations around a value of 2.8 percent (annual rate).

There are, however, two noticeable differences: the size of the estimated gap is somewhat smaller toward the end of the

Table 4

Vector Error-Correction Model for Core Goods Inflation and Core Services Inflation
1968:1-2002:4

Panel A:

$$\Delta\pi_t^{Goods} = \lambda_{10}(\pi_{t-1}^{Services} - \alpha - \beta\pi_{t-1}^{Goods}) + \sum_i \gamma_i^{11}\Delta\pi_{t-i}^{Goods} + \sum_i \gamma_i^{12}\Delta\pi_{t-i}^{Services} + \varepsilon_{1t}$$

$$\Delta\pi_t^{Services} = \lambda_{20}(\pi_{t-1}^{Services} - \alpha - \beta\pi_{t-1}^{Goods}) + \sum_i \gamma_i^{21}\Delta\pi_{t-i}^{Goods} + \sum_i \gamma_i^{22}\Delta\pi_{t-i}^{Services} + \varepsilon_{2t}$$

Equation	Right-Hand-Side Variables						
$\Delta\pi^{Goods}$	α	β	λ_{10}	γ_1^{11}	γ_2^{11}	γ_1^{12}	γ_2^{12}
$R^2 = 0.169$	0.730**	0.862**	0.452**	0.136	-0.012	-0.115	0.137
	(0.066)	(0.071)	(0.106)	(0.094)	(0.090)	(0.137)	(0.126)
$\Delta\pi^{Services}$	α	β	λ_{20}	γ_1^{21}	γ_2^{21}	γ_1^{22}	γ_2^{22}
$R^2 = 0.231$	0.730**	0.862**	-0.180**	0.018	0.006	-0.328**	-0.233**
	(0.066)	(0.071)	(0.068)	(0.061)	(0.058)	(0.089)	(0.082)

Panel B: Tests of Cointegration Restrictions

$$\pi_t^{Services} = \underset{(0.0661)}{0.7306} + \underset{(0.07185)}{0.8624}\,\pi_t^{Goods}$$

	Likelihood Ratio Statistic	Degrees of Freedom	*p*-Value
$H_o: \beta = 1$	2.0728	1	0.1499

Sources: In panel A, authors' calculations; in panel B, Johansen and Juselius (1990).

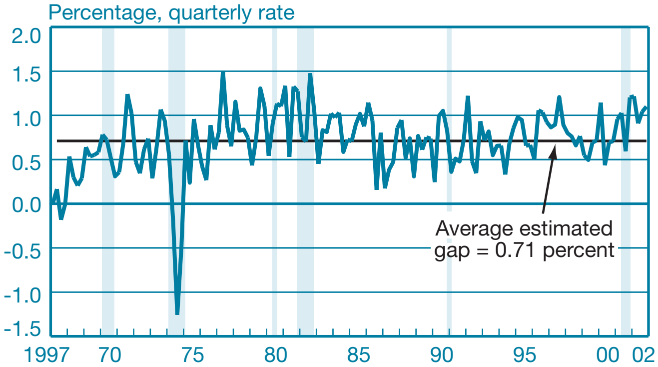
Note: Standard errors are in parentheses.

**Denotes rejection of the hypothesis at the 1 percent level.
*Denotes rejection of the hypothesis at the 5 percent level.

Chart 4

Estimated Gap between Services Inflation and Goods Inflation

1968:1-2002:4



Sources: U.S. Department of Commerce, Bureau of Economic Analysis; Board of Governors of the Federal Reserve System; authors' calculations.

Note: Shaded areas indicate periods designated national recessions by the National Bureau of Economic Research.

sample period and when compared with the value during the mid- and late 1970s. This outcome is a consequence of the estimated cointegrating equation in which $\hat{\beta} = 0.86$ as well as the recent incidence of goods deflation. It can be seen by noting that:

$$(3)\ \pi^{Services} - \pi^{Goods} = (\pi^{Services} - \pi^{Goods}) + (\hat{\beta}\pi^{Goods} - \hat{\beta}\pi^{Goods})$$
$$= (\pi^{Services} - \hat{\beta}\pi^{Goods}) + (\hat{\beta}\pi^{Goods} - \pi^{Goods})$$
$$= (\pi^{Services} - \hat{\beta}\pi^{Goods}) + (\hat{\beta} - 1) \times \pi^{Goods}$$
$$(measured\ gap) = (estimated\ gap) + (\hat{\beta} - 1) \times \pi^{Goods}$$
$$(estimated\ gap) = (measured\ gap) + (1 - \hat{\beta}) \times \pi^{Goods}.$$

As equation 3 shows, the two gaps are equal when $\hat{\beta} = 1$. However, when $\hat{\beta} < 1$ and $\pi^{Goods} < 0$ ($\pi^{Goods} > 0$), the estimated gap will be smaller (larger) relative to the value that emerges from the measured gap between core services and core goods inflation.[15]

Two important conclusions can be drawn from Chart 4. First, the current deviation of services and goods inflation from long-run equilibrium may not be as large as that suggested from a simple inspection of their difference. Second, this same inspection can also be misleading when creating a historical profile. Thus, while the measured gap may be useful for assessing some features of the relationship between goods and services inflation, the estimated gap is the relevant variable for analyzing movements in the series. With this point in mind, we examine some issues related to the forecasting dimension of our VECM.

4. Comparison with a Random-Walk Model

To check our VECM specification, we compare its forecasting performance with that of an alternative model for core PCE deflator inflation. Recently, Atkeson and Ohanian (2001) have argued that simple forecasts from a random-walk model are as accurate as forecasts from a model based on a Phillips curve. Consequently, we compare the VECM with a random-walk model.

Our evaluation procedure involves a pseudo out-of-sample forecast exercise with a four-quarter horizon. Specifically, we initially estimate the VECM through 1989:4, generate forecasts for core goods inflation and core services inflation for 1990:1-1990:4, and combine the forecasts into a composite forecast for each quarter.[16] The quarterly forecasts (annual rate) are then averaged to produce a forecast for the entire year. Using data for core PCE deflator inflation through 1989:4, we can also generate an alternative set of forecasts from the random-walk model for 1990:1-1990:4. The quarterly forecasts (annual rate) can again be averaged to produce a forecast for the entire year. We then update the sample period by four quarters, reestimate the models, construct a new set of forecasts for 1991:1-1991:4 from both models, and repeat the process through 2001:4.[17]

The forecasts from the random-walk model take a particularly simple form. Specifically, the random-walk model is given by:

$$(4)\qquad \pi_t^{Core\ PCE} = \pi_{t-1}^{Core\ PCE} + \varepsilon_t,$$

where ε_t is a mean-zero, serially uncorrelated random disturbance term.[18] Given a value for core PCE deflator inflation in period t-1, that value will represent the forecast for all future periods. For our purposes, we use an average of the quarterly values of PCE deflator inflation during year t-1 to form the forecasts for year t.

The VECM forecasts are based on estimation of equation 2 with two lagged values of the change in core goods inflation and core services inflation:

$$(5)\quad \Delta\pi_t^{Goods} = \lambda_{10}(\pi_{t-1}^{Services} - \alpha - \beta\pi_{t-1}^{Goods}) + \sum_{i=1}^{2}\gamma_i^{11}\Delta\pi_{t-i}^{Goods} + \sum_{i=1}^{2}\gamma_i^{12}\Delta\pi_{t-i}^{Services} + \varepsilon_{1t},$$
$$\Delta\pi_t^{Services} = \lambda_{20}(\pi_{t-1}^{Services} - \alpha - \beta\pi_{t-1}^{Goods}) + \sum_{i=1}^{2}\gamma_i^{21}\Delta\pi_{t-i}^{Goods} + \sum_{i=1}^{2}\gamma_i^{22}\Delta\pi_{t-i}^{Services} + \varepsilon_{2t}.$$

The forecasts are dynamic in nature. That is, we initially construct one-quarter-ahead forecasts for goods and services inflation. They are then used in the construction of the two-quarter-ahead forecasts for goods and services inflation, which are then used to generate the three- and four-quarter-ahead forecasts.

It is worth noting that both the random-walk model and the VECM allow for permanent shifts in the rate of inflation. However, the VECM forecast also incorporates information from the long-run equilibrium relationship between the goods and services components. This feature of the VECM may be especially important for forecasting purposes over the near term.

There is something to be gained from analyzing the goods and services components of the [personal consumption expenditures] deflator separately and exploiting information in their gap.

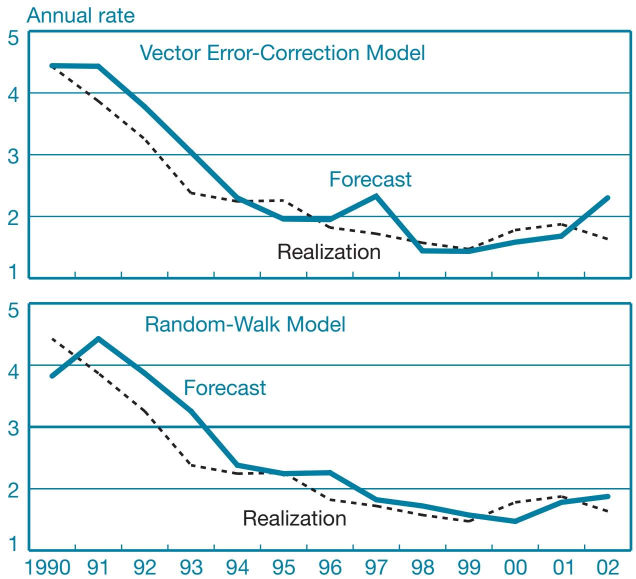
We can compare the accuracy of the inflation forecasts across the two models by using the root mean-squared error (RMSE) of these two sets of forecasts. The RMSE for any forecast is the square root of the average squared differences between the actual inflation rate and the predicted inflation rate over the time period for which the forecasts are constructed. If we let π_{t+1} denote the average annualized inflation rate during the four quarters of year $t+1$ and $E_t(\pi_{t+1})$ denote the forecast in the fourth quarter of year t of π_{t+1}, then:

$$RMSE = \left((1/T) \sum_{t=1}^{T} [\pi_{t+1} - E_t(\pi_{t+1})]^2 \right)^{1/2} . \quad (6)$$

We can then compute the ratio of the RMSE from the VECM to the random-walk model. If the ratio is less than unity, then the VECM is more accurate than the random-walk model. Subtracting 1 from the ratio and multiplying the result by 100 gives the percentage difference in RMSE between the two models.

We find that the forecasts from the VECM are slightly more accurate than those from the random-walk model. The ratio of the VECM's RMSE to the random-walk model's RMSE is 0.96, indicating that the forecast error is approximately 4 percent lower for the VECM.[19] Although this magnitude may not appear large, the results indicate that there is something to be gained from analyzing the goods and services components of the PCE deflator separately and exploiting information in their gap. Moreover, the evidence would seem to contradict the argument of Atkeson and Ohanian (2001) concerning the random-walk model and the usefulness of alterative forecasting schemes.[20] The top and bottom panels of Chart 5 depict, respectively, the forecasts from the VECM and the random-walk model. Although the series display broadly similar behavior, the improved forecasting accuracy of the VECM appears to stem from the subperiods 1990-94 and 1996.[21]

Chart 5
PCE Real-Time Inflation Forecasts
Four-Quarter Average Inflation



Sources: U.S. Department of Commerce, Bureau of Economic Analysis; Board of Governors of the Federal Reserve System; authors' calculations.

Note: PCE is the personal consumption expenditures deflator.

5. Evidence for the Inflation Debate

To help inform the current inflation debate, we provide our own indication of where inflation might be headed by using the vector error-correction model to construct forecasts of trend inflation. Accounting for the recent behavior of the error-correction term and the coefficient estimates for the VECM, the model predicts a rise in goods inflation and a decline in services inflation. However, with regard to any judgment about the overall inflation outlook, the critical question concerns the magnitude of these adjustments.

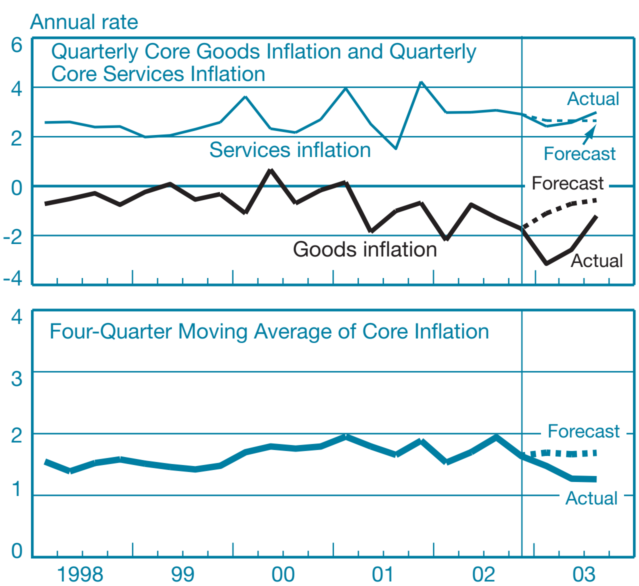
To address this question, we use the VECM in Table 4 estimated over the full sample period to generate dynamic out-of-sample forecasts of the inflation series over the next three quarters.[22] The procedure is identical to the one employed in our forecast comparison exercise. That is, we initially construct forecasts for goods and services inflation for 2003:1. These one-quarter-ahead forecasts are then used to construct the forecasts for 2003:2, with the subsequent forecast for 2003:3 prepared in a similar manner. As we see from the top panel of Chart 6, the VECM forecasts show a slight decline in services inflation and a more pronounced rise in goods inflation. These responses largely reflect the very different speed of adjustment coefficients for goods and services inflation in the VECM. Interestingly, the forecasts from the model suggest a fairly quick return of the error-correction term to its long-run equilibrium value, with the adjustment process completed by the end of 2003.

We can again combine the individual forecasts of goods and services inflation to derive a set of implied predictions for future values of core PCE deflator inflation. Drawing upon our previous approach, we note that the weights for the forecasts in 2003:1-2003:3 are held constant and determined from data on expenditure patterns in 2002:4. As shown in the bottom panel of Chart 6, the VECM forecasts little change in core PCE deflator inflation from the 2002:4 level of approximately 1.6 percent on a four-quarter moving-average basis. This forecast reflects the combined effect of predicted steady behavior on the part of both inflation series and a greater weight attached to the services inflation series in the construction of the composite measure.

Although caution should always be exercised in the use of forecasts, the evidence from our model does not support concerns that a dramatic slowing or a marked acceleration in core inflation may be imminent.

Finally, Chart 6 also plots the actual values of core goods inflation and core services inflation as well as core PCE deflator inflation for 2003:1-2003:3. As the chart shows, the VECM overpredicted core PCE deflator inflation during 2003. However, it is easy to identify the source of the forecast errors. While there was a slight decline in core services inflation, we did not observe an immediate rise in core goods inflation. Instead, the rate of decline in core goods prices exceeded the rate predicted by the model. Because we are measuring actual core PCE deflator inflation on a four-quarter moving-average basis, the influence of the large forecast errors for core goods inflation in 2003:1 and 2003:2 becomes more evident during the period. It is not immediately clear why core goods inflation did not display the anticipated response, and we suggest that this may be a subject for further study.

Chart 6
Core PCE Inflation Forecasts



Sources: U.S. Department of Commerce, Bureau of Economic Analysis; Board of Governors of the Federal Reserve System; authors' calculations.

Note: Core PCE is the core personal consumption expenditures deflator, or the PCE deflator excluding the food and energy components.

6. Conclusion

This article analyzes the relationship between core PCE goods inflation and core PCE services inflation from 1967:2 to 2002:4. We conclude that while each inflation measure experiences permanent shifts in its level, there is evidence that they tend to move together in the long run. Consequently, our findings support the view that there is a stable gap between services price inflation and goods price inflation.

We also find that the gap offers useful information for understanding the behavior of the two series, and that forecasts of core PCE deflator inflation incorporating the behavior of the gap compare favorably with forecasts produced by other popular models. Furthermore, while the measured gap between services price inflation and goods price inflation has widened recently, we find that this measure may overstate the magnitude that is relevant for gauging near-term movements in the two series. Although we anticipate a narrowing of the gap through a rise in goods inflation and a fall in services inflation, our forecasts suggest that neither a dramatic slowing in overall inflation nor a marked acceleration is likely to occur in the near future.

Endnotes

1. A comprehensive revision of the National Income and Product Accounts (NIPA) has recently been released. The revision includes changes in definitions of implicit services provided by property and casualty insurance companies and implicit services of commercial banks. These changes in definition alter both the level and growth rate of the PCE deflator, particularly the services component, and therefore could affect some of the results of our analysis.

Importantly, the NIPA revision also precludes our analysis, which uses the pre-revised data, from proceeding beyond 2003:3. This consideration explains why our forecast exercise for core PCE deflator inflation does not extend beyond 2003.

2. In statistical terms, core goods inflation and core services inflation are said to contain a unit root and to be cointegrated series. We provide a more detailed discussion of these properties of the data later.

3. Our analysis distinguishes between the measured gap and the estimated gap between core services inflation and core goods inflation. The former term refers to the difference between these two inflation measures, while the latter refers to the deviation of services inflation and goods inflation from their estimated long-run relationship.

4. These features of the data correspond directly to the statistical tests conducted in this article. Specifically, the stationarity tests focus on whether the inflation series exhibit permanent shifts, while the cointegration tests focus on whether permanent shifts in the series are related to each other.

5. The results using the CPI data are available from the authors upon request.

6. Like the core PCE deflator, the core CPI also displays a 30 percent/70 percent split between core goods and core services. However, within core services, shelter has a much smaller weight in the PCE deflator than in the CPI, whereas medical care has a much larger weight.

7. Note that over our sample period, the Bureau of Labor Statistics has modified its methodologies for estimating many of the price series included in the CPI. See McCarthy and Peach (2004) for a review of the changes in methodology for estimating rent of primary residence and owners' equivalent rent: the two main components of shelter.

8. The process for a random variable X_t is said to be (weakly) stationary if neither the mean nor the autocovariances of the series depend on t.

9. A process is said to contain a unit root if it is necessary to difference the data before arriving at a stationary time series.

10. See Enders (2004, ch. 6) for a discussion of the Johansen procedure.

11. The Johansen cointegration testing procedure requires the selection of lagged differences of the inflation series. The lag length was again selected using the AIC.

12. Because neither inflation series displays evidence of an underlying trend, we only allow for an intercept in the cointegrating equation.

13. As noted, our study draws upon the work of Freeman (1998). Specifically, Freeman examines two measures of trend inflation—changes in the CPI less food and energy and changes in the median CPI—and compares their usefulness as forecasts of overall CPI inflation. Statistical evidence indicates that each inflation measure is nonstationary, while each trend-inflation measure is cointegrated with overall inflation. As a result, Freeman argues that the two trend-inflation series provide a meaningful measure of the permanent component of inflation. Moreover, he interprets the error-correction term, which represents the difference between actual and trend inflation, as the transitory component of CPI inflation.

14. Recall, however, that the measures of goods inflation and services inflation in Chart 1 are constructed as a year-over-year percentage change in the price index, whereas the inflation measures underlying the estimated gap in Chart 4 are constructed as quarterly percentage changes in the price index. This difference in data construction also accounts for the smoother behavior of the series and the measured gap in Chart 1.

15. When $\hat{\beta} < 1$, equation 3 also demonstrates that the estimated gap will be larger than the measured gap during episodes of goods inflation. This consideration accounts for the relatively higher value of the estimated gap during the beginning and middle parts of the sample.

16. The appropriate weights for combining the goods and services inflation series into a composite measure depend on actual expenditure patterns. However, these patterns will not be known at the time of the forecasts. Consequently, we construct the composite forecasts by holding the weights fixed at their last known values. For example, the VECM forecasts for 1990:1-1990:4 use the weights available for 1989:4. Because expenditure patterns display little

Note 16 continued
variation over a four-quarter period, there was little difference between our assumed values for the weights and their ex-post values.

17. That is, our last set of forecasts from both models covers the subperiod 2002:1-2002:4.

18. Inspection of the autocorrelation and partial autocorrelation function also supported the random-walk specification for the core PCE deflator inflation series. We excluded a constant term from the model because it proved to be statistically insignificant.

19. Although we do not report the results for the core CPI, the VECM produces much more accurate forecasts than the random-walk model does. Specifically, the forecast error is almost 30 percent lower for the VECM.

20. Note that the VECM forecasts may be slightly disadvantaged because we hold the weights for goods and services fixed at values that (we recognize) will differ from those relevant in the construction of the realized rates of inflation.

21. Recall from equation 6 that the formula for the RMSE involves squared forecast errors, so large misses are heavily penalized.

22. Recall that our analysis is based on the pre-revised NIPA data, which end in 2003:3.

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