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## Examining contributions to core consumer inflation measures

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Examining Contributions to Core  
Consumer Inflation Measures

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**Abstract:** The purpose of this paper is to examine the composition of inflation over time. The authors calculate the contributions to inflation for individual series of the consumer price index (CPI) and personal consumption expenditures price index (PCEPI) and then aggregate those contributions into major consumer expenditure categories. This technique provides a wealth of information concerning aggregate inflation behavior in a concise way, enabling the authors to describe the composition of inflation at any point in time. A particularly important benefit of this method is that it allows them to distinguish broad-based changes in inflation from changes due to relative price movements of a few components. The authors examine long-term trends in contributions to PCEPI core inflation and make inferences about the direction of inflation in the near term. In addition, they examine the decline in CPI core inflation over the 2002–03 period and find that the decline was largely driven by relative price changes of two components.

JEL classification: C43, E31

Key words: CPI, consumer price index, PCE price index, inflation, prices

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# Examining Contributions to Core Consumer Inflation Measures

## Introduction

Recent declines in U.S. core inflation measures have prompted a renewed effort to understand inflation dynamics. Since late 2001, core consumer inflation rates have declined to levels not seen since the early 1960s. Core inflation as measured by the consumer price index (CPI) declined to 1.1 percent (year-over-year) by the end of 2003 while the core personal consumption expenditures price index (PCEPI) moved below 1 percent. This decline in measured inflation rates, coupled with uncertainty about future demand conditions, generated concern and debate among analysts and policymakers about near-term inflation prospects. That concern was reflected in the May 2003 Federal Open Market Committee (FOMC) statement: "...the probability of an unwelcome substantial fall in inflation, though minor, exceeds that of a pickup in inflation from its already low level."

As core consumer inflation rates have edged lower, an increasing and probably undue amount of attention is being placed on the most recent observation. An aggregate inflation rate is limited in the information it provides, especially with regard to the sources of its movements. It is generally difficult to know whether changes in aggregate inflation result from broad-based price changes or from price changes in only a few components. There may be instances in which significant but otherwise idiosyncratic relative price changes among a few underlying components drive movements in the aggregate inflation rate for a sustained period of time.

Analysts often attempt to confront this issue by looking at price changes of major components and making inferences about the impact of those changes on the aggregate inflation rate. However, these inferences are imprecise and do not provide a complete accounting of

aggregate inflation. A more rigorous approach is to provide a precise decomposition of the inflation rate.

In this paper we take the latter, more rigorous approach. We calculate and plot the percentage point contributions of major consumer expenditure categories to core inflation measures over time. This technique provides a wealth of information concerning aggregate inflation behavior in a concise way, enabling us to describe the composition of inflation at any point in time. By highlighting the composition of aggregate inflation, we gain greater insight into the underlying trends in inflation and are able to make more informed inferences about the direction of inflation in the near term. A particularly important benefit of this method is that it allows us to distinguish broad-based changes in inflation from changes due to relative price movements of a few components.

Using this approach to examine long-run trends in core inflation, our analysis finds that the primary contributor to core inflation over the last two decades has been core services. As core services inflation has moved lower over this period, its composition has been relatively stable, with contributions of major components moderating uniformly. In contrast, core goods inflation experienced a distinct downward shift in the early 1990s, marked by a dramatic change in its composition. From examining the long-term trends in the composition of core services and core goods inflation, we believe low inflation will likely persist in the near term.

Short-term movements in core services and core goods inflation largely reflect relative price changes of a few components. These relative price changes are generally not persistent enough to drive sustained movements in the aggregate inflation rate. However, in 2002 and 2003, we conclude, movements in core inflation mostly resulted from significant relative price

changes of two components that were persistent enough to alter the path of core inflation for a sustained period.

The paper is organized in the following manner. Section I describes the methodology we use in calculating contributions to inflation. We also discuss the accuracy of our method in terms of our ability to reproduce BEA and BLS published price indexes. Section II reviews the historical and recent composition of inflation for the core PCEPI and core CPI, respectively. Section III examines the issue of the breadth of disinflation in the 2002-2003 period. We construct counterfactual inflation indexes to highlight the impact of significant and persistent relative price changes in two components on the overall CPI core inflation rate. Section IV examines the shift in the composition of PCEPI core goods inflation that occurred in the early 1990s. Section V concludes.

## **I. Methodology**

This analysis examines the two most widely followed measures of consumer inflation, the consumer price index (CPI) and the personal consumption expenditures price index (PCEPI). More specifically, the analysis focuses on the core components of these two measures. The core measures are preferable because they strip out the more volatile food and energy components. While large, persistent movements in food and energy prices may represent important relative price changes, these movements could potentially mask other important price changes that we are more interested in identifying.

Our approach follows the methodologies of the Bureau of Labor Statistics (BLS) and the Bureau of Economic Analysis (BEA) to calculate contributions for both CPI and PCEPI

inflation, respectively.<sup>1</sup> A contribution is the amount in percentage points of the aggregate inflation rate that is attributed to a particular component.<sup>2</sup> We use the following general formula for the CPI:<sup>3</sup>

$$C_{i,t} = 100 * \left( \frac{(\beta X_{i,t} * \beta W_i) - (\beta X_{i,t-1} * \beta W_i)}{(\beta X_{I,t} * \beta W_I) - (\beta X_{I,t-1} * \beta W_I)} \right) * \left( \frac{(X_{I,t} - X_{I,t-1})}{(X_{I,t-1})} \right), \quad (1)$$

where  $\beta X_{i,t}$  is the price index of the component  $i$  in period  $t$  based to the reference period  $\beta$ ;  $\beta X_{I,t}$  is the price index of the aggregate  $I$  in period  $t$  based to the reference period  $\beta$ ;  $\beta W_i$  is the relative importance of the component  $i$  at the reference (or base) period  $\beta$ ; and  $\beta W_I$  is the relative importance of the aggregate  $I$  at the reference period  $\beta$ .<sup>4</sup>

For the PCEPI we use the general formula

$$C_{i,t} = 100 * \left( \frac{[q_{i,t-1} + (q_{i,t} / Q_t^F)] * (p_{i,t} - p_{i,t-1})}{\sum_j [q_{j,t-1} + (q_{j,t} / Q_t^F)] * p_{j,t-1}} \right), \quad (2)$$

where  $q_{i,t}$  is the chained-dollar quantity of the component  $i$  in period  $t$ ;  $p_{i,t}$  is the chain-type price index of the component  $i$  in period  $t$ ;  $Q_t^F$  is the Fisher quantity index for the aggregate in period  $t$  relative to period  $t - 1$ ; and the subscript  $j$  includes all the components of the aggregate.

As the formulas suggest, the magnitude of the contribution of a particular component reflects its change in price and its relative share, or weight, in the aggregate. The sum of contributions of all components equals the aggregate inflation rate at any point in time. For the

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<sup>1</sup> For the PCEPI, the methodology is derived from formulas in BEA (2001). For the CPI, the methodology is derived from information in BLS (1997) and from conversations with BLS staff members.

<sup>2</sup> The BLS refers to contributions to percent change for the CPI as “effects” although these effects are not published. The BEA does not publish contributions to percent change for the PCEPI. However, the BEA does publish contributions to percent change for the gross domestic product and gross domestic purchases price indexes.

<sup>3</sup> We modify the general formulas for both the CPI and PCEPI to account for contributions to year-over-year price changes. All year-over-year price changes and contributions for the CPI are calculated using not seasonally adjusted data, consistent with BLS reporting procedures.

<sup>4</sup> From 1998 to 2001, the BLS uses 1993–95 base period relative importances. From 2002 to 2003, the BLS uses 1999–2000 base period relative importances.

purposes of this paper, contributions of individual goods and services are aggregated into major consumer expenditure categories, such as transportation goods, recreation services, and information processing equipment.<sup>5</sup>

We first decompose aggregate core inflation into its contributions of core services and core goods.<sup>6</sup> Then, to obtain greater detail on the underlying trends and recent movements in core inflation, we analyze separately the contributions of major components to core services inflation and core goods inflation. We use the PCEPI to examine the composition and underlying trends of core inflation over the long term. For our short-term focus on the recent past, we use the CPI because it garners the most attention from analysts and markets.<sup>7</sup> It is important to note that the BEA relies heavily on CPI series in the construction of its price indexes. Consequently, we believe our analysis of the long-term trends in the PCEPI applies to the CPI as well.

The methodologies used to calculate contributions to inflation necessitate that we be able to create or reproduce aggregate price indexes to a high degree of accuracy. In the case of the PCEPI, we create aggregate price indexes for both core goods and core services because published indexes do not exist. In order to check the accuracy of the PCEPI methodology, we compare published PCEPI core inflation with our calculated measure in Figure 1. The average (absolute) error in terms of year-over-year growth rates is 0.017 over the 1983-2003 period. In the case of the CPI, the methodology requires us to calculate an aggregate index ( $X_t$  in equation 1). We compare our constructed aggregate price measures with published BLS indexes in

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<sup>5</sup> See the Appendix for a detailed description of how we constructed these categories.

<sup>6</sup> The CPI splits items into commodities and services while the PCEPI splits items into categories of goods and services. For the sake of consistency, commodities in the CPI will be referred to as goods.

<sup>7</sup> The PCEPI is a methodologically consistent index—that is, it revises historical data when there is a change in methodology. The CPI, however, does not revise history when new methodologies are introduced. This distinction was a primary factor considered in choosing to focus on the PCEPI for long-term trend analysis. In addition, the comprehensive change in the structure of the CPI in 1998 complicates calculating contributions before 1998.



Figures 2, 3, and 4. Figure 5 plots the discrepancies between the calculated and actual inflation rates. The average (absolute) error for the overall core CPI is 0.033 when using the 48 subcomponents detailed in the Appendix and 4 un-sampled categories to aggregate up to the core CPI. When we use only two major components in aggregation—core commodities and core services—the error falls to 0.026. We find a similar degree of accuracy in our construction of CPI core services—0.033. However, the average (absolute) error for CPI core goods is higher—0.093. The higher error for core goods is a result of the fact that several goods price indexes do not have history dating back to the 1993-95 reference period. Equation 1 requires us to rebase component price indexes to reference period  $\beta$ . When there was no history for a particular index, we used the history of a similar good as a proxy. However, in some cases no suitable proxy was apparent. Consequently, we used the starting value of the index (100) as the average index value for the reference period. As a result, the error over the 1999-2001 period is higher than for the 2002-03 period, during which time the 1999-2000 reference period is used.

## **II. Contributions to PCEPI and CPI Core Inflation**

### ***II.A. Overall Core Inflation***

Figures 6 and 7 show core inflation broken down into its contributions of core services and core goods for the PCEPI and CPI, respectively. Both figures clearly indicate that core services is the principal contributor to overall core inflation. This prominence reflects both its larger weight and rate of price increase relative to core goods.<sup>8</sup> The figures also indicate that the contribution of core goods eventually turned negative. But note in Figure 6 that the contribution of core goods in the PCEPI turned negative as early as 1995. Core goods in the CPI did not turn negative

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<sup>8</sup> The nominal expenditure share of core services to core PCE has increased from 65 percent in 1983 to 70 percent currently. The average rate of price increase for PCEPI core services from 1983 to 2003 is 3.8 percent, compared to 1.1 percent for PCEPI core goods.

until 2001. Figure 6 brings to light the point that weakness in core goods prices is not as recent a phenomenon as commonly thought.<sup>9</sup> Focusing on recent inflation movements in Figure 7 shows that CPI core inflation peaked in November 2001 at 2.8 percent and fell to 1.1 percent in December 2003.<sup>10</sup> The contribution of core services fell 0.9 percentage point while the contribution of core goods dropped 0.7 percentage point. The decline in the CPI core inflation rate garnered a great deal of attention among the media, analysts, and policymakers. Although there was some dispute about its significance, many interpreted the decline as an indication that the economy may be headed toward overall price deflation.

### *II.B. Core Services Inflation*

Having identified core services as the primary contributor to core inflation, the analysis now turns to the historical composition of core services inflation. Figure 8 plots the PCEPI core services inflation rate and the contributions of its major components from 1983 to 2003. Rent, medical care, and personal services are the primary contributors to core services inflation. The long-run movements in rent and medical care largely determine the long-run trend in core services inflation.<sup>11</sup> The contribution of personal services exhibits sharp fluctuations over time, resulting in short-run peaks and troughs in core services inflation. Outside of rent, medical care, and personal services, components' contributions are relatively small and stable over time. Overall, core services inflation has slowed over the last two decades, with contributions of major components moderating uniformly. These results are summarized in Table 1.

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<sup>9</sup> The decline in core goods prices in the CPI in late 2001 garnered much attention. The decline was easily identifiable because core goods in the CPI is a published index. The decline in core goods prices that was exhibited much earlier in the PCEPI may have been less perceptible because core goods is not a published index in the PCEPI.

<sup>10</sup> The decline in the core CPI inflation rate over this period is 1.6 percentage points, rounded to one decimal place.

<sup>11</sup> Over the 1983–2003 period, the correlation between the PCEPI core services inflation rate and the contribution of rent is 0.92, and the contribution of medical care services, 0.81.

We now turn our attention to the behavior of core services inflation over the recent past. Recall from Figure 7 that the disinflation in the overall core CPI in 2002 and 2003 resulted in part from a sustained moderation in the contribution of core services. To better describe this movement, we plot the CPI core services inflation rate and its contributions from 1999 to 2003 in Figure 9.<sup>12</sup> Most notably, the figure reveals that the movement in CPI core services inflation was almost entirely driven by rent during this period. The contributions of other components were relatively stable. Core services inflation fell from a peak of 4.0 percent in February 2002 to 2.6 percent in December 2003, a decline of 1.4 percentage points. The contribution of rent to core services inflation was 2.3 percentage points in February 2002 and fell to 1.1 percentage points in December 2003, a decline of 1.2 percentage points. Consequently, the decline in core services inflation in the 2002–03 period did not reflect broad-based disinflation. Instead, it reflected a significant and persistent relative price change in rent.

### II.C. Core Goods Inflation

The shift in core goods over the past twenty years from being a positive contributor to core inflation to being a negative contributor reflects a number of changes in major components that have dramatically altered its long-run trend. We plot the PCEPI core goods inflation rate and the contributions of its major components from 1983 to 2003 in Figure 11.<sup>13</sup> From 1983 through 1991, most components contributed positively to core goods inflation. A number of relative

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<sup>12</sup> Figure 9 displays some notable differences from Figure 8. In contrast to the PCEPI, rent is by far the largest contributor to core services inflation in the CPI, with relatively small contributions coming from medical care and personal services. In the CPI, rent has a much larger weight than in the PCEPI, while medical care and personal services have smaller weights. For a thorough examination of the differences in the CPI and PCEPI as well as a detailed discussion of weighting issues, see Clark (1999). For comparison purposes, we plot our calculated PCEPI core services inflation rate against the published CPI core services inflation rate in Figure 10.

<sup>13</sup> Alcoholic beverages are not included in the BEA's core PCEPI. In Figure 6, we presented the BEA core PCEPI without alcoholic beverages. However, in Figure 11, we include alcoholic beverages in our PCEPI core goods in order to be consistent with CPI core goods, which does include alcoholic beverages.

price changes drove short-term fluctuations in the core goods inflation rate. However, these relative price changes were often offsetting and were not persistent enough to significantly drive the core goods inflation rate from its relatively flat trend.

In 1992 there was a distinct drop in the core goods inflation rate, characterized by broad-based downward movement in its composition. Many components that contributed positively before this shift began to either contribute less positively or began to contribute negatively. In addition, the negative contribution of information processing equipment increased dramatically. From 1997 on, it is difficult to identify the trend in core goods inflation mainly because the core goods inflation rate drops sharply from 2001 through 2003. However, the composition of core goods has been relatively stable since 1997, suggesting that the core goods inflation rate has settled to a lower, perhaps slightly negative long-run mean.

We noted in our discussion of Figure 7 that the steepened decline in core goods prices in 2002 and 2003 was a significant factor in overall core disinflation. This movement is described in Figure 12, which plots the CPI core goods inflation rate and its contributions from 1999 to 2003.<sup>14</sup> From November 2001 to December 2003, the CPI core goods inflation rate fell from 0 percent to -2.5 percent. This drop resulted from a less positive contribution of other goods (largely tobacco) and increasingly negative contributions of household furnishings and transportation.<sup>15</sup> The largest contributor to the decline was transportation. From November 2001 to December 2003 the contribution of transportation fell 1.4 percentage points, with used

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<sup>14</sup> Figure 12 shows the same pattern of contributions in CPI core goods as exhibited in the PCEPI during this period in Figure 11. However, there are some differences in the magnitude of the contributions, reflecting the different weighting in the two indexes. Most notably, the negative contribution of information processing equipment is considerably less for CPI core goods because the CPI uses fixed expenditure weights from historical base periods. CPI core goods inflation did not turn negative until late 2001 largely because of the smaller negative contributions of information processing equipment prior to 2002. For comparison purposes, we plot our calculated PCEPI core goods inflation rate (including alcohol) against the published CPI core goods inflation rate in Figure 13.

<sup>15</sup> In order to highlight the impact of tobacco's contribution to both PCEPI and CPI core goods inflation, we plot the contributions to core goods inflation excluding tobacco in Figures 14 and 15.

vehicles accounting for 0.9 percentage point. The collective contribution of other goods and household furnishings also fell 0.9 percentage point during this period. Thus, the drop in core goods inflation resulted from price declines in several components. Most notable among these was the large price decline in used vehicles (see the box).

### **III. Significant and Persistent Relative Price Changes: The Case of Rent and Used Vehicles**

Analysts have widely discussed rent and used vehicle prices as important factors in CPI core disinflation during the 2002–03 period. But the precise degree to which these components were lowering core inflation was not clear. Our analysis shows that, from November 2001 (the date of the peak in CPI core inflation) to December 2003, the contribution of rent to CPI core inflation fell 0.8 percentage point while the contribution from used vehicles dropped 0.3 percentage point—a total of 1.1 percentage points, a considerable portion of the 1.6 percentage point decline in CPI core inflation (see Figure 16).

#### ***III.A. Counterfactual I***

What would CPI core inflation have looked like without these recent movements in rent and used vehicles? As a counterfactual exercise, we construct a hypothetical CPI core inflation measure assuming alternative rates of price change for rent and used vehicles. We compare this alternative measure to the actual CPI core inflation rate in Figure 17. In the counterfactual index, we hold the rates of inflation of rent and used vehicles constant from November 2001 through December 2003.<sup>16</sup> In contrast to the steep decline in the actual CPI core inflation rate, our

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<sup>16</sup> The November 2001 inflation rate was 4.7 percent for tenants' rent, 4.4 percent for owners' equivalent rent, and –1.2 percent for used vehicles. We do not exclude rent and used vehicles from our alternative index because doing so would significantly alter the consumer basket, in effect redistributing the weights of these two components to the remaining components. For comparison purposes, in Figure 18 we compare the actual CPI core inflation rate, our

constructed measure of core inflation shows relatively moderate disinflation over the past two years. This exercise indicates that the decline in actual CPI core inflation reflected significant, persistent relative price changes of rent and used vehicles, not broad-based disinflation. We further argue that these price changes reflect not a fundamental weakening in housing and vehicle demand, but, instead the dynamic effects of interest rates on consumer demand for substitutes.

### III.A.1 Rent

Downward pressure on rental prices mainly resulted from an increase in demand for homeownership, which was spurred by historically low mortgage interest rates (see Figure 19). As housing starts and home sales surged in the recent recession and recovery, the national rental vacancy rate jumped from 7.8 percent in the fourth quarter of 2000 to 10.2 percent in the fourth quarter of 2003. This effect was compounded by the way owner-occupied housing prices are measured in the CPI. The CPI uses a rental-equivalence approach, measuring the value of the shelter services an owner receives from his or her home. Price movements in owners' equivalent rent reflect changes in prices of rental units that are comparable in characteristics to owner-occupied homes. Therefore, increased demand for homeownership put downward pressure not only on tenants' rent but also on owners' equivalent rent—the largest component in the CPI.

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Counterfactual inflation rate, and the CPI core inflation rate excluding rent and used vehicles. By excluding rent and used vehicles there is a clear downward level shift in the core inflation rate. In addition, the 0.5 percentage point decline in the actual core inflation rate not attributed to rent and used vehicles is magnified when rent and used vehicles are excluded. This magnification reflects the redistribution of the weights of rent and used vehicles to the remaining components in the core CPI.

### III.A.2 Used Vehicles

The decline in prices of used vehicles largely reflected an increase in demand for new vehicles in response to record-low financing and rebate offers (see Figure 20). Used vehicle prices in the CPI are derived from wholesale auction prices. The surge in demand for new vehicles increased the supply of used autos in the wholesale market while also decreasing dealers' demand for used autos. According to Manheim Auctions, a leader in the used vehicle wholesale auction market, its used vehicle value index (see <[manheimvalueindex.com](http://manheimvalueindex.com)>) fell 5.3 percent between November 2001 and December 2003. Manheim has cited new vehicle incentives as a primary contributor to this decline.

### III.B. Counterfactual II

In Counterfactual I we held the inflation rates of rent and used vehicles constant after November 2001. That exercise showed how much of the decline in CPI core inflation from November 2001 to December 2003 was a result of these components. However, rental price inflation rose significantly in 2000 and 2001 and was near its peak in November 2001. The rise in core inflation during this period in large part reflected this acceleration in rental price inflation. What would CPI core inflation have looked like without this rise in rent and the subsequent decline in rent and used vehicle price inflation? We construct a hypothetical CPI core inflation measure holding rent and used vehicle inflation rates constant after December 1999. Figure 21 compares the counterfactual inflation rate with the actual CPI core inflation rate. The counterfactual inflation rate exhibits the same moderate decline as in the first counterfactual, albeit at a different level of inflation. In fact, this moderate rate of decline is also similar to the rate of decline in actual CPI core inflation rate over the course of the 1990s (see Figure 22). Consequently, it

seems to be the case that the recent decline in CPI core inflation (after accounting for significant and persistent relative price changes) reflects the continuation of a long-run downward trend. The recent downturn in the business cycle appears to have had little impact on the path of overall core inflation (again, after accounting for significant and persistent relative price changes).

#### **IV. Examining the Shift in the Composition of Core Goods Inflation**

The composition of PCEPI core goods inflation has displayed a dramatic shift over the past twenty years. Prior to 1992, the contributions to core goods inflation were mostly positive. Since that time, many components have become consistently negative contributors to core goods inflation. Consequently, core goods inflation has fallen from an average rate of 2.6 percent during the 1983–91 period to an average rate of –0.1 percent post 1991. To understand this shift, we look at the magnitudes, signs, and volatility of the contributions by component both within and across the pre- and postshift periods. We then examine those components that have changed most dramatically.

Table 2 presents the average contribution, the standard deviation, and the high/low contribution for each major component within each period.<sup>17</sup> The table also shows the difference in the average contribution for each component across periods. We see relatively large average contributions across periods from apparel (0.44 and –0.30) and transportation (0.54 and 0.19) and increasingly large negative contributions in the postshift period from information processing (–0.55) and recreation (–0.21).<sup>18</sup> The most notable changes in sign across periods are within

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<sup>17</sup> Table 3 presents the average contribution of goods and services components to overall PCEPI core inflation. It also presents the standard deviation and the high/low contribution for each major component within each period

<sup>18</sup> “Other” goods also has a large contribution across periods. The magnitude and volatility of this contribution mostly reflect large price swings in tobacco goods.



apparel, recreation, and household furnishings.<sup>19</sup> The most volatile components across periods, as measured by standard deviation of contributions, are transportation (0.27 and 0.46) and other goods (0.20 and 0.32). Apparel too is quite volatile in the preshift period (0.38) although the volatility in contributions decreases notably in the 1990s (0.24).

There have been significant changes in market structure, trade patterns, productivity growth, and price measurement that have placed downward pressure on goods prices in many components. The components most affected have been apparel, information processing equipment, recreation goods, and transportation goods. We explore the impact of these changes in the following sections.

#### IV.A. Apparel

The change in apparel from positive contributor to negative is not especially surprising. Significant changes have occurred in the apparel industry at both the manufacturing and retail level. Most apparel manufacturing has shifted abroad to low-cost producers, increasing the volume of apparel imports. Since 1994 U.S. industrial production of apparel has fallen by nearly 40 percent. At the retail level, discount retailers have become more prominent in the industry. Both of these developments have put downward pressure on apparel prices. During the 1983–91 period, apparel prices grew 1.8 percent on average, but during the 1992–2003 period, they fell 1.4 percent, subtracting 0.30 percentage point on average from core goods inflation.

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<sup>19</sup> See Figure 23 for the composition of household furnishings' contribution to PCEPI core goods inflation.

#### IV.B. Information Processing Equipment<sup>20</sup>

The magnitude of the negative contributions of information processing equipment is remarkable. The rapid pace of computer innovation and the role of hedonic quality adjusting in contributing to price declines have been well documented.<sup>21</sup> In addition, productivity gains have been especially strong among high-technology manufacturers, reducing production costs. On average, prices of computers, peripheral equipment, and software declined 14.5 percent in the 1983–91 period, and this decline accelerated to 23.4 percent in the 1992–2003 period. At the same time, the nominal expenditure share of computers, peripheral equipment, and software to core goods personal consumption expenditures rose from 0.4 percent in January 1983 to 2.5 percent in December 2003. Together, the steepened price decline and greater nominal expenditure share resulted in a dramatic increase in the magnitude of the average contribution over the two periods from –0.10 to –0.55.

#### IV.C. Recreation Goods<sup>22</sup>

The increasingly negative contribution from recreation goods reflects a variety of factors, including quality adjustment of price indexes, the introduction of new products, and import competition. Over the last several years, the BLS has introduced hedonic quality adjustment procedures for many consumer electronic goods, including televisions, VCRs, DVD players, and audio equipment.<sup>23</sup> In addition, the BLS changed its sampling procedures in 1998 to facilitate

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<sup>20</sup> See Figure 24 for the composition of information processing equipment's contribution to PCEPI core goods inflation.

<sup>21</sup> Beginning in 1991, the BEA used the BLS producer price index (PPI) series for electronic computers, which adjusts for quality changes in computers. Once the BLS began using hedonic quality adjustment for computers in the CPI in 1998, the BEA switched to the CPI series. For a good discussion and example of hedonic quality adjustment for computers, see Holdway (2000).

<sup>22</sup> See Figure 25 for the composition of recreation goods' contribution to PCEPI core goods inflation.

<sup>23</sup> Hedonic quality adjustments were incorporated for televisions in January 1999 and for VCRs and DVD players in April 2000. The impact of hedonic pricing does not necessarily translate to a downward adjustment to the published

the introduction of new goods on a more frequent basis (Cage 1996). Incorporating items early in their product cycle captures the dramatic reduction in price that is often associated with relatively new products. This change is particularly relevant for consumer electronic goods. Import competition has also put downward pressure on recreation goods prices. Import prices for most recreation goods began to fall considerably in the mid 1990s—averaging –2.7 percent for home entertainment equipment and –0.8 percent for toys and sporting goods. The increase in discount retailers has also placed greater downward pressure on recreation goods prices.

#### IV.D. Transportation Goods<sup>24</sup>

The contribution of transportation goods prices is noteworthy in that it is large in magnitude, exhibits considerable volatility, and turns negative in the mid-1990s. Expenditures on motor vehicles and parts are a relatively large share of total core goods consumption, averaging 23 percent of core goods personal consumption expenditures from 1983 to 2003. Prices fluctuate considerably, especially for used vehicles, resulting in large swings in contributions to core goods inflation. Since 1983, the average year-over-year price change for used autos was 3.4 percent, with a standard deviation of 7.0 percent. In addition, motor vehicle prices shifted downward in the mid-1990s. Before 1995, price changes for motor vehicles and parts averaged 2.8 percent. Since 1995, they have averaged just 0.3 percent. This shift in prices reflects the changing structure of the motor vehicle industry. Since 1996, the share of domestic light vehicle sales to total light vehicle sales has fallen by nearly 10 percentage points. Domestic vehicle manufacturers' attempt to retain market share has placed downward pressure on new vehicle

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(nonadjusted) index. Liegey (1994) and Liegy and Shepler (1999) show that the introduction of hedonic pricing for apparel and VCRs, respectively, did not greatly affect the price changes. However, Moulton, LaFleur, and Moses (1998) show that the introduction of hedonic pricing of televisions did result in a downward adjustment.

<sup>24</sup> See Figure 26 for the composition of transportation goods' contribution to PCEPI core goods inflation.

prices. Meanwhile, leasing has increased dramatically over the past decade, resulting in an influx of late-model, low-mileage used cars into the vehicle market. In essence, leasing has produced a new category of used cars that is a closer substitute for new vehicles. Used car superstores have emerged, increasing competition at the retail level.

## **V. Conclusion**

In this paper, we determine the precise impact of major components on aggregate inflation measures. We calculate and plot the percentage point contributions of major consumer expenditure categories to core inflation measures over time. This technique provides an information-rich picture of inflation behavior, highlighting its composition and underlying trends. By analyzing the composition of aggregate inflation, we are able to make more informed inferences about the direction of inflation in the near term. We are also able to distinguish broad-based changes in inflation from changes in inflation due to relative price movements of a few components.

We find that core services has been the primary contributor to core inflation over the last two decades. The composition of core services inflation is relatively stable over time and largely driven by movements in a few major components. The story is quite different for core goods inflation. The composition of core goods inflation has changed dramatically over time, resulting in a distinct downward shift in the core goods inflation rate in the early 1990s.

Trends in the composition of core inflation lead us to believe that low inflation will likely persist in the near term. The relative stability in the composition of core services inflation suggests little change, in either direction, in the aggregate core services inflation rate. The composition of core goods inflation suggests that core goods deflation will likely continue into

the near term. There have been significant changes in market structure, trade patterns, productivity growth, and price measurement that suggest continued downward pressure on goods prices going forward. At the same time, it is not obvious to us that the decline in goods prices will accelerate. The general stability in the composition of core goods inflation since 1997 suggests that the core goods inflation rate will rather revert to a moderately negative rate of decline. With stable core services inflation and stable core goods deflation, we expect that overall core inflation will remain low.

We note that short-term movements in core services and core goods inflation largely reflect relative price change of a few components. These relative price changes are generally not persistent enough to cause the aggregate inflation rate to deviate considerably from its perceived trend. However, for 2002 and 2003, we conclude that movements in core inflation mostly resulted from two significant relative price changes—the moderation in the increase of rental prices and the decline in used vehicle prices—that were persistent enough to alter the path of core inflation for a sustained period.

From November 2001 to December 2003, the contribution of rent to core CPI inflation fell 0.8 percentage point while the contribution of used vehicles dropped 0.3 percentage point—totaling 1.1 percentage points. The core CPI inflation rate over this period declined 1.6 percentage points. Absent the movements in these two components, core disinflation over the past two years has been very moderate. These results suggest that the concern and discussion regarding overall price deflation were perhaps overstated. Moreover, our results highlight the importance of gauging the impact of relative price changes in a low-inflation environment.

## **APPENDIX**

### **Constructing Major Components for PCEPI and CPI Core Goods and Core Services**

The BEA publishes only the aggregate core PCEPI, not indexes for core goods and core services.

We create these indexes to obtain comparable measures to the core commodities and core services series of the CPI. Within core goods and core services, we aggregate the PCEPI series to create major components that are comparable to the general breakdown of major components in the CPI. Note that the BEA does not include alcoholic beverages in its definition of the core PCEPI. However, we include alcoholic beverages in PCEPI core goods in Figure 11 to be consistent with the BLS definition of the core CPI.

#### **PCEPI Core Goods**

- Alcoholic beverages
- Household furnishings: semi-durable furnishings; cleaning, light supplies and miscellaneous paper products; flowers, seeds and potted plants; furniture, mattresses and bedsprings, kitchen and other household appliances; china, glassware, tableware and utensils; and other durable house furnishings
- Apparel: clothing and shoes and jewelry and watches
- Transportation: motor vehicles and parts
- Medical care: drug preparations and sundries and ophthalmic and orthopedic equipment
- Recreation: toys and sports equipment; magazines and newspapers; audio, video, and musical instruments; sports, photographic equipment, and cycles; and boats and aircraft
- Education: books and maps
- Information processing: computers, peripherals, and software.
- Other: tobacco; toilet articles and preparations; stationary and writing supplies; and expenditures abroad by US residents.

#### **CPI Core Goods**

- Alcoholic beverages
- Household furnishings: window and floor coverings and other linens; furniture and bedding; appliances; other household equipment and furnishings; tools, hardware, outdoor equipment and supplies; and housekeeping supplies
- Apparel

- Transportation: new vehicles; used cars and trucks; and motor vehicles parts and equipment
- Medical care: medical care commodities
- Recreation: televisions; other video equipment, video cassettes and discs; audio equipment, audio discs, tapes and other media; pets and pet products; sporting goods; photographic equipment and supplies; other recreational goods; and recreational reading materials
- Education: educational books and supplies
- Information processing: personal computers and peripheral equipment; computer software and accessories; and other information processing equipment
- Other: tobacco and smoking products; personal care products; and miscellaneous personal goods

### **PCEPI Core Services**

- Rent: owner-occupied nonfarm dwellings, space rent; tenant-occupied nonfarm dwellings; and rental value of farm dwellings
- Other housing: household insurance premiums; household insurance benefits paid; and other housing services
- Household operations: water and sanitary services; domestic services; moving and storage; rug and furniture cleaning; electrical repair; upholstery and furniture repair; and other household operations
- Transportation: transportation services
- Medical care: medical care services
- Recreation: recreation services
- Education: private education and research services
- Communication and information: telephone and telegraph and postage
- Personal: personal care services; personal business services; religious and welfare activities; and net foreign travel

### **CPI Core Services**

- Rent: rent of primary residence and owners' equivalent rent of primary residence
- Other shelter: lodging away from home and tenants' and household insurance
- Household operations: water and sewer trash collection services and household operations
- Transportation: transportation services
- Medical care: medical care services
- Recreation: cable television; rental of video tapes and discs; pet services, including veterinary; photographers and film processing; and recreation services
- Education: tuition and other school fees and childcare
- Communication and information: telephone services and computer information processing services
- Personal: personal care services and miscellaneous personal services

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Figure 1

**PCEPI Core Inflation**

y/y percent change

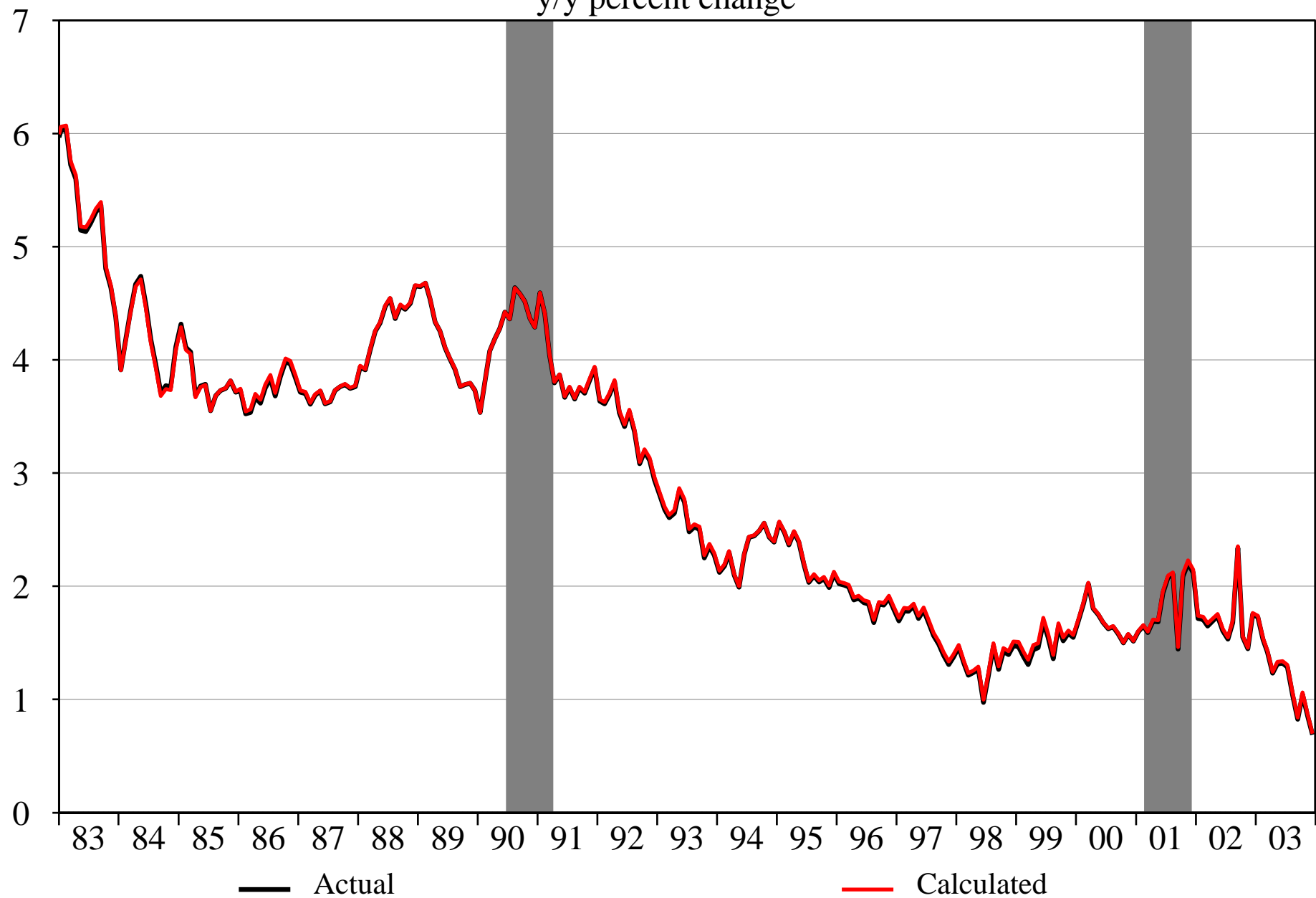


Figure 2

# CPI Core Inflation

y/y percent change

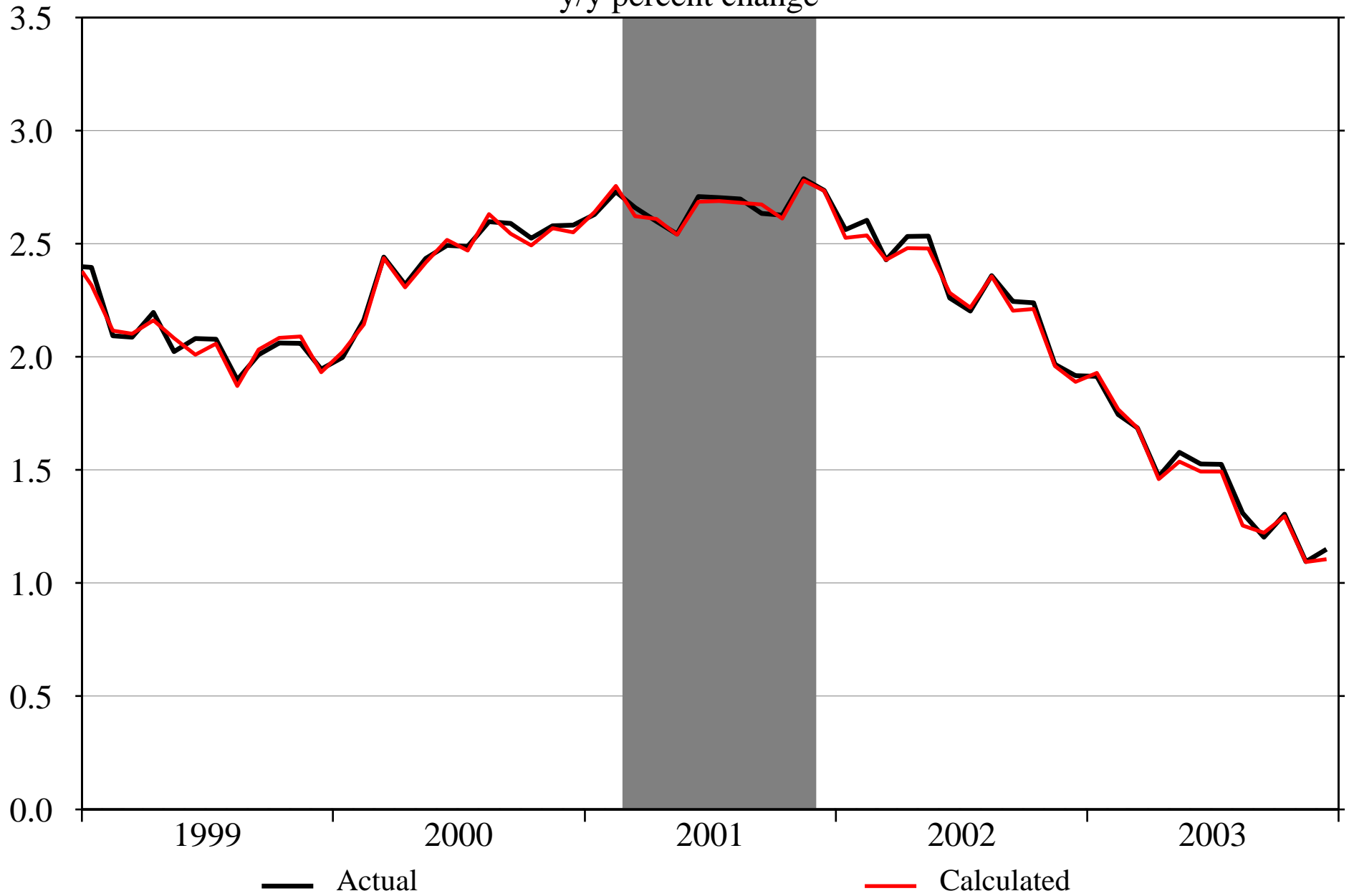


Figure 3

# CPI Core Services Inflation

y/y percent change

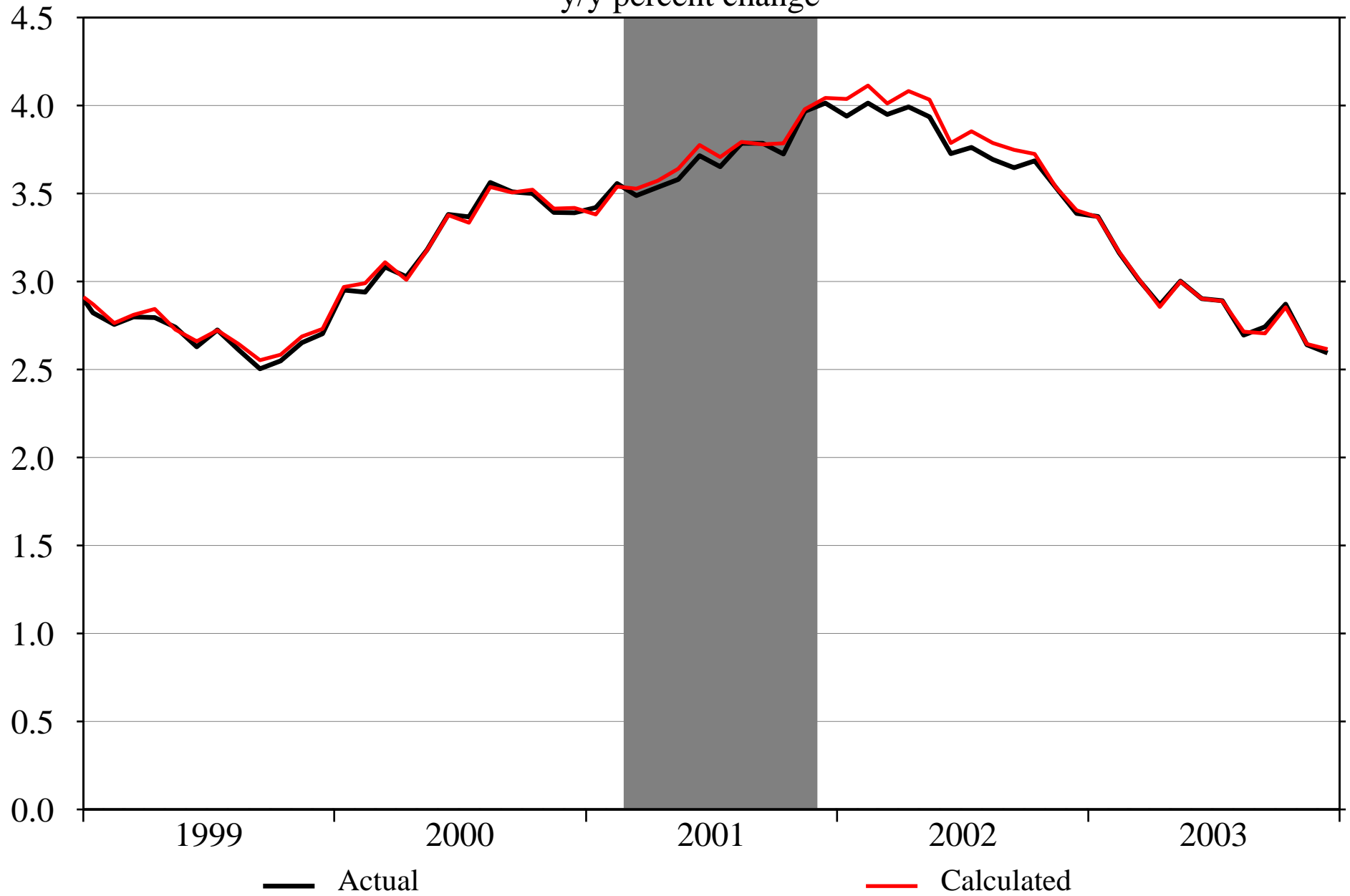
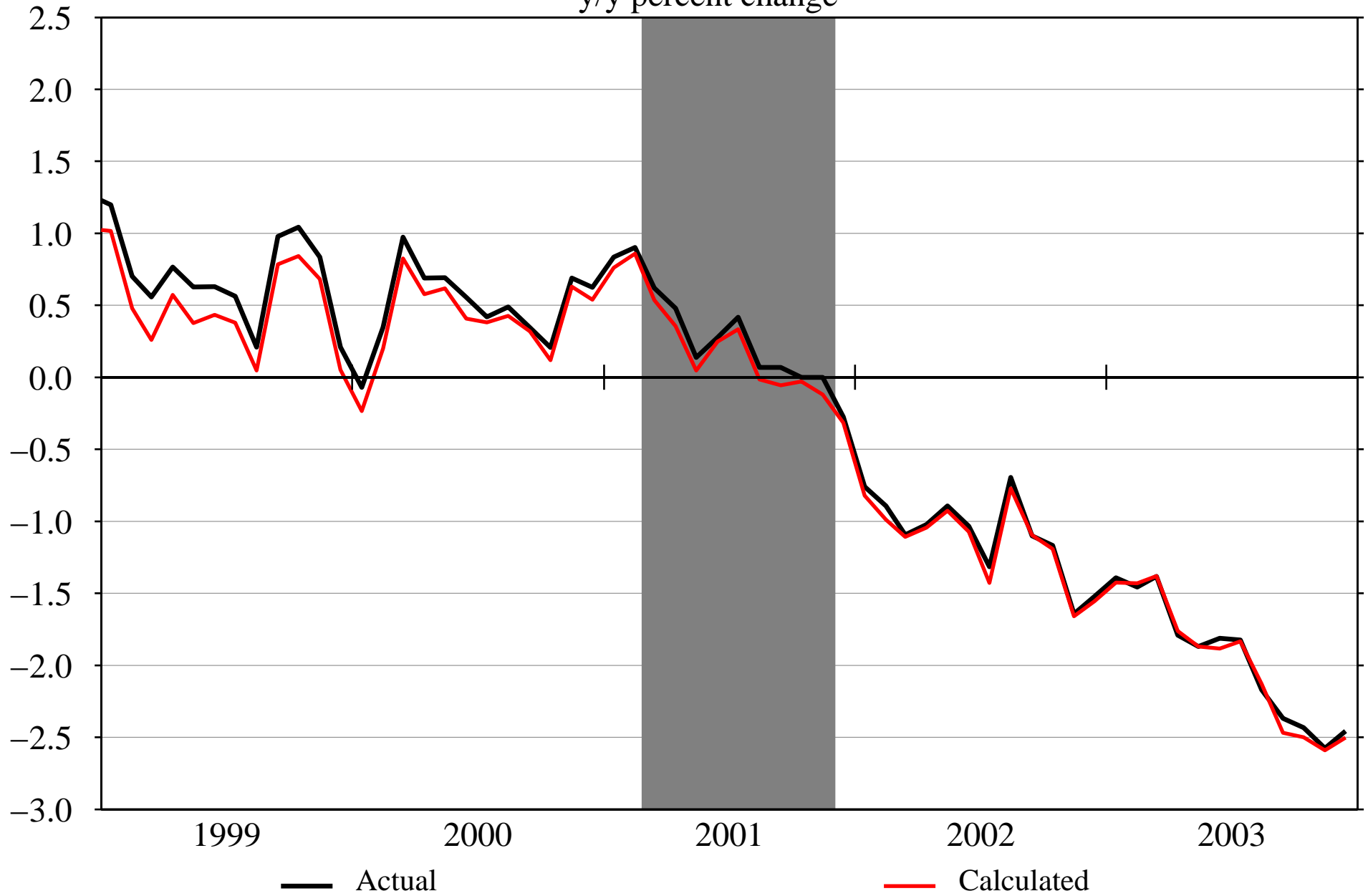


Figure 4

# CPI Core Goods Inflation

y/y percent change



# Calculated vs Actual Inflation Rates

percentage points (calculated less actual)

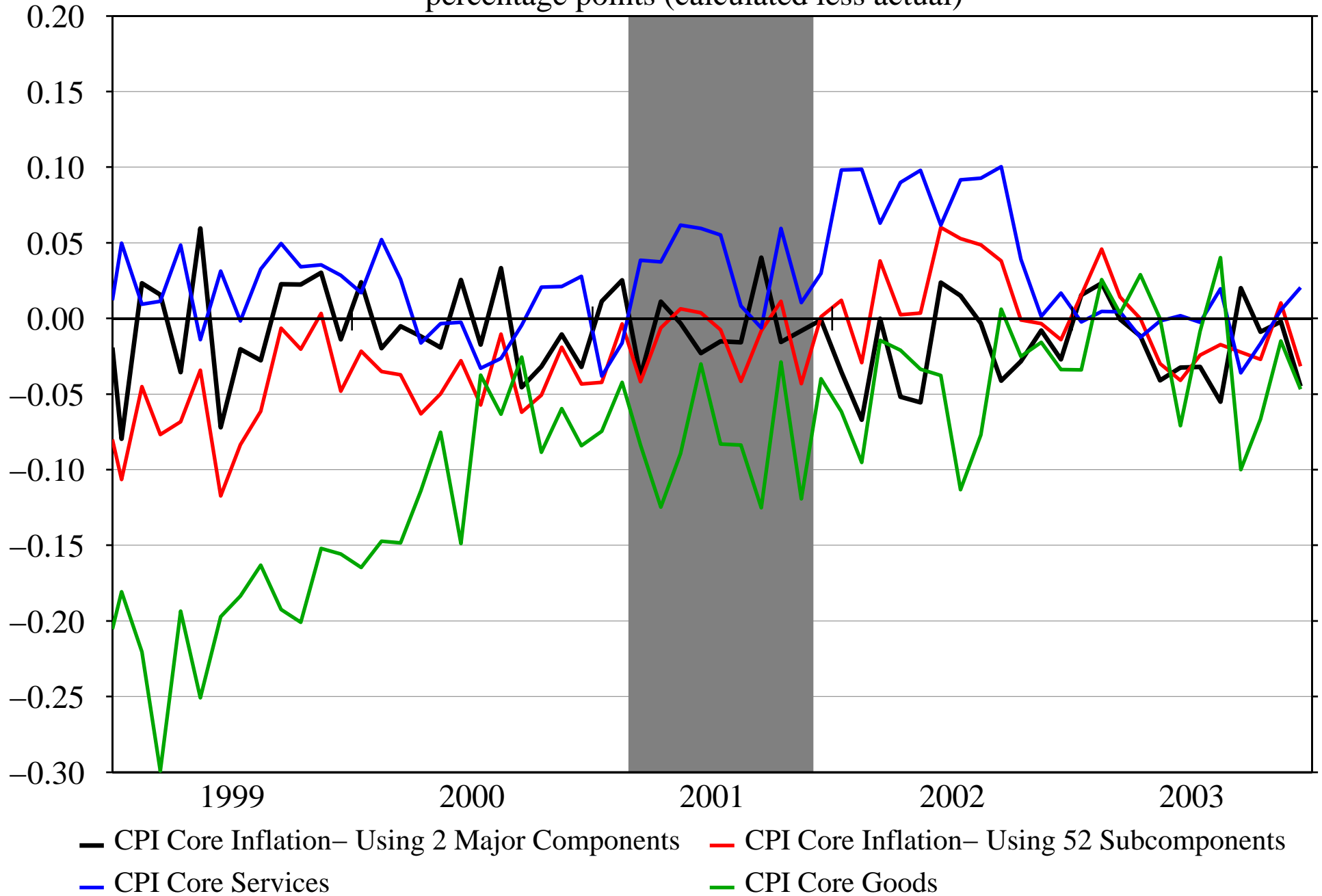


Figure 6

# Contributions to PCEPI Core Inflation

percentage points

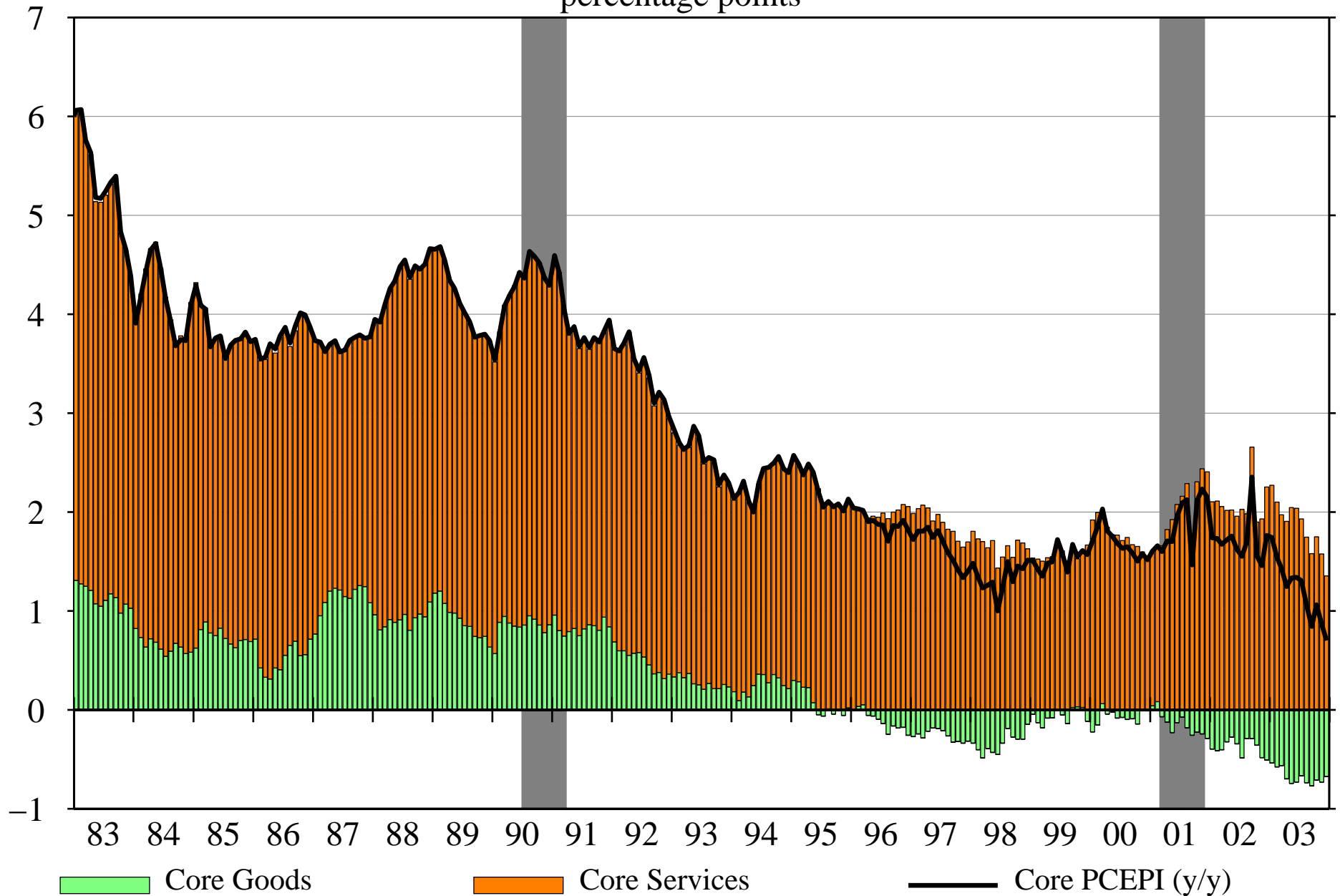
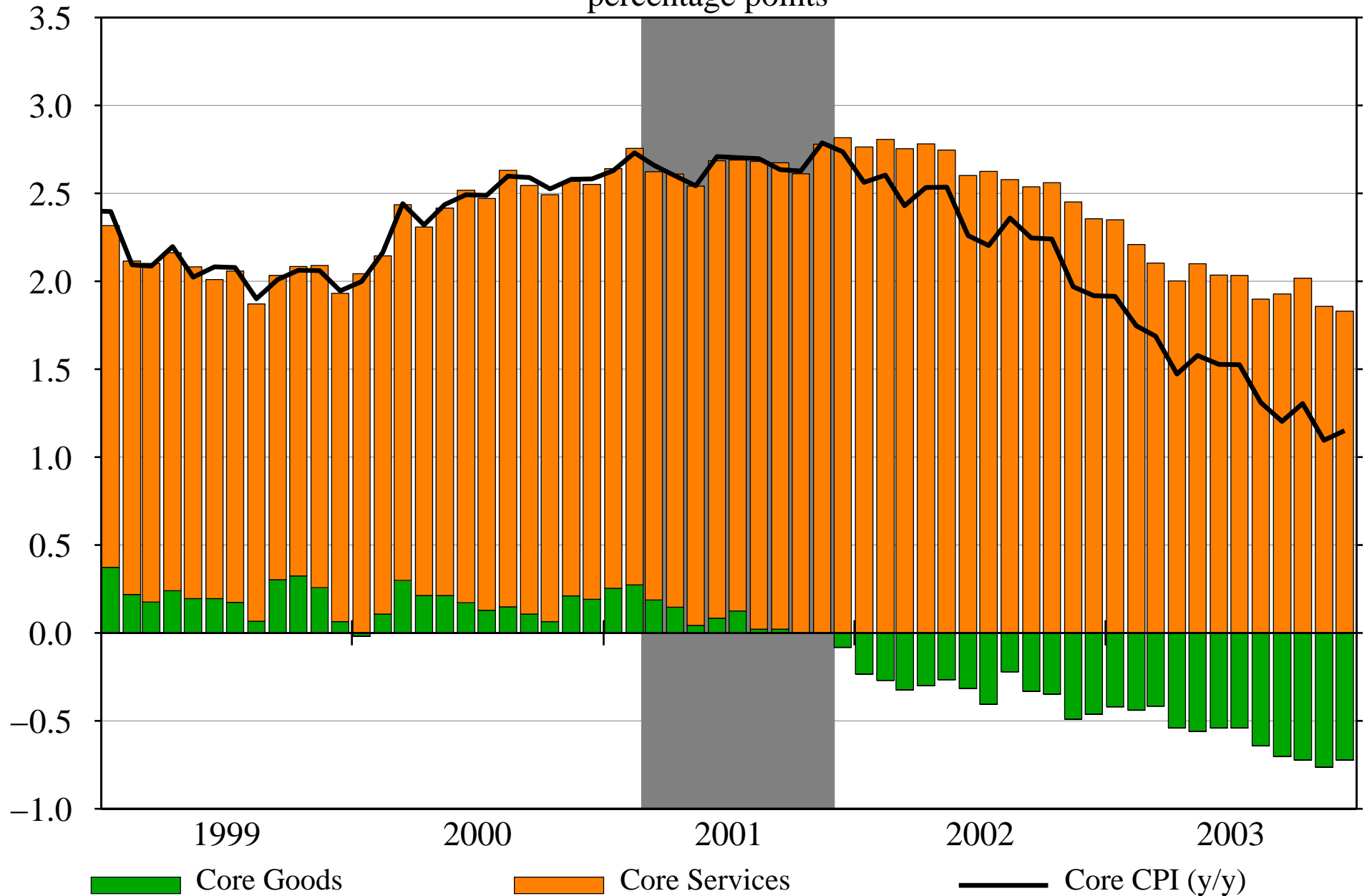


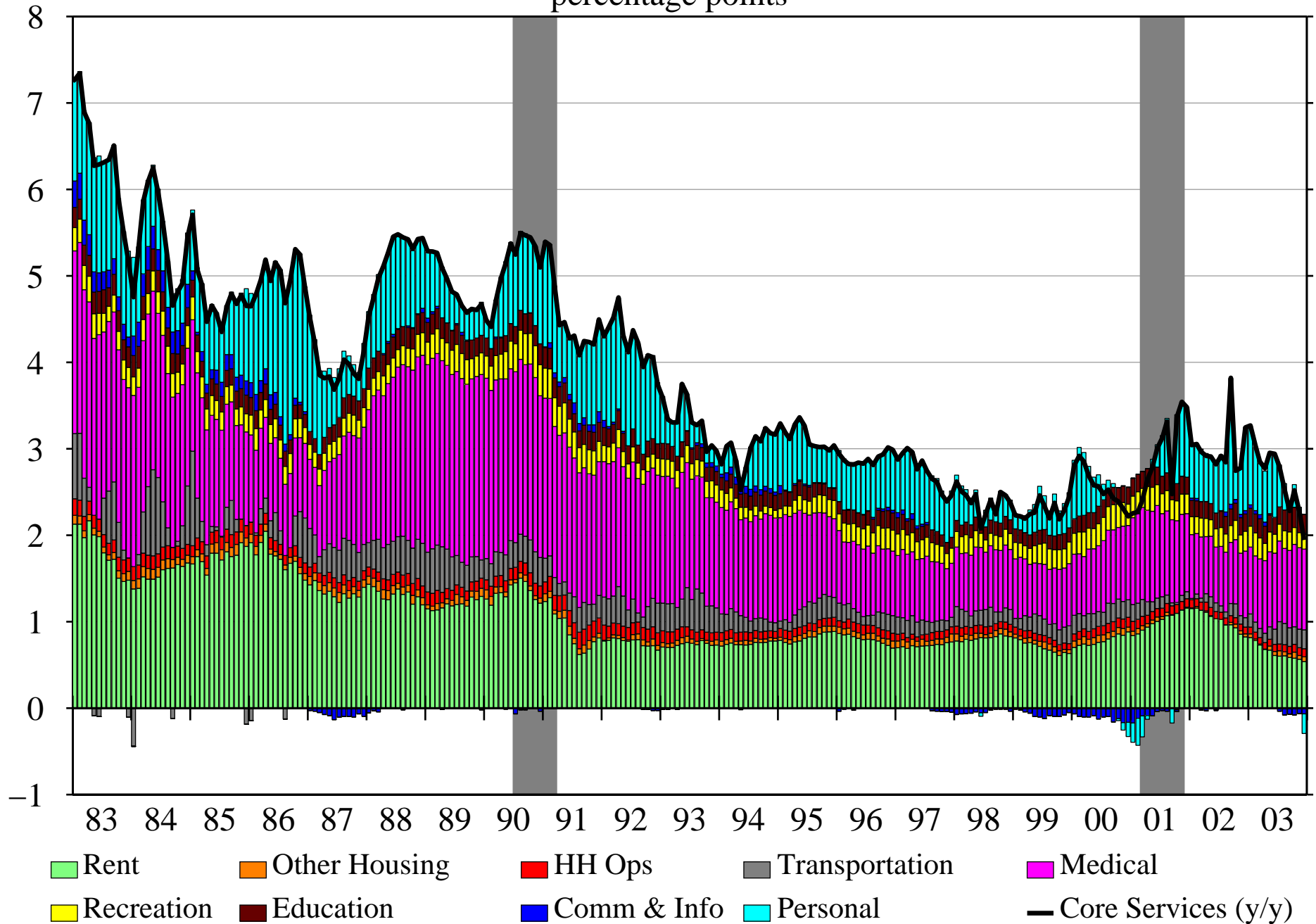
Figure 7

# Contributions to CPI Core Inflation

percentage points



percentage points





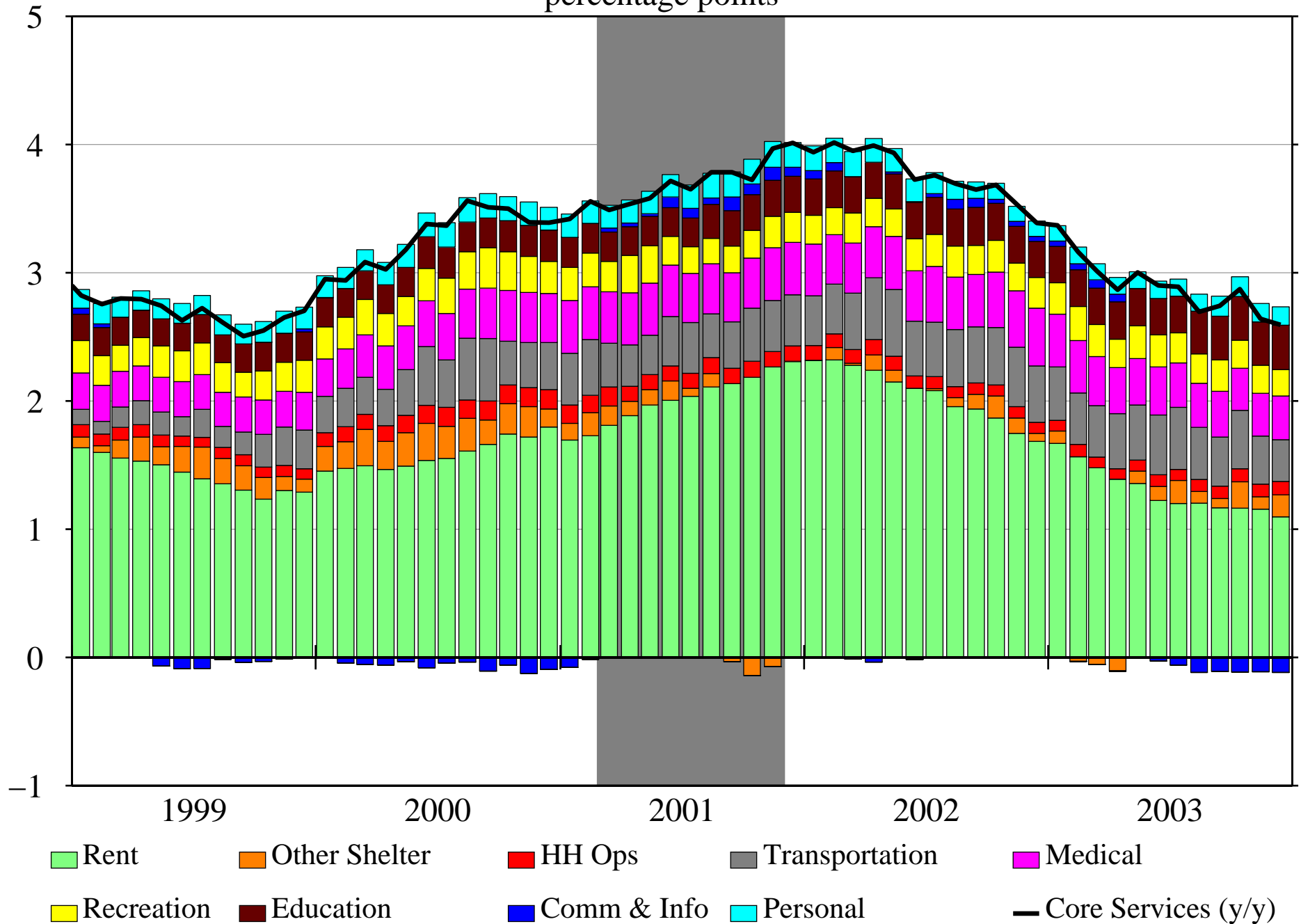
**Table 1: Breakdown of the Contributions to PCEPI Core Services Inflation**

	Core PCE Services Inflation	Rent	Other Housing	Household Operations	Transp. Services	Medical Services	Recreation Services	Education Services	Comm. & Info. Services	Personal Services
<b><u>1983-1991</u></b>										
<b>Ave. Growth/Contrib.</b>	<b>5.02</b>	<b>1.44</b>	<b>0.08</b>	<b>0.14</b>	<b>0.31</b>	<b>1.64</b>	<b>0.25</b>	<b>0.21</b>	<b>0.08</b>	<b>0.87</b>
Standard Deviation	0.74	0.32	0.02	0.02	0.23	0.45	0.05	0.03	0.11	0.35
High	7.34	2.17	0.13	0.19	1.09	2.21	0.37	0.27	0.31	1.78
Low	3.68	0.62	0.04	0.10	-0.44	0.78	0.17	0.15	-0.14	0.21
<b><u>1992-2003</u></b>										
<b>Ave. Growth/Contrib.</b>	<b>2.92</b>	<b>0.79</b>	<b>0.05</b>	<b>0.10</b>	<b>0.19</b>	<b>0.95</b>	<b>0.20</b>	<b>0.18</b>	<b>-0.01</b>	<b>0.48</b>
Standard Deviation	0.55	0.12	0.02	0.02	0.08	0.29	0.04	0.03	0.06	0.32
High	4.75	1.15	0.09	0.17	0.50	1.61	0.29	0.24	0.09	1.45
Low	1.94	0.54	-0.02	0.05	0.01	0.59	0.09	0.12	-0.17	-0.31
<b><u>1992-2003 Period Less 1983-1991 Period</u></b>										
<b>Difference in Average Growth/Contribution</b>	<b>-2.10</b>	<b>-0.65</b>	<b>-0.03</b>	<b>-0.04</b>	<b>-0.12</b>	<b>-0.70</b>	<b>-0.05</b>	<b>-0.04</b>	<b>-0.09</b>	<b>-0.38</b>

Figure 9

# Contributions to CPI Core Services Inflation

percentage points



# Core Services Inflation: Actual CPI vs Calculated PCEPI

y/y percent change

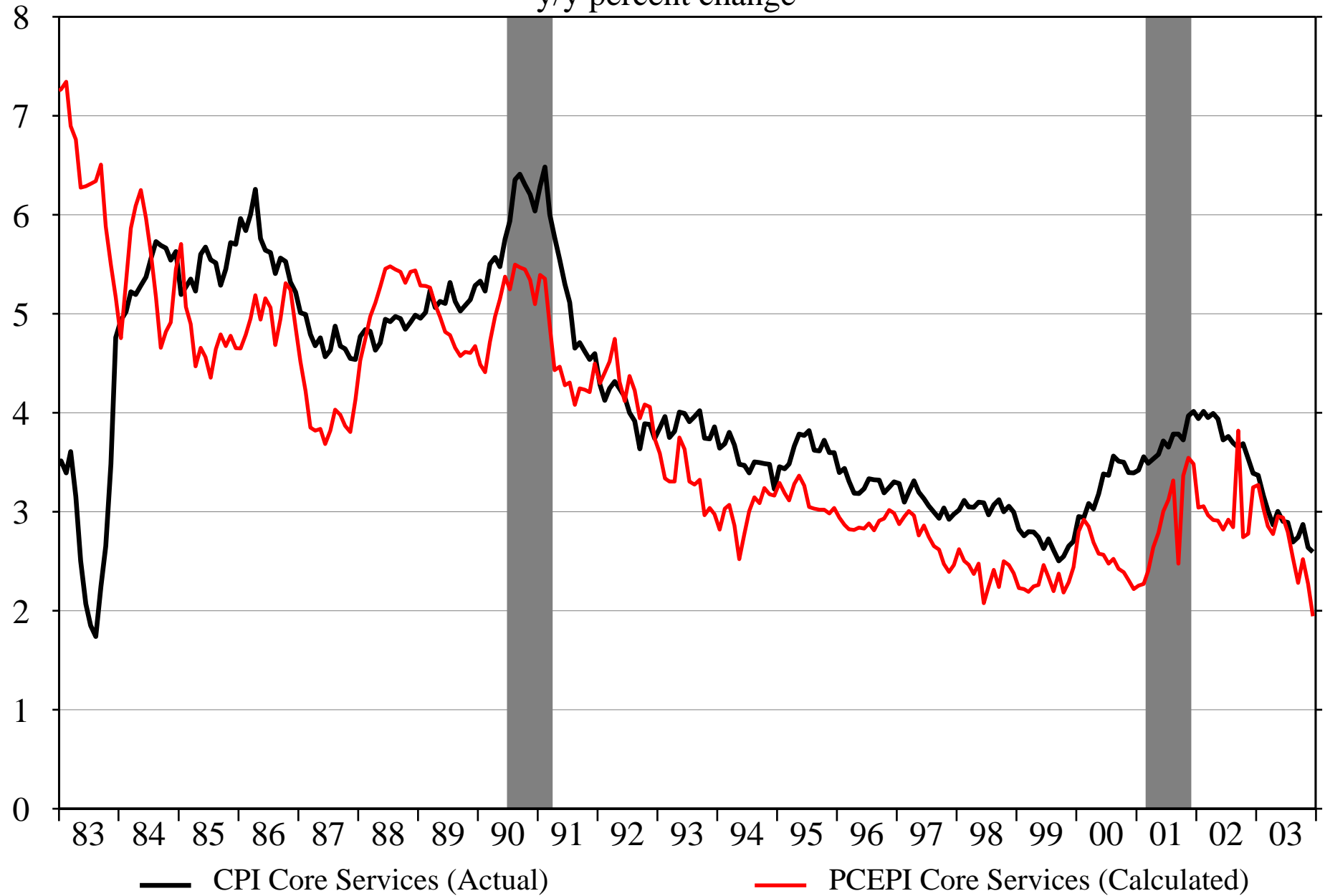


Figure 11

# Contributions to PCEPI Core Goods Inflation

percentage points

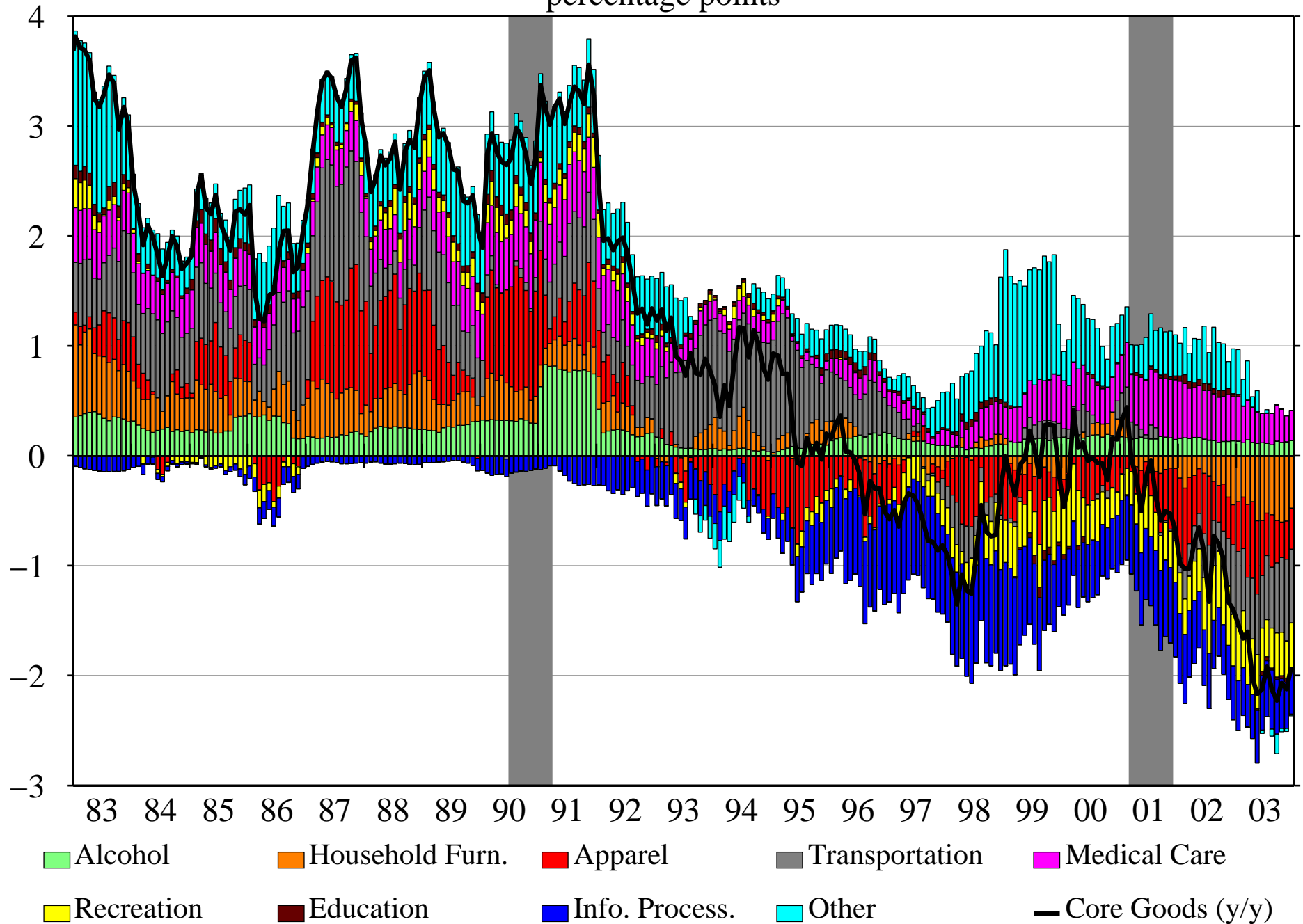
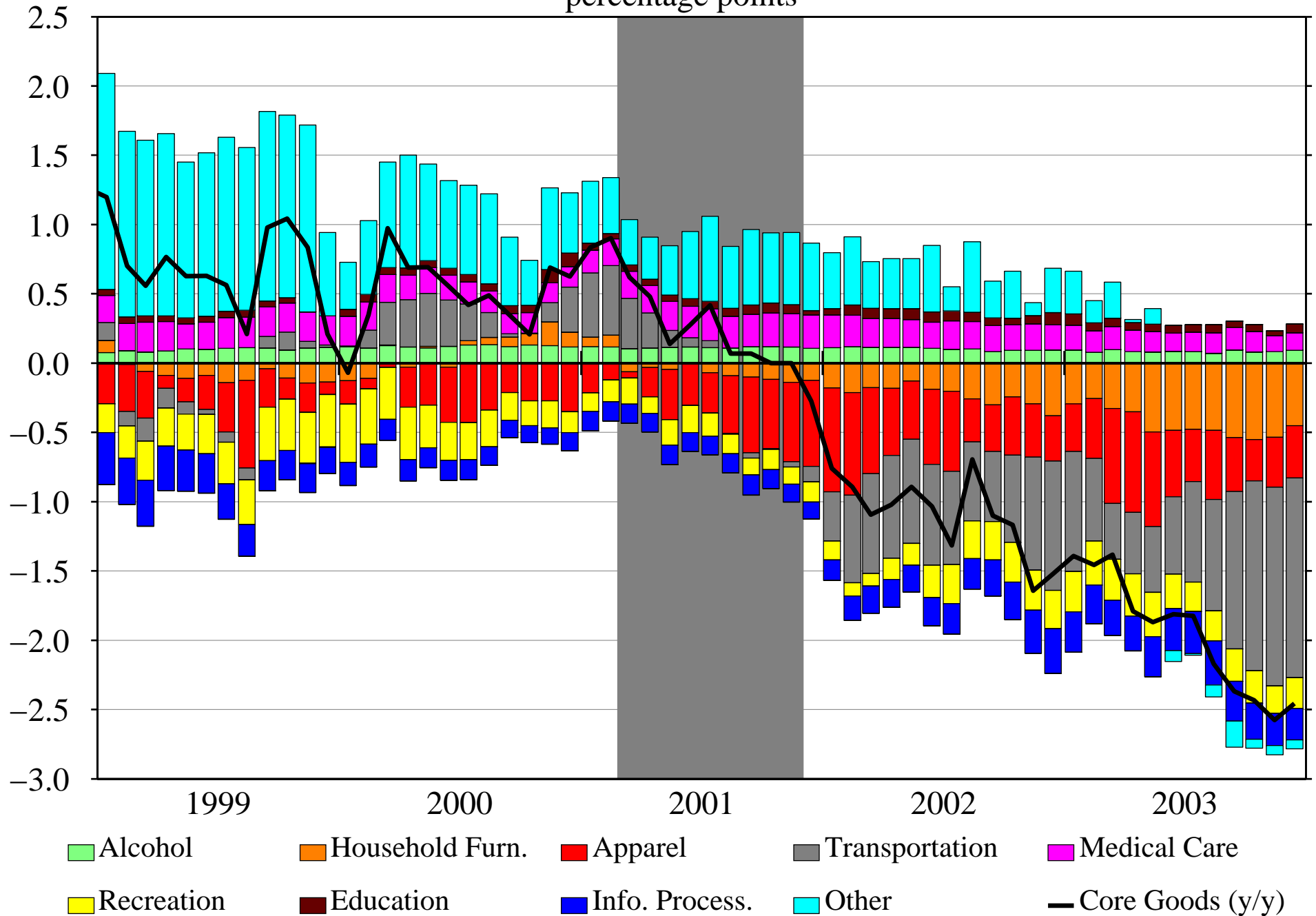


Figure 12

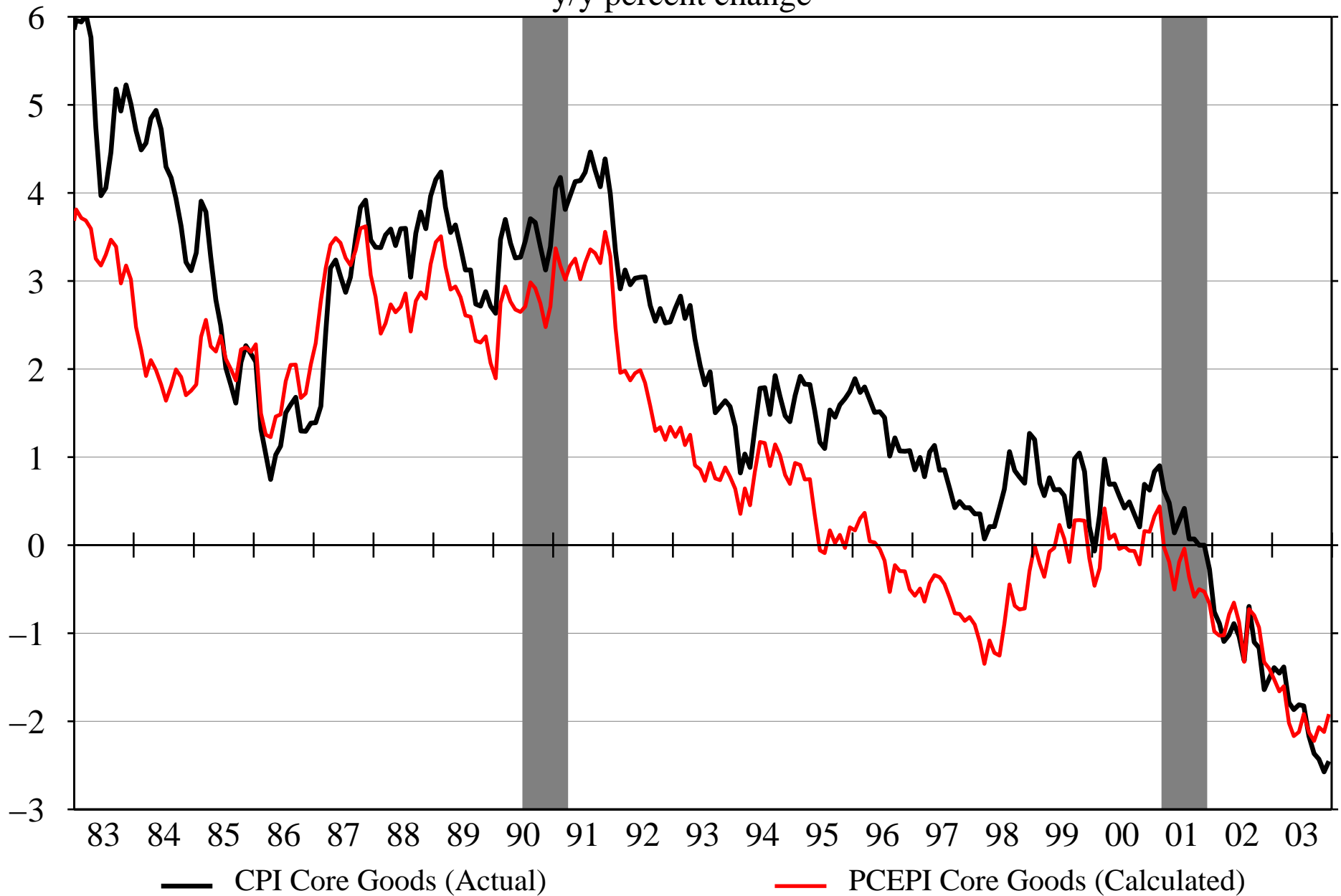
# Contributions to CPI Core Goods Inflation

percentage points



# Core Goods Inflation: Actual CPI vs Calculated PCEPI

y/y percent change



# Contributions to PCEPI Core Goods Inflation (Ex Tobacco)

percentage points

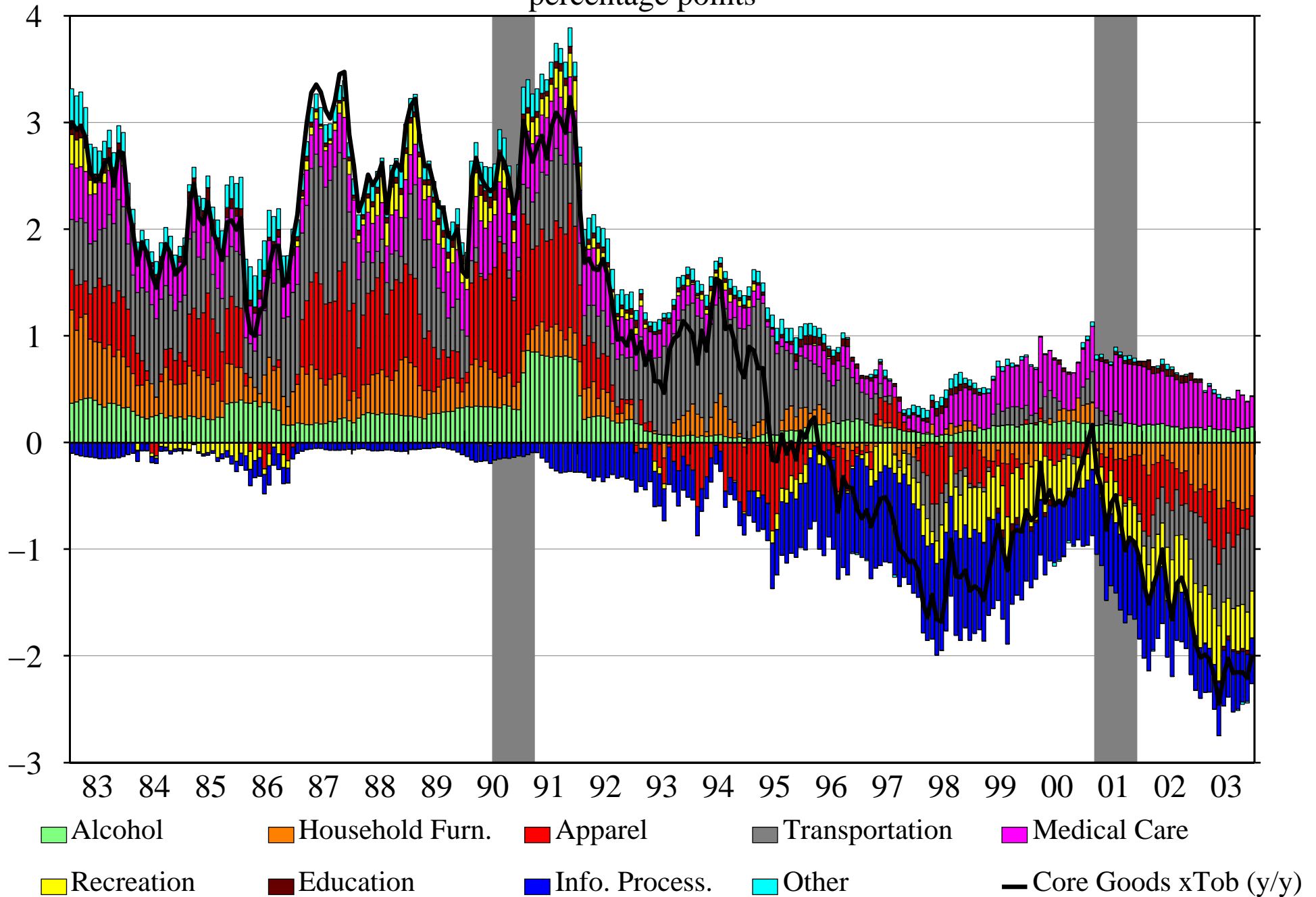
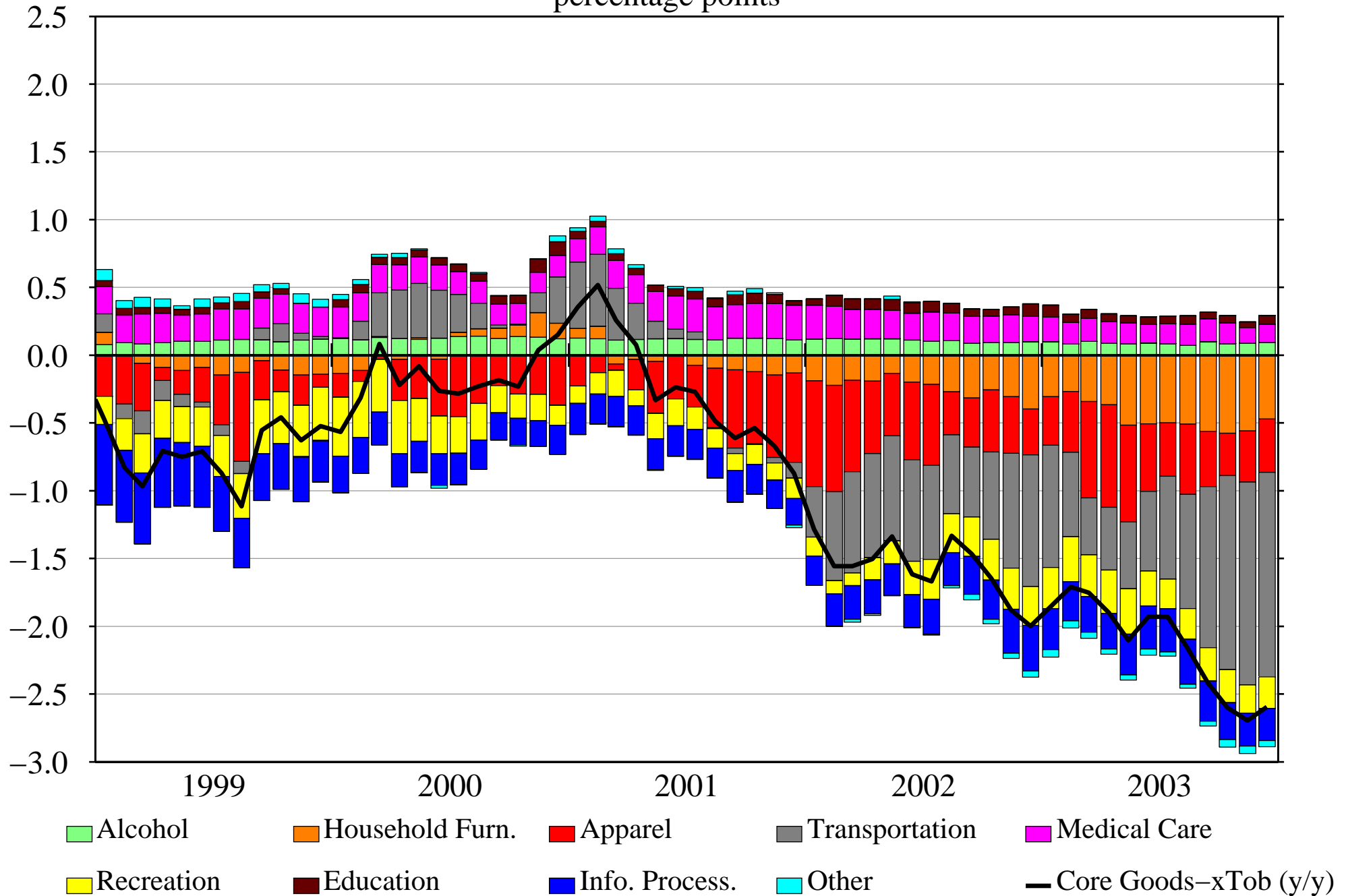


Figure 15

# Contributions to CPI Core Goods (Ex Tobacco)

percentage points





# CPI Core Inflation

percentage points

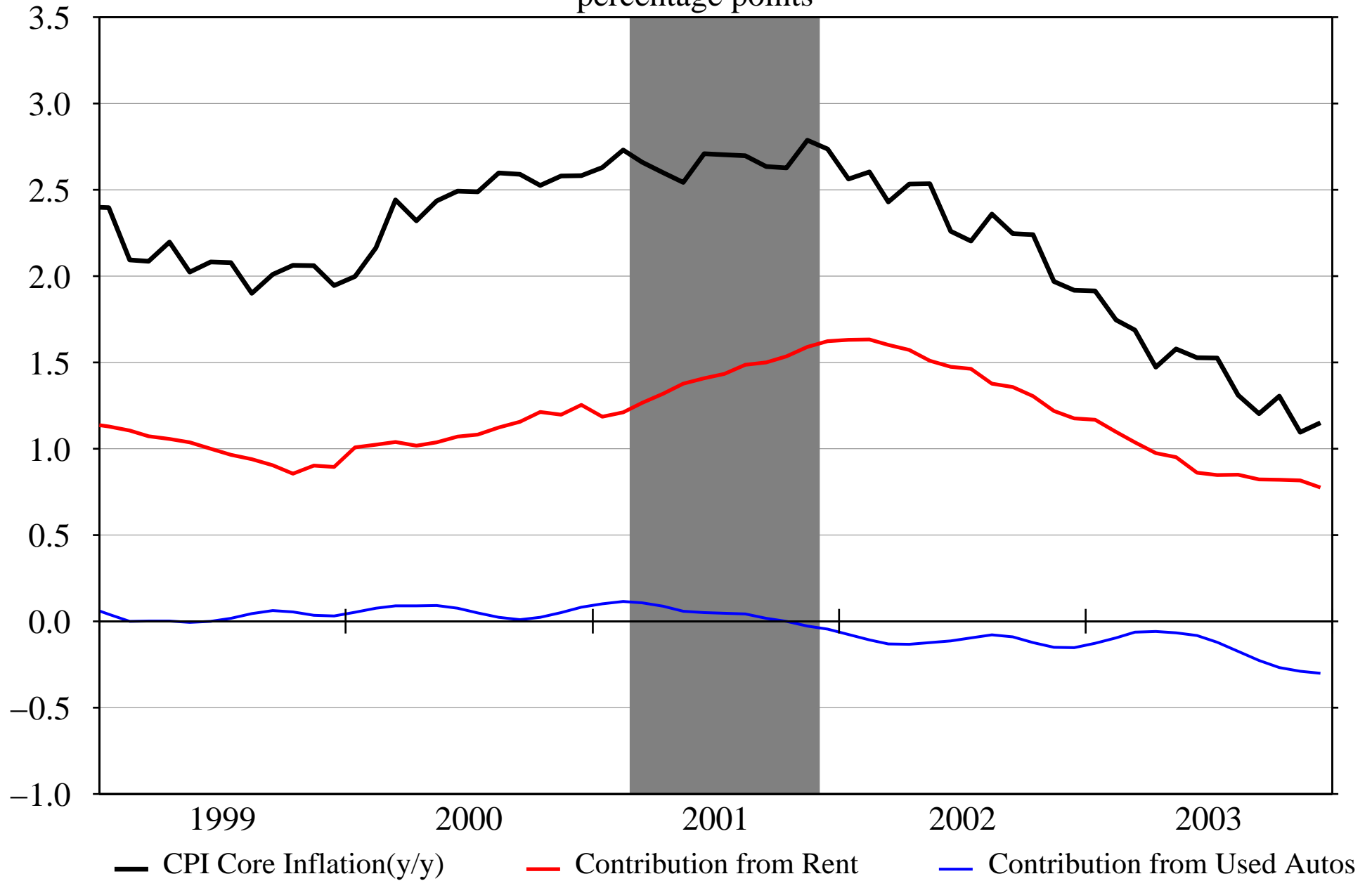


Figure 17

**CPI Core Inflation**

y/y percent change

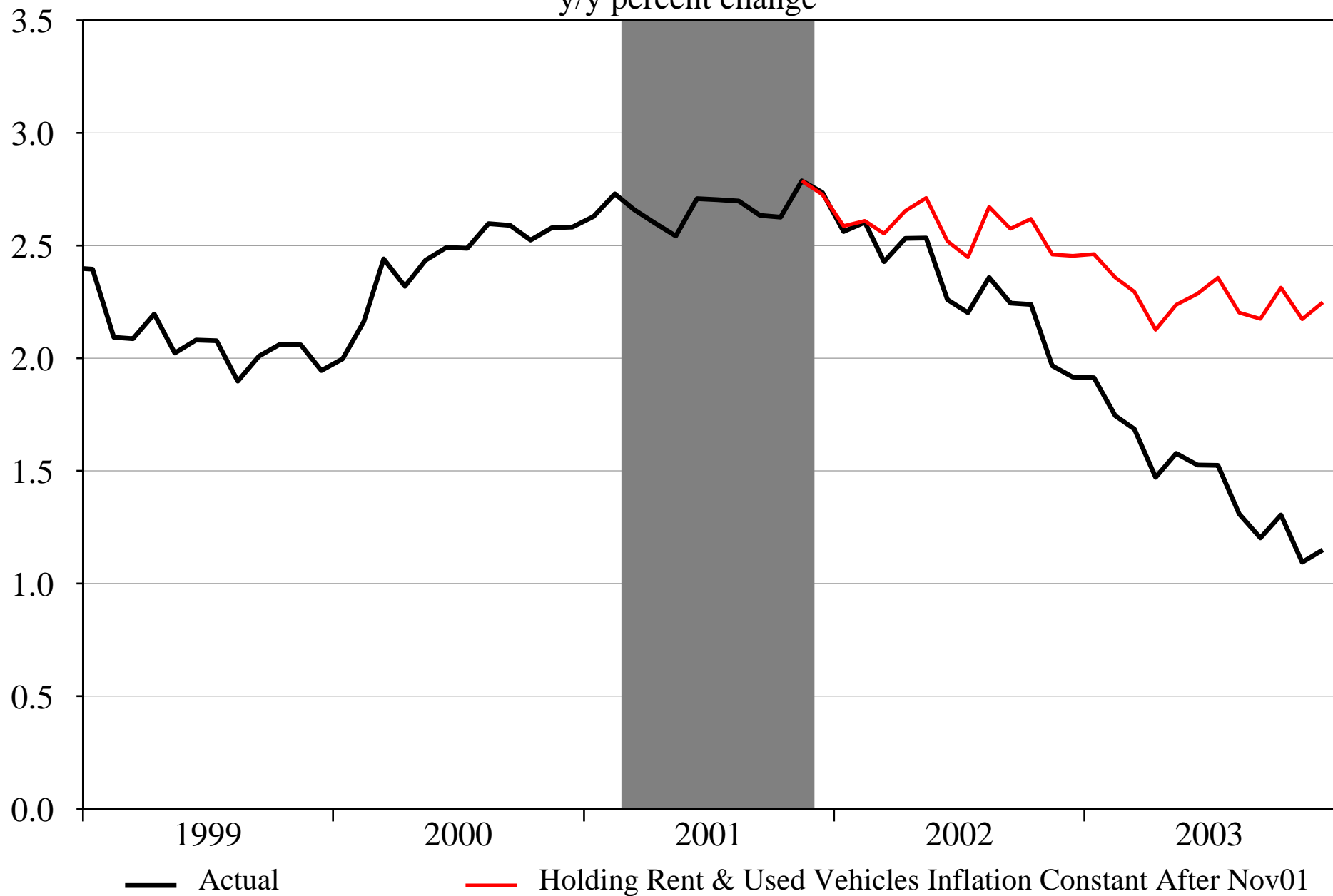


Figure 18

**CPI Core Inflation**

y/y percent change

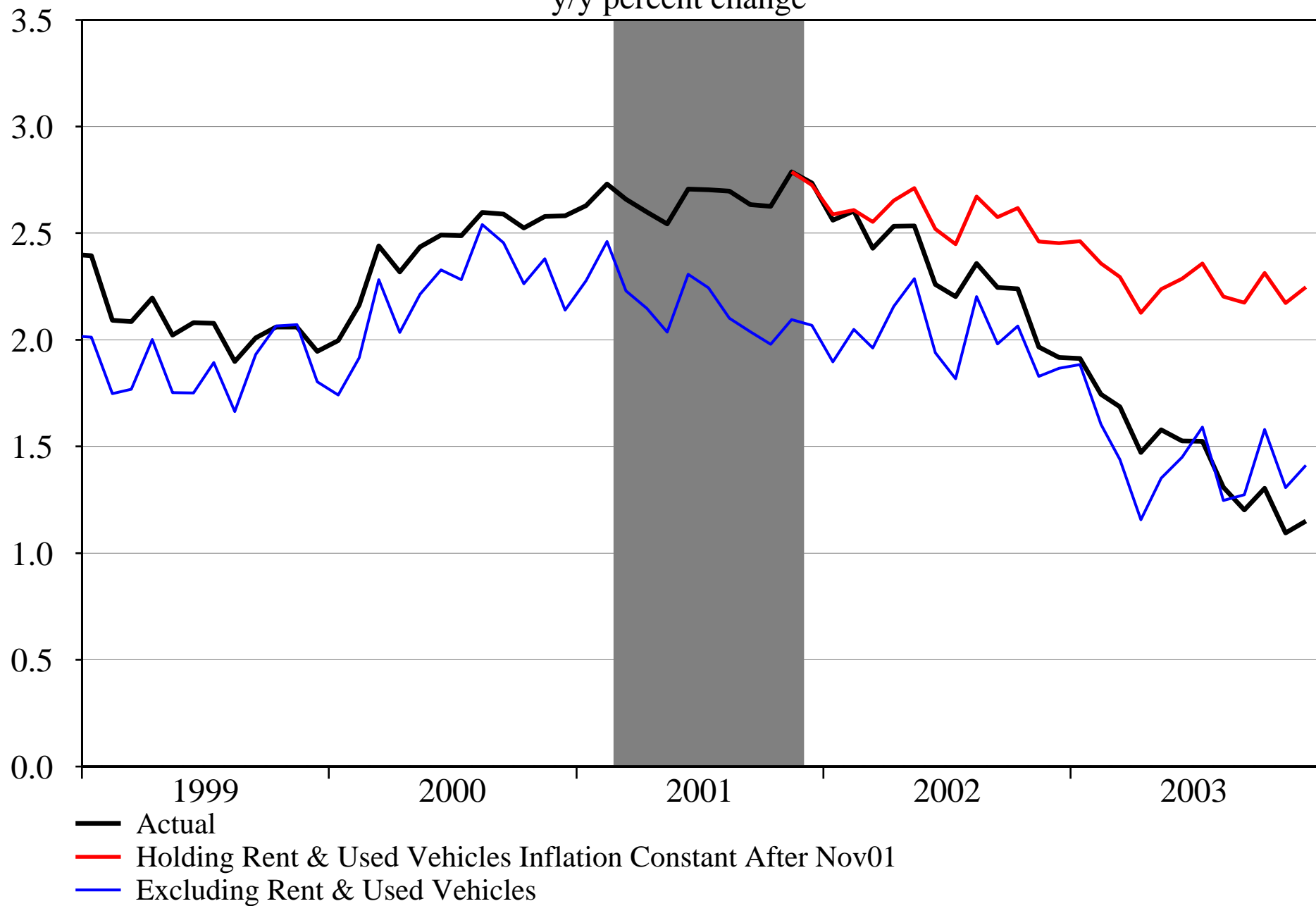


Figure 19

# Owners Equivalent Rent and Mortgage Interest Rates

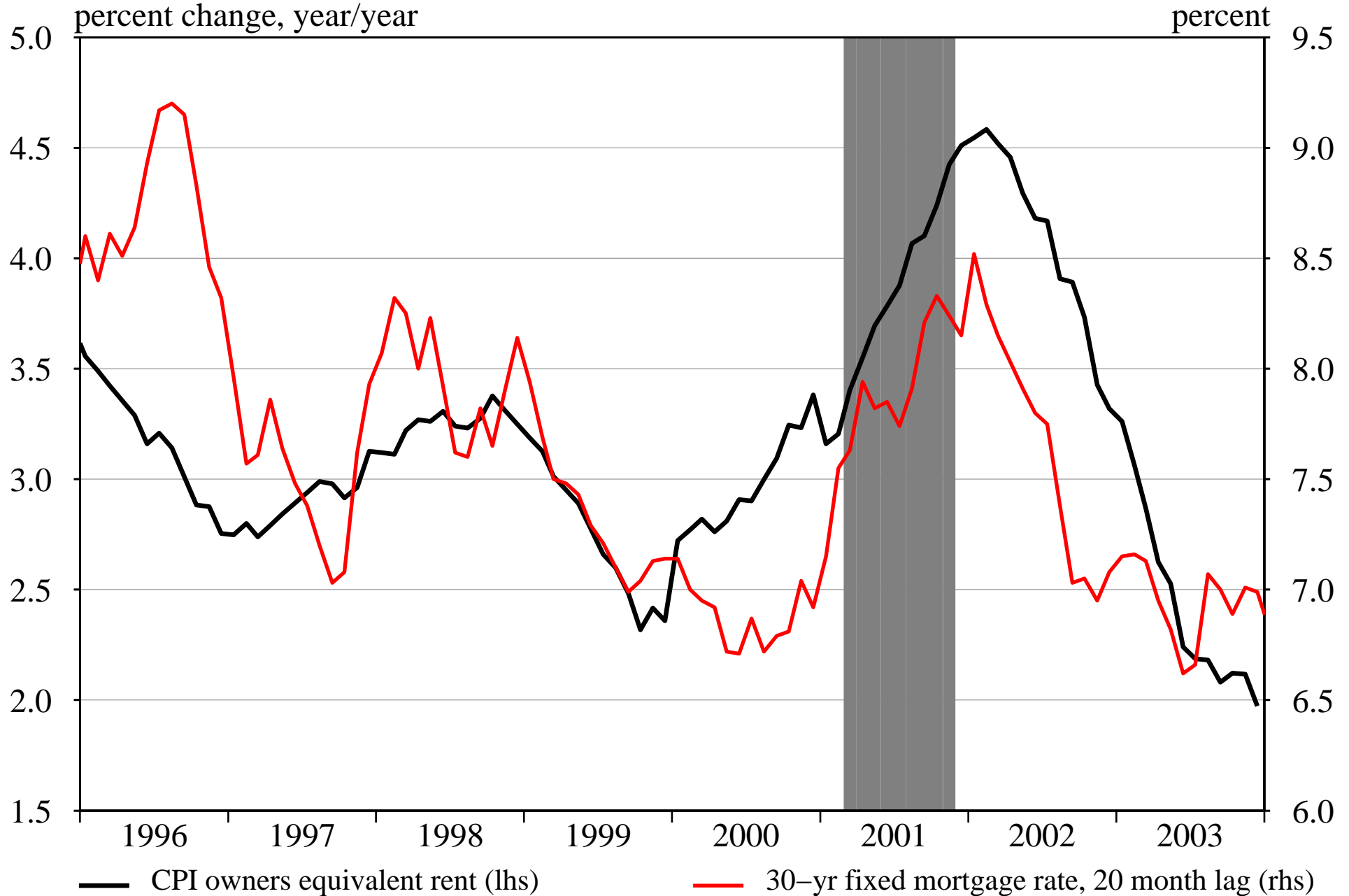
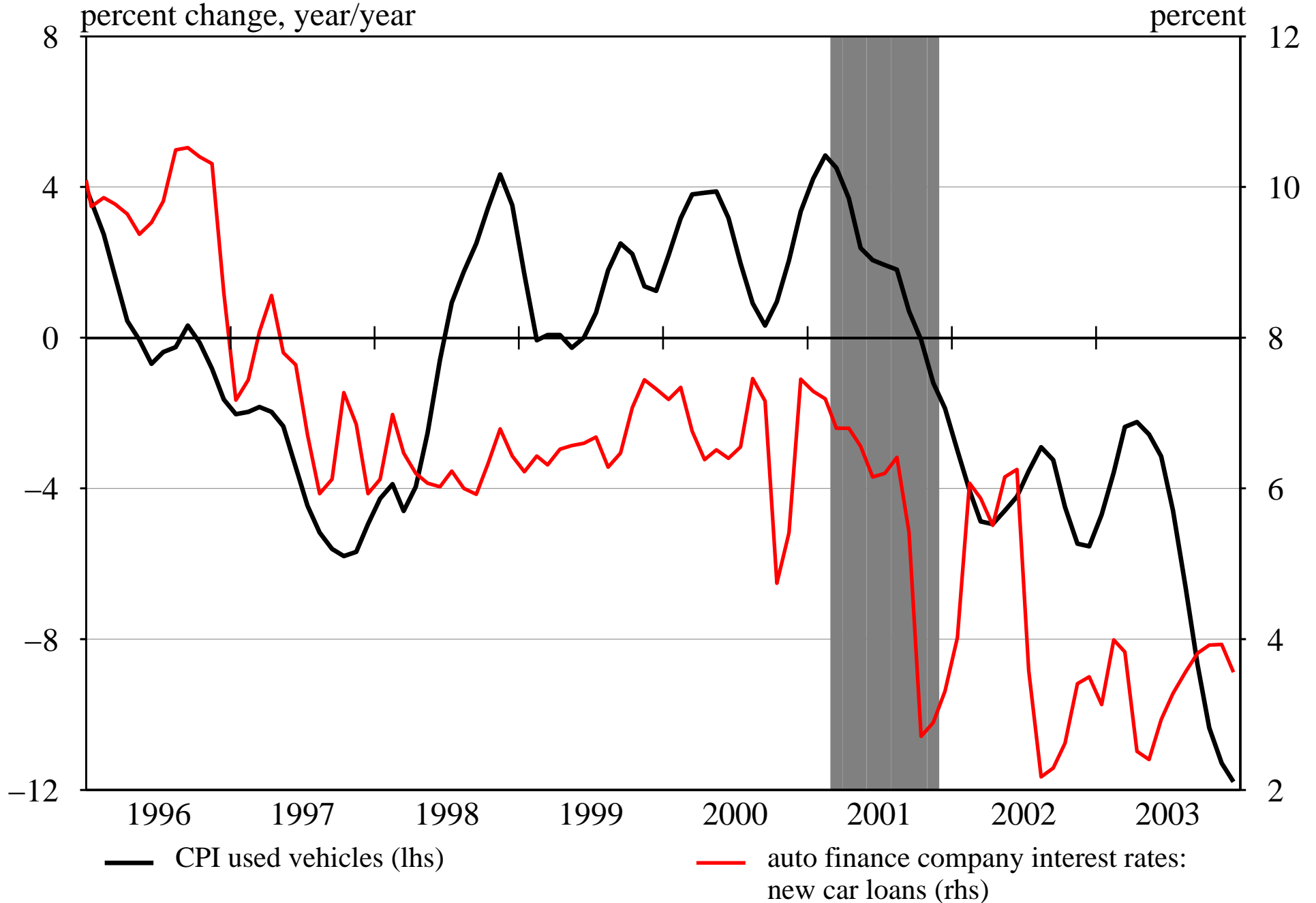


Figure 20

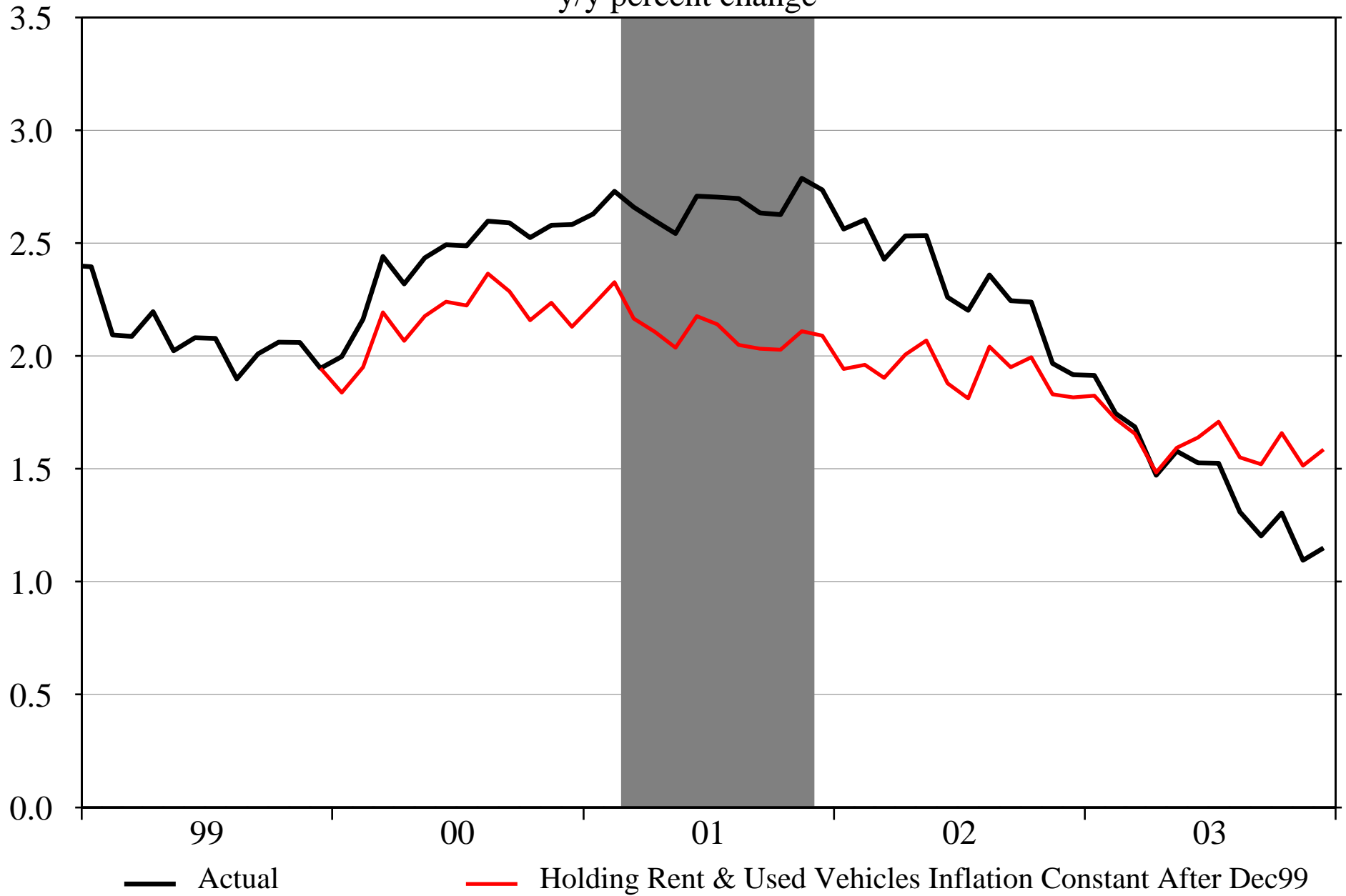
42

## Used Vehicle Prices and New Auto Finance Rates



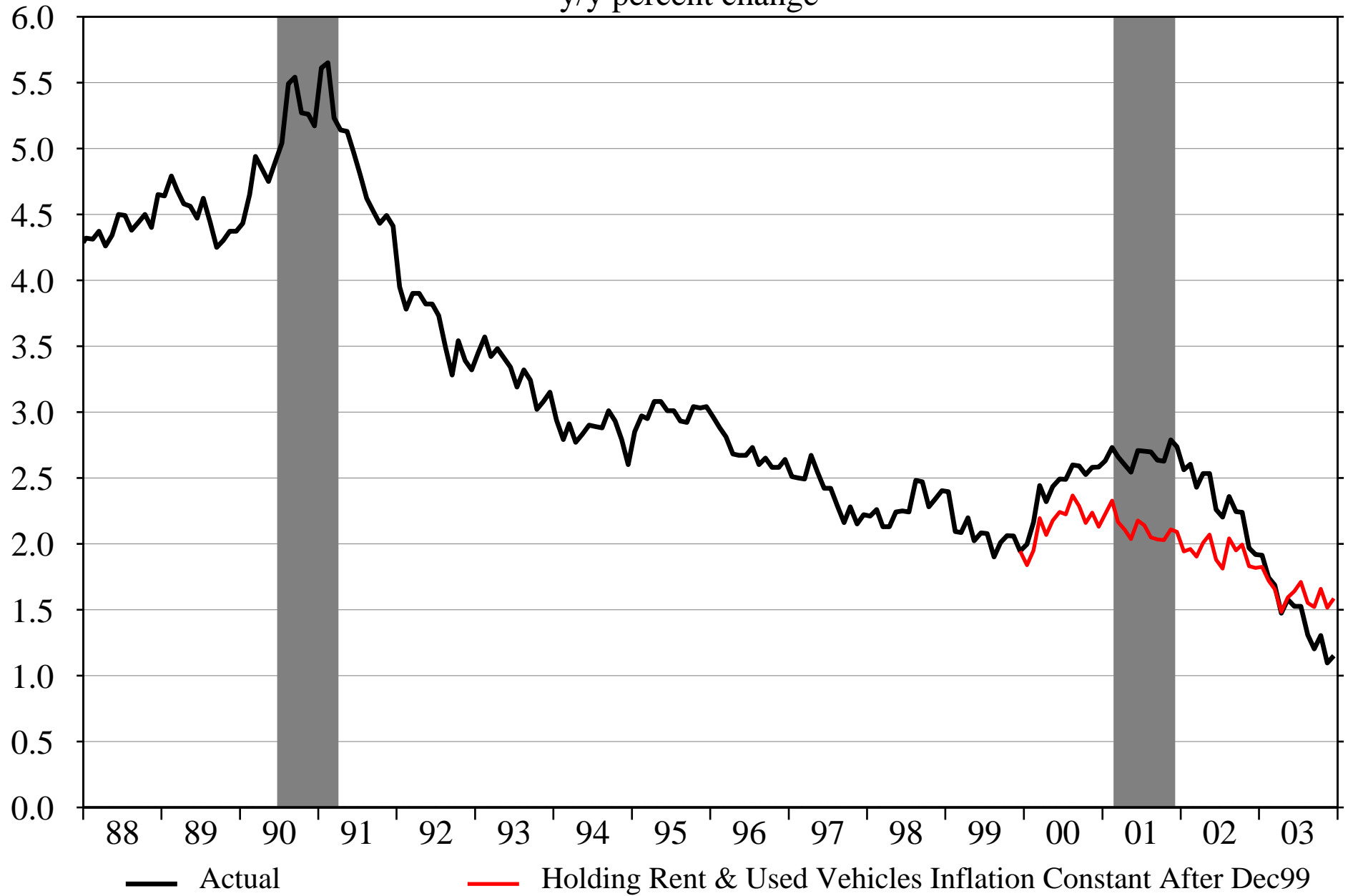
# CPI Core Inflation

y/y percent change



# CPI Core Inflation

y/y percent change



**Table 2: Breakdown of the Contributions to PCEPI Core Goods Inflation**

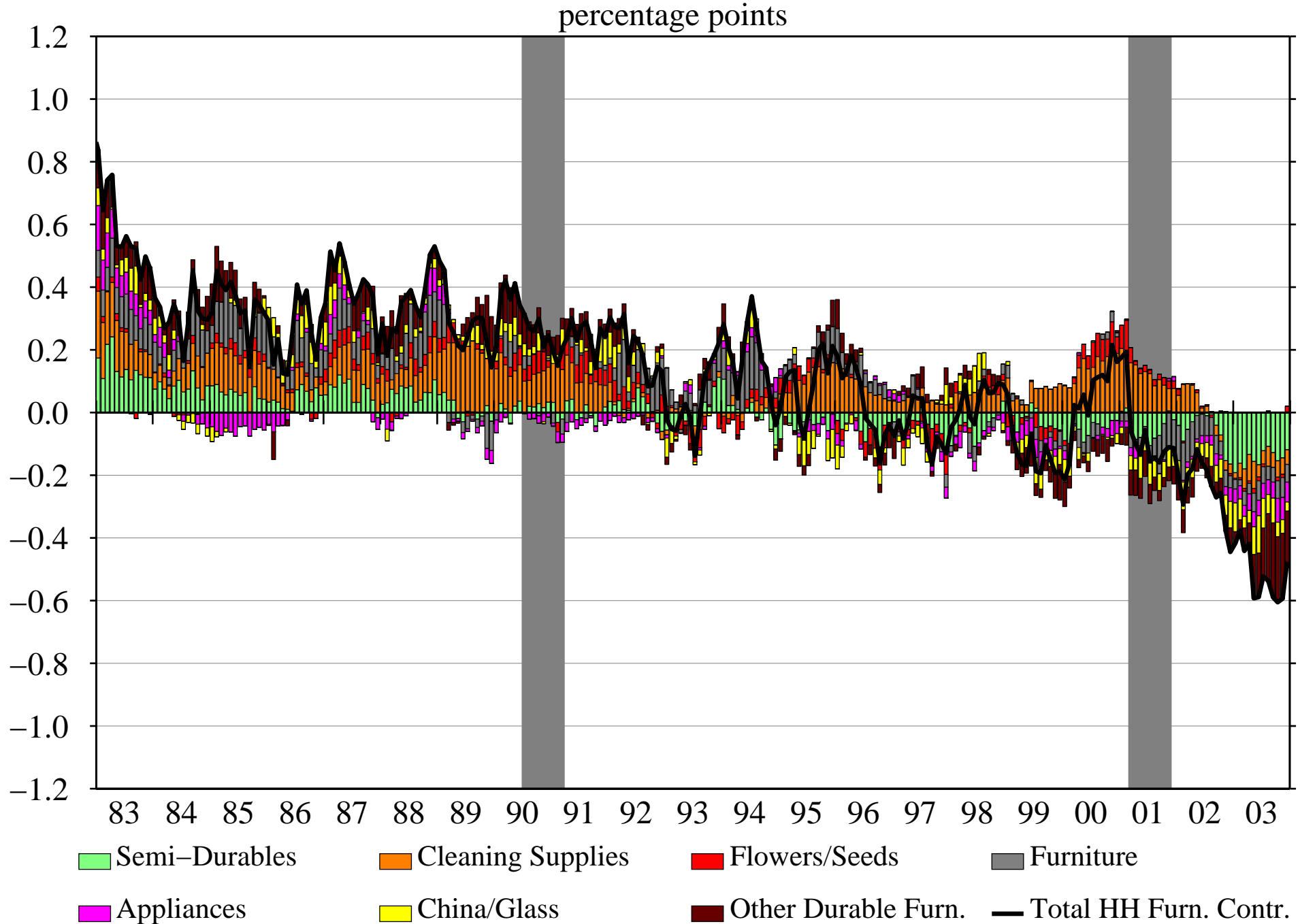
	Core PCE Goods Inflation	Alcohol	HH Furn.	Apparel	Transp. Goods	Medical Goods	Recreation Goods	Education Goods	Info. Goods	Other Goods
<b><u>1983-1991</u></b>										
<b>Ave. Growth/Contrib.</b>	<b>2.65</b>	<b>0.33</b>	<b>0.34</b>	<b>0.44</b>	<b>0.54</b>	<b>0.39</b>	<b>0.07</b>	<b>0.06</b>	<b>-0.10</b>	<b>0.55</b>
Standard Deviation	0.63	0.17	0.13	0.38	0.27	0.07	0.12	0.03	0.06	0.20
High	3.81	0.83	0.84	1.15	1.21	0.54	0.29	0.14	-0.01	1.22
Low	1.23	0.16	0.12	-0.42	-0.03	0.29	-0.17	-0.01	-0.27	0.28
<b><u>1992-2003</u></b>										
<b>Ave. Growth/Contrib.</b>	<b>-0.08</b>	<b>0.13</b>	<b>-0.03</b>	<b>-0.30</b>	<b>0.19</b>	<b>0.28</b>	<b>-0.21</b>	<b>0.03</b>	<b>-0.55</b>	<b>0.34</b>
Standard Deviation	0.99	0.06	0.21	0.24	0.46	0.13	0.21	0.03	0.23	0.32
High	2.47	0.42	0.37	0.43	1.11	0.55	0.22	0.08	-0.14	1.39
Low	-2.23	0.02	-0.61	-0.75	-0.74	0.05	-0.55	-0.09	-0.95	-0.30
<b><u>1992-2003 Period Less 1983-1991 Period</u></b>										
<b>Difference in Average Growth/Contribution</b>	<b>-2.73</b>	<b>-0.19</b>	<b>-0.37</b>	<b>-0.74</b>	<b>-0.35</b>	<b>-0.11</b>	<b>-0.28</b>	<b>-0.04</b>	<b>-0.45</b>	<b>-0.21</b>



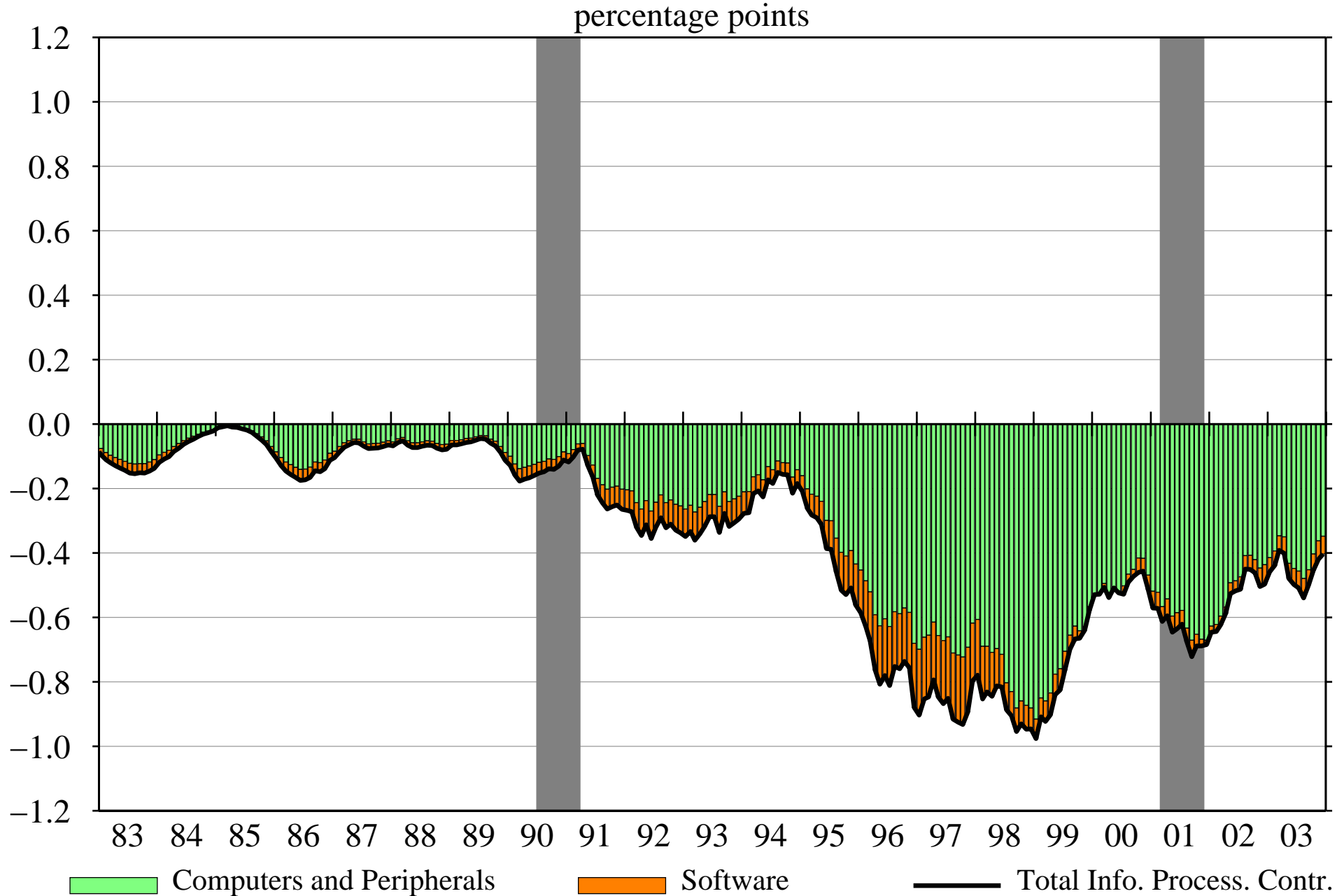
**Table 3: Breakdown of the Contributions to PCEPI Core Inflation**

	Core PCE Inflation	HH Furn.	Apparel	Transp. Goods	Medical Goods	Recreation Goods	Education Goods	Info. Goods	Other Goods	
<b><u>1983-1991</u></b>										
Ave. Growth/Contrib.	4.16	0.13	0.16	0.20	0.14	0.03	0.02	-0.04	0.20	
Standard Deviation	0.55	0.05	0.14	0.10	0.02	0.05	0.01	0.02	0.08	
High	6.07	0.32	0.42	0.47	0.19	0.11	0.05	0.00	0.47	
Low	3.54	0.05	-0.16	-0.01	0.11	-0.06	0.00	-0.09	0.11	
<b><u>1992-2003</u></b>										
Ave. Growth/Contrib.	1.95	-0.01	-0.10	0.07	0.09	-0.07	0.01	-0.18	0.11	
Standard Deviation	0.62	0.07	0.08	0.15	0.04	0.07	0.01	0.08	0.10	
High	3.82	0.12	0.14	0.37	0.18	0.07	0.03	-0.05	0.46	
Low	0.70	-0.19	-0.25	-0.24	0.02	-0.18	-0.03	-0.31	-0.10	
<b><u>1992-2003 Period Less 1983-1991 Period</u></b>										
Difference in Average Growth/Contribution	-2.20	-0.14	-0.26	-0.14	-0.05	-0.09	-0.01	-0.15	-0.09	
	Core PCE Inflation	Rent	Other Housing	Household Operations	Transp. Services	Medical Services	Recreation Services	Education Services	Comm. & Info. Services	Personal Services
<b><u>1983-1991</u></b>										
Ave. Growth/Contrib.	4.16	0.94	0.06	0.09	0.20	1.08	0.17	0.14	0.05	0.57
Standard Deviation	0.55	0.20	0.01	0.02	0.15	0.30	0.03	0.02	0.07	0.23
High	6.07	1.41	0.08	0.13	0.70	1.46	0.25	0.18	0.20	1.13
Low	3.54	0.42	0.03	0.07	-0.29	0.51	0.11	0.10	-0.09	0.14
<b><u>1992-2003</u></b>										
Ave. Growth/Contrib.	1.95	0.55	0.04	0.07	0.13	0.65	0.14	0.12	-0.01	0.33
Standard Deviation	0.62	0.09	0.02	0.01	0.06	0.20	0.03	0.02	0.04	0.22
High	3.82	0.80	0.06	0.12	0.35	1.11	0.20	0.17	0.06	1.01
Low	0.70	0.37	-0.01	0.03	0.01	0.41	0.06	0.09	-0.12	-0.22
<b><u>1992-2003 Period Less 1983-1991 Period</u></b>										
Difference in Average Growth/Contribution	-2.20	-0.40	-0.02	-0.02	-0.07	-0.43	-0.03	-0.02	-0.06	-0.24

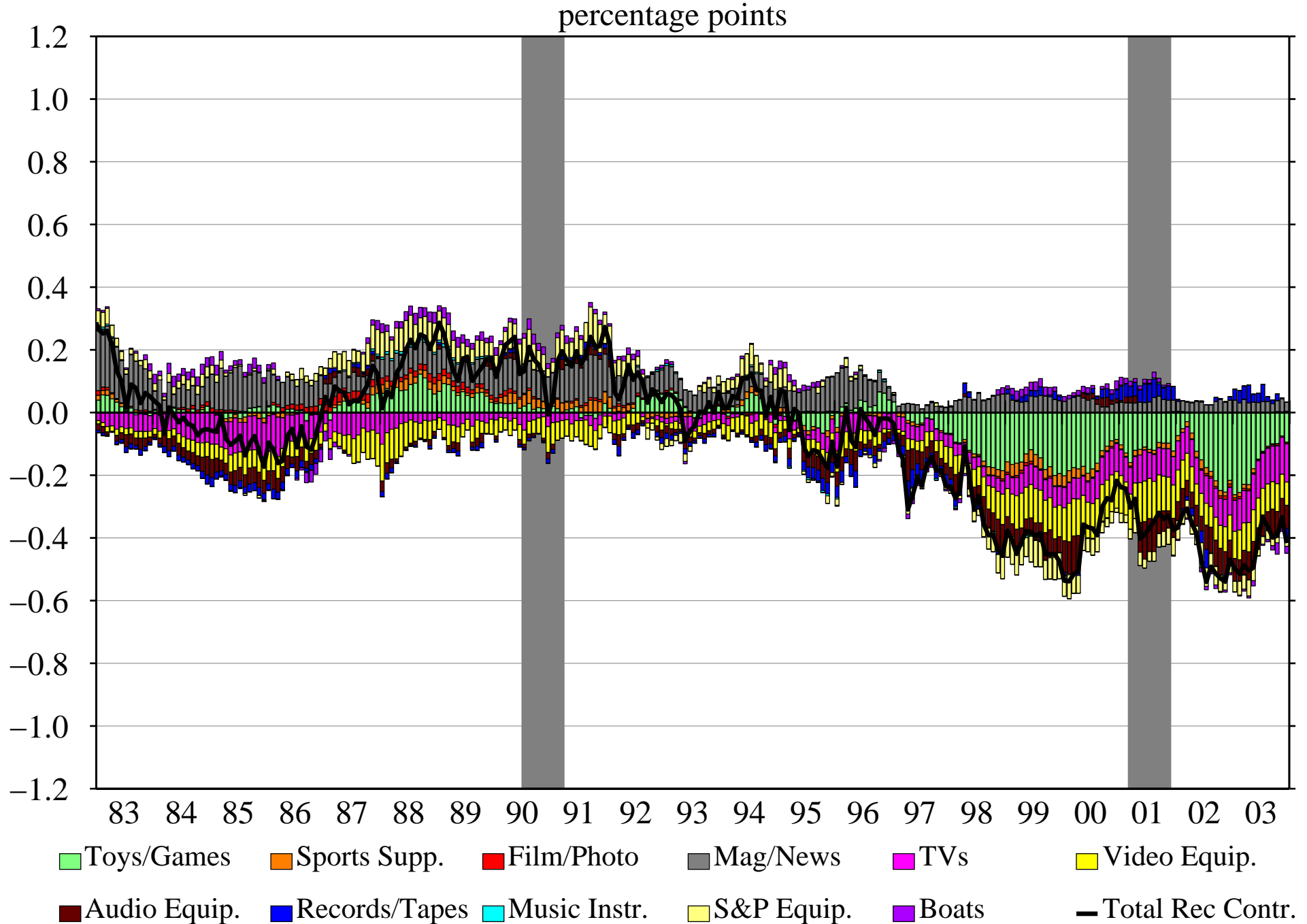
# Composition of HH Furn. Contribution to PCEPI Core Goods Inflation



# Composition of Info. Process. Contribution to PCEPI Core Goods Inflation



# Composition of Recreation Contribution to PCEPI Core Goods Inflation



# Composition of Transportation Contribution to PCEPI Core Goods Inflation

