Comparing PPI energy indexes to alternative data sources

The trend in measures constructed using alternative sources of price data for energy products tracks fairly well with changes in the Producer Price Index

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The Bureau of Labor Statistics produces a family of indexes, called Producer Price Indexes, that measure the average change in prices received by domestic producers for their output. These indexes, updated monthly, are published at numerous levels of product aggregation and in a variety of classification schemes. Periodically, BLS reviews its indexes by comparing them with alternative measures of price trends. This article presents the results of one such test, which focuses on the important and price-volatile group of energy commodities, as arrayed within a stage-of-processing system of price indexes.

Background

The stage-of-processing (SOP) system is one of the primary classification schemes used by BLS to develop Producer Price Indexes (PPIs). The SOP indexes are commodity-based measures that regroup commodities at the subproduct class,[1] according to the class of buyer and the amount of physical processing or assembling the products have undergone. There are three major, or aggregate, SOP categories of goods: finished, intermediate, and crude. Finished goods are defined as commodities that are ready for sale to the final user, which could be either an individual or a business firm. Examples include bread, gasoline, apparel, and passenger cars. Intermediate goods are materials, supplies, and components that have been partially processed but require further processing. Intermediate goods also consist of nondurable, physically complete goods purchased by business firms as inputs to their operations. Intermediate goods include flour, cotton yarn, steel mill products, and lumber. Crude materials are defined as unprocessed commodities entering the market for the first time, such as crude petroleum, natural gas to pipelines, gravel, sand, steel scrap, and coal.[2]

Movement in aggregate PPIs, including movement in the stage-of-processing indexes, is driven in large part by the price fluctuations for energy commodities. This is due to the large relative importance of energy product indexes in the aggregate PPIs, as indicated in the following tabulation:

Stage-of-processing category	*Relative importance*
Finished energy goods as a part of total finished goods	13.575
Intermediate energy goods as a part of total intermediate materials	13.132
Crude energy materials as a part of total crude materials	36.173

Historically, Crude, Intermediate, and Finished energy PPIs experience large month-to-month price fluctuations. (See chart 1.) For example, the PPI for Crude energy materials increased 11.1 percent in November 1996 and 19.3 percent the following month. One of the factors driving this increase was a rise in natural gas prices: the index for Natural gas increased 33.8 percent in November 1996 and 39.9 percent in December 1996 due to low inventory levels. With storage

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levels already low due to the previous year's severe winter, the early onset of winter weather in 1996 caused a further drawdown of natural gas inventories, creating concern over supply shortages. The Crude energy materials index subsequently showed large decreases of 17.9 percent in February 1997 and 21.3 percent in March 1997, as prices for natural gas declined from the previous year's high.

Another example of energy price volatility occurred in 1990, as the result of Iraq's invasion of Kuwait. This event caused sharp increases in crude and refined petroleum prices, in anticipation of oil shortages caused by the hostilities. In August 1990, the Crude energy materials index increased 25.1 percent and the Finished energy goods index rose 8.96 percent. The PPI for Crude petroleum increased 62.4 percent and the PPI for Gasoline was up 17.4 percent over the same month.

Given the volatility of the PPIs for energy commodities, BLS periodically reviews the indexes. Such reviews include checks on methodology, analysis of trends, and, recently, a rigorous comparison to movements in prices for energy commodities published by BLS and other statistical agencies.

In the sections that follow, the movements of several PPIs for energy products are compared with trends in other published measures for the period January 1995–December 1997. (See exhibit 1 for a list of the PPI series selected for study and the alternative data sources used.) Means and variance tests are used for statistical analysis. (See appendix.)

Statistical test methodology

Conducting statistical tests to compare two data sources has certain advantages and limitations. These tests do not indicate the accuracy of the data or how closely the data reflect actual market price movements. However, they can provide insight into the similarities or differences between the data being compared. Specifically, the tests can show the extent to which the data sources have similar movements, and the extent to which the variances of the data sources are comparable.

Two tests were used to compare the PPI data series being examined to similar data from alternative sources. The first was a means test, conducted to determine if these series have significantly different average month-to-month percentage changes. Second, a variance test was conducted to compare the monthly movements of the two data series. The methodology for these two tests is presented in the appendix.

Chart 1. Month-to-month percent changes in the Producer Price Indexes for Crude, Intermediate, and Finished energy goods, January 1990–March 1998

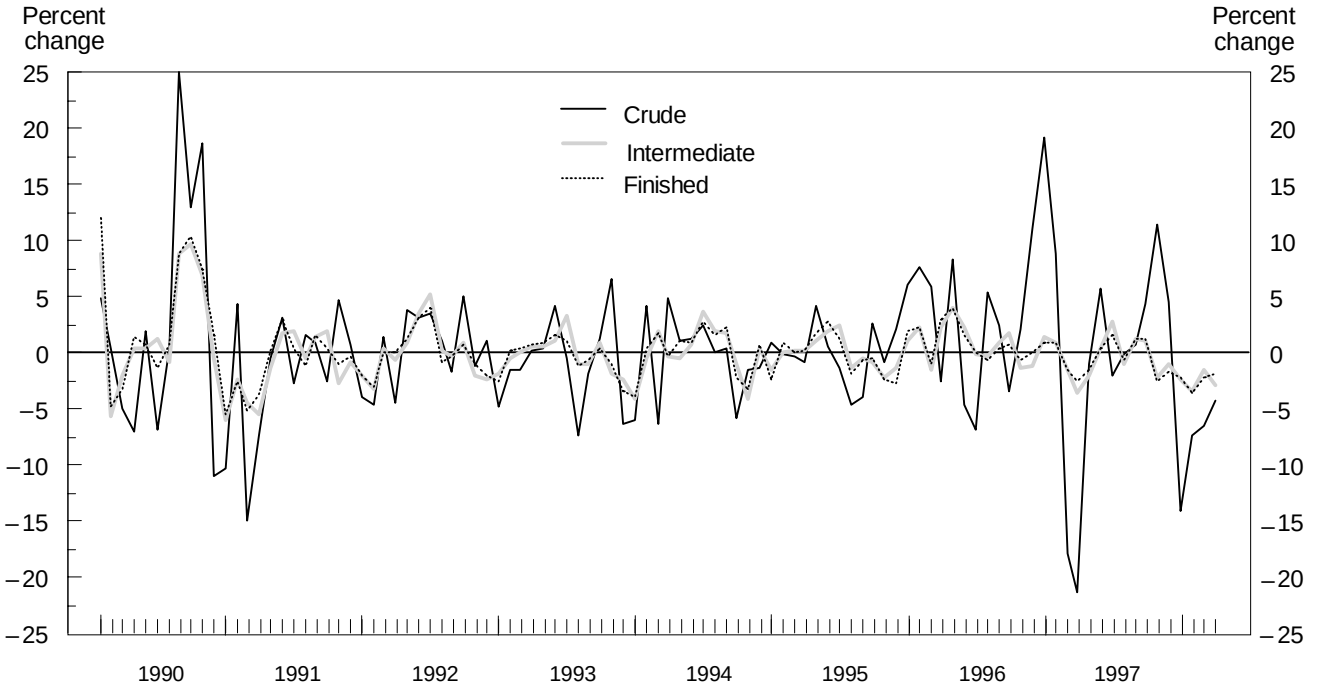


Exhibit 1. Selected Energy product indexes and corresponding alternative source data

Index number	Index	Alternative source data
PPI0531	Natural gas (Crude materials)	Energy Information Agency Natural gas data
PPI0561	Crude petroleum (Crude materials)	Energy Information Agency Crude petroleum data
PPI05730201	Fuel oil #2 (Finished goods)	Energy Information Agency Fuel oil #2 data
PPI0571	Gasoline (Finished goods)	Energy Information Agency Gasoline data
PPI0541	Residential electric power (Finished goods)	CPI for Residential Electric power
PPI0551	Residential natural gas (Finished goods)	CPI for Residential Natural gas

Performance measures

Most of the information used in calculating Producer Price Indexes is obtained through systematic sampling of the mining, manufacturing, and service sectors of the economy.[3] The energy industries covered by the PPI include crude and refined petroleum, natural gas at the wellhead, electric and natural gas utilities, and coal. Measures, or indexes, of price change classified by industry form the basis of the PPI program. These indexes reflect the price trends of a constant set of goods and services that represent the total output of an industry.[4] For example, the crude petroleum index includes both the Eastern and Western petroleum producing regions of the United States. The electric power and natural gas utilities indexes cover the residential, commercial, industrial, and "other" sectors.

In the PPI program, the preferred price to be collected is for an actual shipment that occurred as close as possible to the pricing date. The pricing date is the Tuesday of the week containing the 13th day of the month, and can range between the 9th and the 15th of the month. There are exceptions to the Tuesday pricing date for some products, however. A number of farm products are priced on a day of the week other than Tuesday. Prices for some refined petroleum products are commonly an average of prices during the first 10 working days of the month or the prices received by oil refineries on the tenth working day. Price indexes for liquefied petroleum gas, some industrial chemicals, and compact discs and audiotapes are based on data for the calendar month as a whole, and therefore lag 1 month behind other indexes. The November index for liquefied petroleum gas, for example, would reflect price changes that actually occurred in October.

Although most prices reported to BLS are the selling prices of selected producers that are referred to as free-on-board (f.o.b.) point of production, some prices are those quoted on organized commodity exchanges or at central markets. This practice is most often applied to farm products.[5] Order prices and "futures" prices are not included, because the PPI is intended to reflect the selling price for output being shipped in the reference month, not in some other period. Changes in transportation costs are reflected in industry price indexes only when the producing company delivers the product itself, rather than hiring a third-party shipper.[6]

For the purposes of the PPI program, a price is defined as the net revenue accruing to a specified producing establishment from a specified kind of buyer for a specified product shipped under specified transaction terms on a specified day of the month. Although the same product usually is priced month after month, it is necessary to provide a means for bridging over changes in detailed specifications so that only real price changes will be measured. Such an adjustment is especially important when an existing product is replaced by a new one. Even when companies report their selling prices based on altered transaction terms (such as price per 1,000 sold, instead of price per 100), routine steps are taken to ensure that only true price changes influence the index.

Because the Bureau of Labor Statistics publishes price indexes rather than the prices themselves, the BLS measures cannot be directly compared to published prices from other sources. To perform the analysis presented here, month-to-month percentage changes were calculated from the Producer Price Indexes. These changes were then compared with month-to-month percentage changes in the alternative data sources.

The alternative source data used include data published by the Energy Information Administration (EIA), and data from the Consumer Price Index (CPI), which is produced by the Bureau of Labor Statistics. The function of the EIA is to provide information to decisionmakers on energy policy issues. The primary users of the EIA data include the congress, the U.S. Government, the energy industry, academia, the media, and the public.[7] The major users of the CPI include the Federal Reserve Board, the congress, government, business executives, labor leaders, and the public.

Chart 2. **Month-to-month percent changes in the Producer Price Index for Natural gas (PPI0531) and EIA Natural gas wellhead prices, February 1995–December 1997**

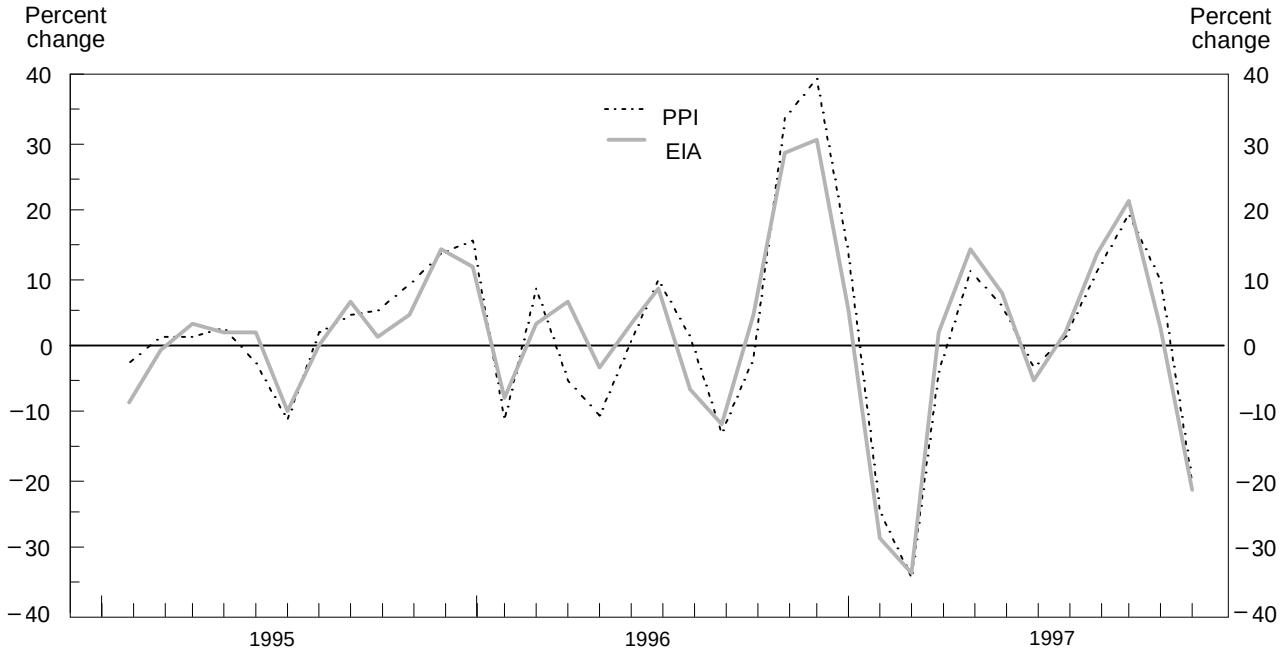
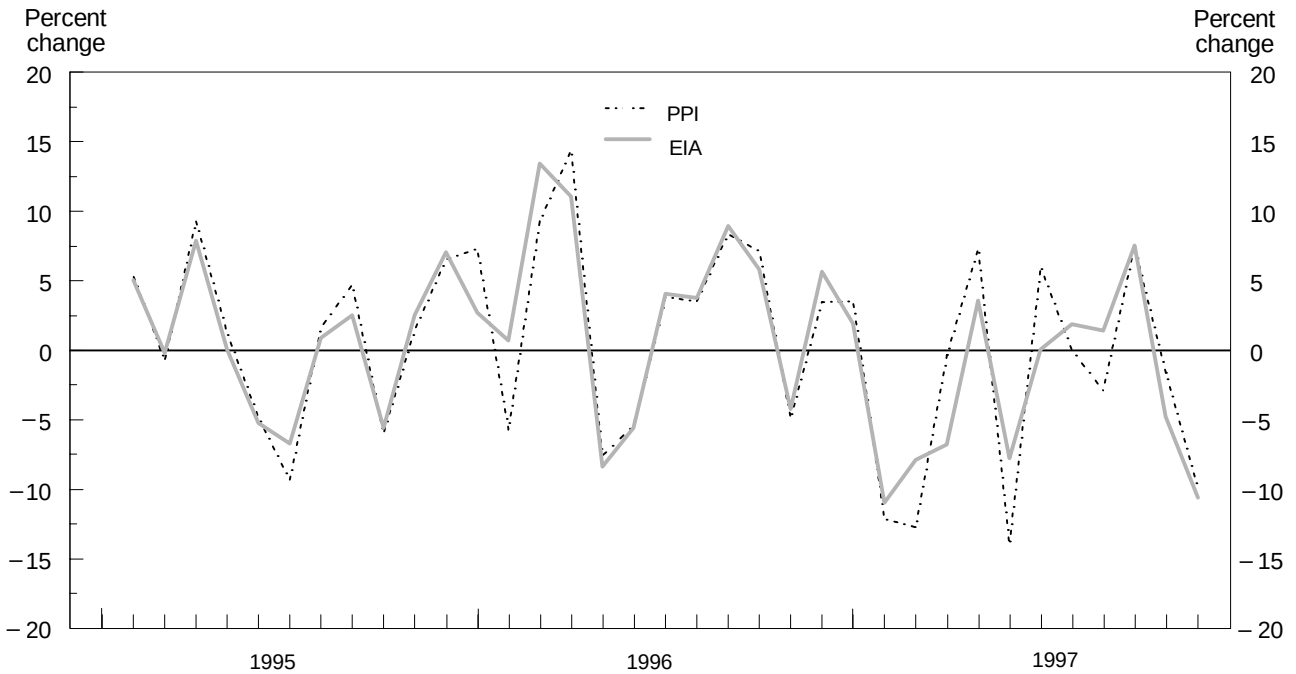


Chart 3. **Month-to-month percent changes in the Producer Price Index for Crude Petroleum (PPI0561) and EIA Crude oil prices, February 1995–December 1997**



The EIA and CPI data sources are described in detail below. An accompanying chart compares the month-to-month percentage changes in the PPI and in the alternative data source.

Comparisons with EIA data

The Energy Information Administration collects large amounts of energy product data. This information is valuable because of its variety, and includes data on prices, production, and sales, as well as detailed breakdowns.

The EIA publishes monthly average prices for natural gas, crude oil, fuel oil #2, and gasoline. While these data are useful for purposes of this analysis, it should be noted that the published prices represent full-month averages, as opposed to PPI data, which pertain to a specified pricing date within the month. Also, final data from the EIA are available after a 2- to 3-month lag, while Producer Price Indexes are published for the express purpose of month-to-month analysis of price change.

EIA Natural gas data. Final monthly average data on natural gas prices at the wellhead are obtained from Form EIA-627 and Form EIA-176, along with numerous other data related to natural gas production. Data on all aspects of monthly and annual natural gas production, including wellhead prices, are collected using Form EIA-627. The appropriate State agencies participate voluntarily in the survey. States complete the form by collecting information from natural gas producers. Form 176 is a mandatory form, and wellhead price data from this form are used here in cases for which EIA-627 wellhead price data are not available. Form 176 data are collected directly from field, well, or processing plant operators, synthetic natural gas plant operators, underground natural gas storage operators, investor and municipally owned natural gas distributors, and interstate and intrastate natural gas pipeline companies. Estimates for monthly natural gas prices are based on the change in production-weighted gas prices from Kansas, Mississippi, New Mexico, Oklahoma, and Texas. The gas production from these five States represents approximately 50 percent of total U.S. production, and its prices are readily available. Final revisions to the EIA monthly natural gas wellhead price data are made when the final annual data reported on the forms described above become available. This means that the current year's prices are estimated.[8] Chart 2 compares the month-to-month percentage changes in the PPI for Natural gas to changes in the EIA data.

EIA Crude oil data. The EIA publishes first-purchase prices for domestic crude oil on a monthly basis. These data, collected on Form EIA-182—Domestic Crude Oil First Purchase Report, are average wellhead price data from petroleum producers, and represent the average price at the wellhead at which domestic crude oil is purchased.[9] Chart 3 compares the month-to-month percentage changes in the PPI for Crude petroleum with the corresponding changes in the EIA data.

EIA Fuel oil #2 data. Each month, the EIA publishes data on prices of refined petroleum, as obtained from Form EIA-782A—Refiners'/Gas Plant Operators' Monthly Petroleum Product Sales Report, and Form EIA-782B, Resellers'/Retailers' Monthly Petroleum Product Sales Report. This survey collects data on a monthly basis from respondents who either directly or indirectly control a refinery or gas plant facility.[10] Chart 4 compares the month-to-month percentage changes in the PPI for Fuel oil #2 to changes in the EIA data.

EIA Gasoline data. The EIA survey forms described for Fuel oil #2 are the same ones used to collect Gasoline data. Chart 5 compares the month-to-month percentage changes in the PPI for Gasoline to corresponding changes in the EIA data.

Comparisons with the CPI

For purposes of this analysis, PPI data also were compared with CPI data, primarily because of the quality of both data series. But, while both the PPI and CPI are measures of price change over time for a fixed set of goods and services, they differ in two critical areas: (1) the composition of the set of goods and services, and (2) the types of prices collected for the goods and services included.

The target set of goods and services included in the PPI is the entire marketed output of U.S. producers; thus, imports would be excluded. The set includes both goods and services purchased by other producers as inputs to their operations or as capital investment, and goods and services purchased by consumers, either directly from the service provider or indirectly from a retailer. In contrast, the target set of items included in the CPI is the set of goods and services purchased by urban U.S. households; this set includes imports. This difference in the target sets of goods means that, while the CPI program collects prices only for electricity and natural gas sales made to residential consumers, the PPI program also collects prices for sales to commercial and industrial consumers.

The other area of difference between the PPI and CPI is in the type of price collected. The price collected for an item included in the PPI is the revenue received by the producer. Sales and excise taxes are not included because they do not represent such revenue. The price collected for an item included in the CPI is the out-of-pocket expenditure by a consumer for the item. Sales and excise taxes are included in the collected price because they are necessary expenditures by the consumer for the item.

More significant differences in the CPI and PPI occur as the lower level indexes are aggregated into higher level indexes. This is because the CPI and the PPI have different intended objectives and uses. A primary use of the PPI is to deflate revenue streams in order to measure real growth in output. The objec-

Chart 4. **Month-to-month percent changes in the Producer Price Index for Fuel oil #2 (PPI05730201) and EIA Fuel oil #2 prices, February 1995–December 1997**

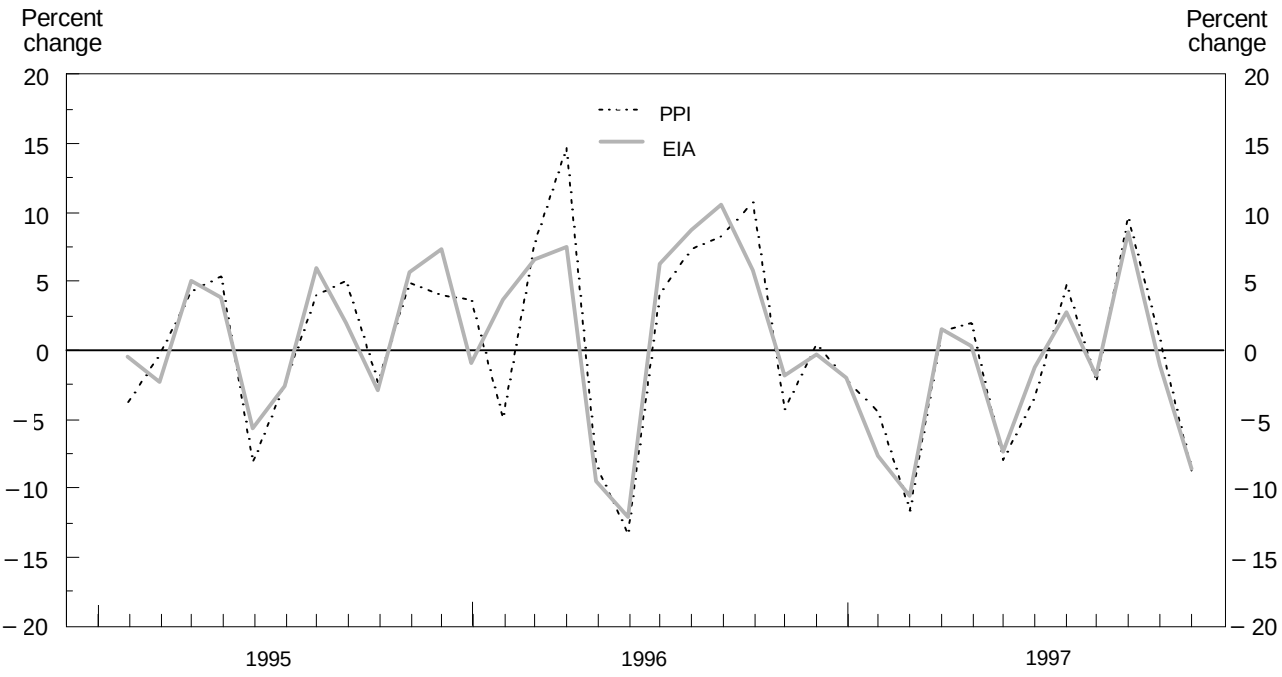
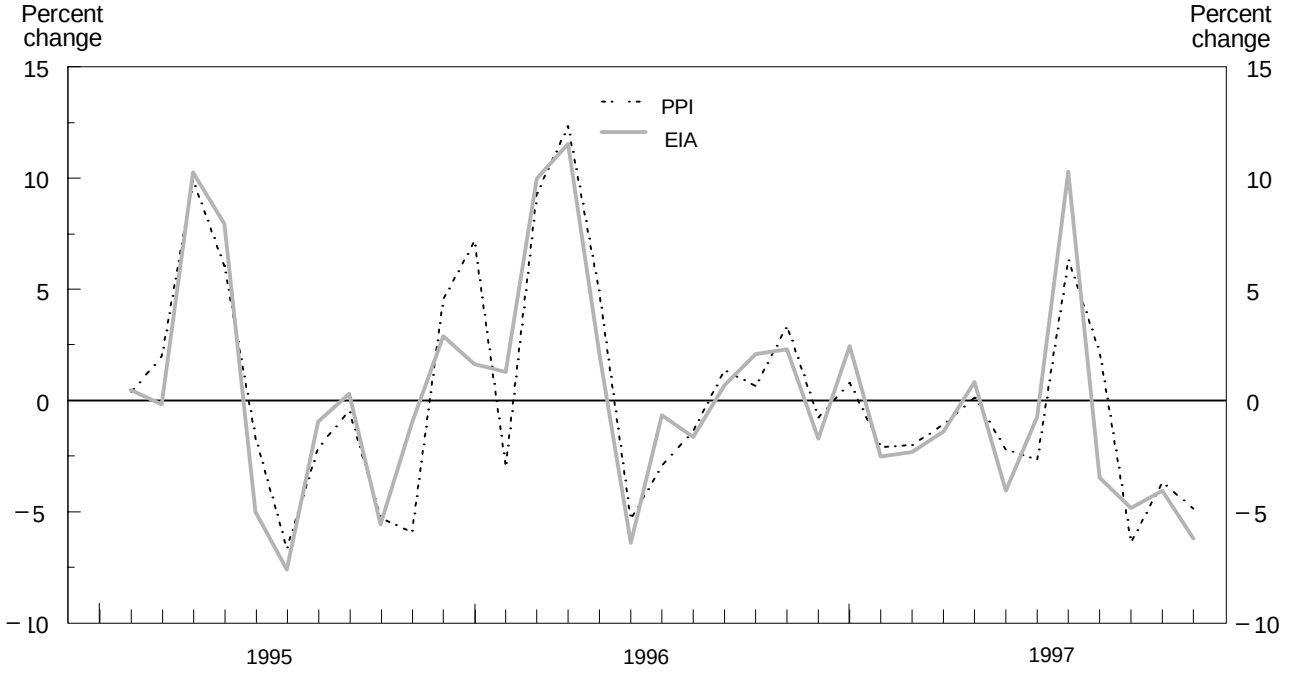


Chart 5. **Month-to-month percent changes in the Producers Price Index for Gasoline (PPI0571) and EIA Gasoline prices, February 1995–December 1997**



tive of the CPI program is to approximate a cost-of-living index conditioned on market prices—in other words, to measure the change in consumers' well being that results from changes in consumer prices. (One use of the CPI is to adjust income streams such as Social Security payments.) Because of the different uses of the PPI and CPI, each program utilizes a different weighting scheme. PPI weights currently are based on the value of shipments of products as reported by producers for the 1992 economic census. For the period through December 1997, CPI weights were based on expenditures reported by households for the years 1982–84. Because of the difference in the weights for the Electricity and Natural gas indexes in the two programs, price changes have differing degrees of impact on the higher level aggregate indexes in each program.

Aggregation of the indexes in the two programs also results in index series that are unique to each program. The CPI program calculates indexes for Residential electricity and for Natural gas for 32 metropolitan areas plus 12 region-city size classes (not all of which are published). The national-level indexes for electricity and for natural gas are aggregations of these 44 individual indexes. The PPIs for the same products do not approach this level of detail, being published only for nine census regions.

So, at the lowest level, the Electricity indexes in the two programs are relatively similar, but do demonstrate differences. However, as the indexes are combined into higher level aggregates for different objectives or uses, the measures become more dissimilar.

CPI Residential electric power data. The not seasonally adjusted CPI for electricity, U.S. City average for all urban consumers (series ID F01), was used as the alternative data source for comparison to the PPI for Residential electric power (PPI 0541). The CPI was chosen because of the comparability of the data that are collected for each index series, subject to the differences mentioned previously. Both the CPI and the PPI programs price residential utility bills based upon selected usage levels for a given month. In addition, the populations from which the items are chosen and the sampling methodologies used in both programs are virtually identical. Once a utility is selected from the population, analysts in each program use a process called "disaggregation" to select a unique item to be priced from month to month. In each case, prices are collected directly from the utilities. Chart 6 compares the month-to-month percentage changes in the PPI for Residential electric power with changes in the CPI for Electricity.

Table 1. Results of means tests of percent changes in prices for selected energy commodities

Commodity tested	*t*-value of means test	*t*-statistic	Decision on null hypothesis
Natural gas	0.1377	1.69	Fail to reject
Crude petroleum	–.0057	1.69	Fail to reject
Fuel oil #2	.0164	1.69	Fail to reject
Gasoline	.1013	1.69	Fail to reject
Residential electricity	.0382	1.69	Fail to reject
Residential natural gas	.0105	1.69	Fail to reject

Table 2. Results of variance tests of percent changes in prices for selected energy commodities

Commodity tested	*F*-value of variance test	*F*-statistic	Decision on null hypothesis
Natural gas	1.1656	1.57	Fail to reject
Crude petroleum	1.2862	1.57	Fail to reject
Fuel oil #2	1.2204	1.57	Fail to reject
Gasoline	.9619	1.57	Fail to reject
Residential electricity	1.5161	1.57	Fail to reject
Residential natural gas	1.0953	1.57	Fail to reject

CPI Residential natural gas data. The seasonally unadjusted CPI for Piped natural gas, U.S. City average for all urban consumers (series ID F02), was used as the alternative data source for comparison to the PPI measure for Residential natural gas (PPI 0551). The CPI for piped natural gas was chosen for the reasons stated in the section on Electric utility data above. Chart 7 compares the month-to-month percentage changes in the PPI for Residential natural gas to changes in the CPI for Piped natural gas.

Results of statistical tests

Tables 1 and 2 summarize the statistical results of the means and variance tests applied to the differences in changes between the price measures. There are 35 observations for each PPI data series and alternative data source. Unlagged PPI natural gas data were used for the period January 1995 through June 1996.

In table 1, the *t*-value calculated for each item is shown in the first data column. This value was compared to the *t*-statistic shown in the second data column. For all of the means tests, there was a failure to reject the null hypothesis that the means of the percentage changes for each pair of data series are the same.

Table 2 shows the calculated *F*-value and the corresponding *F*-statistic used to test the variances of the percentage changes of the data series. For all of the variance tests, there was a failure to reject the null hypothesis equating the variance for each pair of data series.

MONTH-TO-MONTH PERCENTAGE changes in the PPI energy series perform well when compared with corresponding changes in alternative data sources. There is no indication that the month-to-month percentage changes for the PPIs examined are significantly different from corresponding changes in alternative series. All of the data series examined similarly reflect any unusual price movements in the energy industries selected

Chart 6. **Month-to-month percent changes in the Producer Price Index for Residential electric power (PPI0541) and the Consumer Price Index (CPI) for Electricity, February 1995–December 1997**

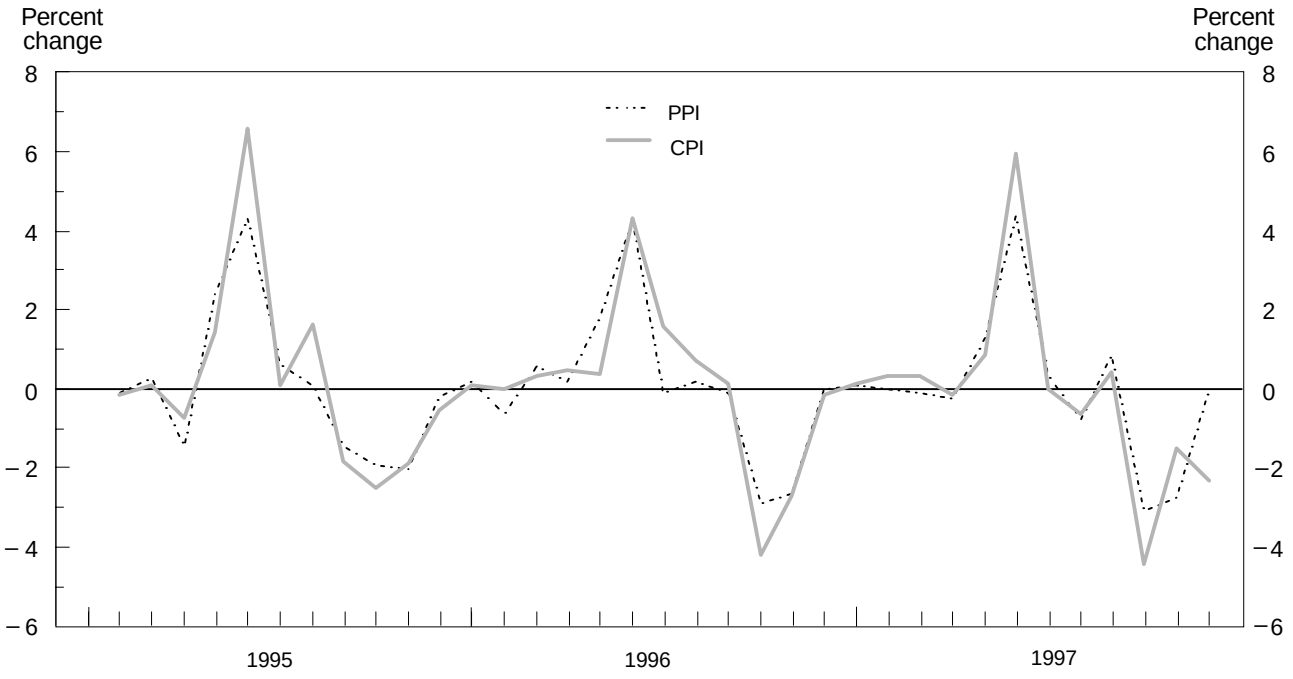
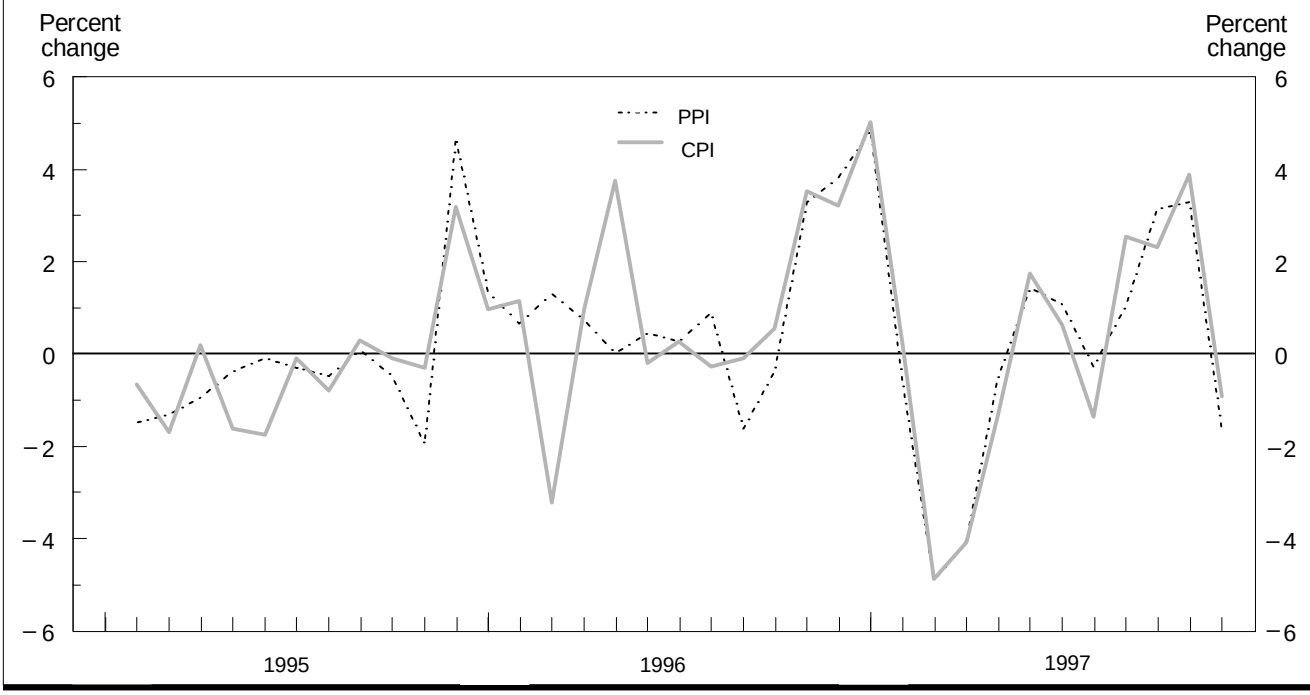


Chart 7. **Month-to-month percent changes in the Producer Price Index for Residential natural gas (PPI0551) and the Consumer Price Index (CPI) for Piped natural gas. February 1995–December 1997**



for study. The tests of the means and the variance tests used to compare the PPI series to the alternative source data failed in all cases to reject the null hypothesis that the trends of the series were essentially similar. □

Footnotes

[1] The subproduct class level is the six-digit level of the Producer Price Index Classification system unique to the PPI program. A complete listing of the commodity structure is avaiable on the Internet at: **ftp://146.142.4.23/pub/time.series/wp/wp.item**

[2] For further information on these indexes see *BLS Handbook of Methods,* Bulletin 2490 (Bureau of Labor Statistics, 1997), ch. 14.

[3] *BLS Handbook of Methods,* ch. 14.

[4] *Ibid.*

[5] *Ibid*.

[6] *Ibid.*

[7] See Energy Information Administration, *1998–2002 Strategic Plan,* section i, pp. 1–3, on the Internet at: **http://www.eia.doe.gov/faq.html**

[8] Energy Information Administration, *Directory of Energy Data Collection Forms* (Washington DC, U.S. Government Printing Office, 1996), pp. 5 and 8.

[9] *Ibid*., p. 5.

[10] *Ibid*., pp. 8–9.

APPENDIX: Test methodology

Means test

A test was conducted to compare the mean 1-month percent change of the measures based on alternative data sources to the mean 1-month percent change of the PPI data series. This test is used to indicate if the series have significantly different month-to-month percentage changes over the period examined.

The null hypothesis, $H_0 : \overline{X}_a = \overline{X}_b$, was tested against the alternative hypothesis, $H_1 : \overline{X}_a \neq \overline{X}_b$, where $\overline{X}_a$ and $\overline{X}_b$ represent the mean 1-month percentage change of the two samples being compared. Rejection of the null hypothesis occurs when the calculated *t*-test values fall outside the bounds of the two-tailed *t*-statistic. The *t*-test is based on a level of significance $\alpha = .10$.

The critical *t*-values are $(t_{\alpha/2})\,(n_a + n_b - 2)$, or $t_{1-(\alpha/2)}\,(n_a + n_b - 2)$.

The test statistic is $t_{obs} = \dfrac{(\overline{X}_a - \overline{X}_b)}{\sqrt{s_p^2\,[(1/n_a) + (1/n_b)]}}$,

where $s_p^2 = \dfrac{(n_a - 1)s_a^2 + (n_b - 1)s_b^2}{(n_a - 1) + (n_b - 1)}$.

H_0 is rejected when[1] $t_{obs} < t_{(\alpha/2)}\,(n_a + n_b - 2)$, or $t_{obs} > t_{1-(\alpha/2)}\,(n_a + n_b - 2)$.

Variance test

The following *F*-test statistic was used to test the homogeneity of the variances of the 1-month percentage changes for the PPI data series and for the corresponding measures based on alternative data sources:

$$F = s_L^2 \Big/ s_S^2 \quad .$$

Here s_L^2 represents the larger sample variance and s_S^2 represents the smaller sample variance. It is assumed that both data series have normally distributed sample populations and that the samples were randomly and independently selected from their respective populations.

The null hypothesis, H_0: $S_L^2 = S_S^2$, was tested against the alternative hypothesis, H_1: $S_L^2 \neq S_S^2$. Rejection of a null hypothesis occurs when the calculated *F*-test value exceeds a critical *F*-value based on the number of degrees of freedom and an established level of significance. The degrees of freedom are the number of observations minus 1. The level of significance used for this test was $\alpha = .10$. The critical *F*-value[2] was $F_{1-(\alpha/2)}\,(n_1 - 1, n_2 - 1)$.

Footnotes to the appendix

[1] Thomas H. Wonnacott and Ronald J. Wonnacott, *Introductory Statistics for Business and Economics* (New York, John Wiley & Sons, 1984), pp. 231–33.

[2] B.J. Winer, *Statistical Principles in Experimental Design* (New York, McGraw Hill Book Co., 1971), pp. 26–35.