Do Producer Prices Lead Consumer Prices?

By Todd E. Clark

From June 1994 to June 1995, producer prices increased rapidly. Excluding food and energy, prices of crude materials and intermediate goods rose at annual rates of 7.2 and 16.7 percent, respectively. At the same time, however, prices of consumer goods and services excluding food and energy increased a more modest 2.9 percent. Many analysts are concerned that recent increases in the prices of crude and intermediate goods may be passed through to consumers, resulting in a higher rate of inflation in consumer prices later this year and perhaps in 1996.

This article examines whether price increases at the early stages of production should be expected to move through the production chain, leading to increases in consumer prices. In the first section, a review of basic economic theory suggests there should be a pass-through effect—that is, producer prices should lead and thereby help predict consumer prices. A more sophisticated analysis, though, suggests the pass-through effect may be weak. In the second section, an examination of the empirical evidence indicates that producer prices are not always good predictors of consumer prices. The article concludes that the recent increases in some producer prices do not necessarily signal higher inflation.

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WHY MIGHT PRODUCER PRICES LEAD CONSUMER PRICES?

Economic reasoning suggests that the chain of production should link movements in producer prices to subsequent movements in consumer prices, so that changes in producer prices will lead changes in consumer prices. Such analysis, however, puts aside the complexities of firms' pricing decisions and the way the producer price and consumer price indexes are constructed.

The production chain

Producer and consumer prices are measured by the producer price index (PPI) and consumer price index (CPI), respectively. The PPI collectively refers to three different indexes, one for crude materials, one for intermediate goods, and one for finished goods. The CPI refers to a single index, covering the prices of a typical basket of goods and services purchased by the typical consumer. More specialized indexes of consumer prices are also available. For example, the so-called core CPI measures the prices of nonfood and nonenergy goods and services purchased by consumers.

The producer and consumer price indexes are often viewed as prices of different goods along a chain of production.[1] Typically, producer prices are seen as prices of input goods, which are used to produce final goods. Consumer prices are seen as prices of the final goods, which are sold to consumers. In this simplified view, the PPIs for crude materials, intermediate goods, and finished goods correspond to different input goods linked by their sequential places in the production chain. Crude materials serve as inputs to the production of intermediate goods, which in turn serve as inputs to the production of finished goods.

In many respects, the construction of the producer and consumer price indexes is consistent with this view. For example, the crude materials PPI includes the price of iron, while the intermediate goods PPI includes the prices of steel mill products, which are produced using iron. The finished goods PPI includes the prices of machine tools, which are constructed from steel mill products. Finally, the CPI includes the prices paid by consumers for goods, such as hand drills, which are produced using machine tools. As this example indicates, the producer and consumer price indexes sometimes represent sequential input and final goods prices (U.S. Department of Labor).

Economic reasoning also suggests there are important links between the prices of different goods along the chain of production. In theory, a firm sets its price as a markup over production cost, where cost is defined in the broad sense used by economists to include a normal return or profit for investors and firm owners.[2] For example, a firm in a highly competitive industry might use a markup of 1.0 times its production cost, which means the firm sets its price equal to the cost of production. A firm in a less-competitive industry might set its price at 1.2 times the cost of production. This markup of price over production cost allows the firm to pay for such things as product advertisement or an above-normal return to investors. Given the markup, a change in cost will cause the price to change. For instance, if a drill manufacturer suffers an increase in production cost, the firm will pass through the higher cost to the price of a drill. Consequently, an increase in the price of an input material will push cost up, causing a firm to raise its price.

Thus, simple theory suggests the chain of production should link movements in the PPI to subsequent movements in the CPI. Changes in producer prices at earlier stages of production should pass through to producer prices at later stages of production and, ultimately, to consumer prices.

Difficulties with the production chain view

While economic theory suggests producer prices lead consumer prices, careful consideration of the construction of PPI and CPI data and more sophisticated economic reasoning suggest the production chain linkage may be weak.

Data construction. Two difficulties with the construction of the two indexes weaken the ties between producer and consumer prices. First, the organization of the PPIs for crude materials, intermediate goods, and finished goods does not always follow a simple production chain. Second, the definitions of the PPI and CPI differ sharply.

The different PPI series are organized by the amount of physical processing or assembling a good has undergone and by the industry classification of the good's buyer. The crude materials index measures the prices of unprocessed commodities. The intermediate goods index measures the prices of nondurable, physically complete goods purchased for use as inputs, as well as commodities which have been processed but will require more processing before sale to the end user. The finished goods index measures prices for items ready to be sold to the final user.

In reality, this organization of the producer price indexes is too broad for the indexes to be linked by a simple chain of production.[3] The complicated and intricate relationships among U.S. industries preclude separating goods into crude, intermediate, and finished categories such that crude materials are used only to produce intermediate goods, which in turn are used only to produce finished goods.[4] Many firms produce goods which are used in a variety of ways to produce a variety of other goods. For example, items included in the crude materials category are often used to produce goods included in both the intermediate and finished goods categories. Accordingly, an increase in the prices of such crude materials will inflate the prices of both some intermediate and some finished goods. If prices were connected by a simple production chain, the crude materials increase would directly cause only intermediate goods prices to rise, with the increase in intermediate prices passing through to finished goods.

A second difficulty with the construction of the two indexes is that they differ sharply in definition.[5] The PPI tracks prices received by domestic producers, while the CPI measures the prices consumers pay. More importantly, the producer and consumer price indexes differ in that the PPI measures only domestic prices, while the CPI includes the prices of both domestic and imported goods. And, the PPI is based largely on goods prices, while the CPI is based on both goods and services prices.

Such differences also weaken the production chain linkage from the PPI to the CPI. Given the definitional disparities, changes in producer prices may not lead to changes in consumer prices. Suppose, for example, that prices of domestic producer goods rise, causing the PPI to rise. With pass-through, the prices of domestic consumer goods would also rise. But if the increase in domestic consumer prices were accompanied by falling import prices, the increase in domestic prices would be at least partially offset by the decrease in import prices. The CPI could then rise much less than the PPI. Similarly, the behavior of producer and consumer prices would differ if goods prices rose but services prices fell. An increase in prices of producer goods would cause the PPI to rise and, in turn, push prices of consumer goods higher. However, falling prices for consumer services would mitigate rising prices for consumer goods. On net, consumer prices could rise much less than producer prices.

While including services in the CPI may weaken the relationship of the PPI to future movements in the CPI, the view that the production chain connects these indexes may still be valid and useful. The Bureau of Labor Statistics (BLS) reports a goods component of the consumer price index, which accounts for roughly one-half of the total index.[6] To the extent services weaken the relationship between producer prices and the total CPI, producer prices and the goods component of the consumer price index might still be linked. Changes in producer prices might lead to changes in the goods CPI, an important component of the overall consumer price index. The empirical analysis presented in the next section considers both the total CPI and the goods CPI.

Further economic analysis. Looking beyond some of the simplifications made in the basic analysis uncovers additional reasons that changes in producer prices may not pass through to consumer prices. The simple analysis treats input materials prices as the primary determinant of production cost, and it presumes the markup of price over cost is constant. More generally, however, production cost depends on elements other than input materials. And the markup of price over cost may vary.

While production cost depends on input materials, it also depends on labor, physical capital, and productivity. The production of most goods requires significant labor and capital input. Production cost also depends on productivity, or on the efficiency with which firms use inputs such as labor. For

example, productivity increases resulting from computer technology might allow a firm to produce goods at lower cost.

The roles of labor and capital in production dilute the cost effects of a change in input materials prices. In the typical U.S. industry, almost one-half of production cost is attributable to labor and physical capital, with the remainder attributable to input materials (Jorgenson, Gollop, and Fraumeni; U.S. Department of Commerce).[7] Consequently, if prices of input materials rise, the importance of labor and capital in the production process will approximately halve the cost effects of such a change. Rising prices for input materials would be mitigated by unchanged prices of labor and capital, so that in percentage terms production cost would rise only half as much as materials prices. For example, if input prices rise by 1 percent, production cost and product prices should rise by only about 0.5 percent.[8]

The effects of changes in input materials prices may also be offset to some degree by productivity changes. Over a typical business cycle expansion, input materials prices often rise sharply (Means; Murphy, Shleifer, and Vishny).[9] For example, inflation for crude materials excluding food and energy averaged 16.7 percent from July 1994 to June 1995, up sharply from an average of less than 1 percent in the 1990-91 recession. Such input price increases exert upward pressure on costs and, in turn, on product prices. However, the typical business cycle expansion is also associated with productivity increases, which reduce costs (Bernanke and Powell). Thus, during the typical economic boom, cost pressures created by rising input prices are at least partly offset by productivity improvements.

Just as the use of other production factors may mitigate changes in input materials prices, changes in the markup of product price over cost may also mitigate movements in input prices. Again, input materials prices typically rise as the economy expands. Holding the markup constant, such increases in input prices cause production costs to rise, leading firms to raise product prices. In reality, however, firms may reduce the markup of price over cost in such situations for a number of reasons (Bils; Rotemberg and Woodford).[10] For example, a firm may choose to lower its markup and hold its price fixed to maintain and perhaps expand its customer base. If in fact firms reduce the markup when increases in input prices force costs higher during an economic expansion, the smaller markup mitigates the increase in costs. On net, product price changes would be smaller than they otherwise would be.

These generalizations of the basic price-setting theory suggest the production chain linkage from the PPI to the CPI may be weak. They imply that changes in input prices may not necessarily lead to changes in product prices. Accordingly, the prices of crude materials, intermediate goods, finished goods, and consumer goods and services may not always be linked by pass-through effects. Determining whether these generalizations rule out producer prices leading consumer prices requires going beyond theory and examining the data.

THE EMPIRICAL EVIDENCE

If the PPI and CPI are connected by the production chain, changes in producer prices should lead and therefore help predict subsequent changes in consumer prices. Changes in prices of crude materials should pass through to prices of intermediate and finished goods and ultimately to consumer prices. Given this implied sequential linkage between the PPI and CPI, the production chain view can be tested by examining whether producer prices help predict consumer prices.

This section uses historical evidence to test the production chain view. Because most policymakers and firms are chiefly concerned with consumer price inflation, the focus is on whether the different producer price indexes help predict consumer prices. In examining the relationship of producer

prices to consumer prices, the analysis abstracts from the production chain relationships among the different producer price indexes. The section first examines historical movements of producer and consumer price inflation to see if PPI changes precede CPI changes. The section then uses forecasting models to examine whether PPI changes help predict future CPI changes.

Historical movements

To examine whether changes in PPI inflation lead changes in CPI inflation, this section compares the historical movements in the indexes from 1958 to early 1995. The analysis excludes food and energy prices from the CPI measures but not from the PPI measures. Food and energy prices are excluded from the CPI because they vary sharply and can obscure underlying trends in consumer prices. Food and energy prices are not excluded from the PPI series simply because the PPI data excluding food and energy prices are available only since 1974. The results of the analysis, however, are not sensitive to the treatment of food and energy prices. Results based on the total CPI are very similar to results based on the CPI excluding food and energy—the so-called core CPI. Also, for the shorter period over which data are available, results based on the PPI excluding food and energy are very similar to results based on the PPI.

The examination of historical movements focuses on whether producer prices lead consumer prices. If a production chain links consumer prices to producer prices, increases in producer prices should cause subsequent increases in consumer prices. Therefore, to evaluate the evidence on the production chain linkage, this section focuses on whether changes in producer prices *precede* changes in consumer prices. The analysis puts aside the tendency of producer and consumer prices to move together over time, without producer prices leading consumer prices. The general forces of inflation will naturally cause producer and consumer prices, as well as other types of prices such as wages, to move together over time. In periods of sustained inflation, increases in producer and consumer prices and wages reinforce one another.

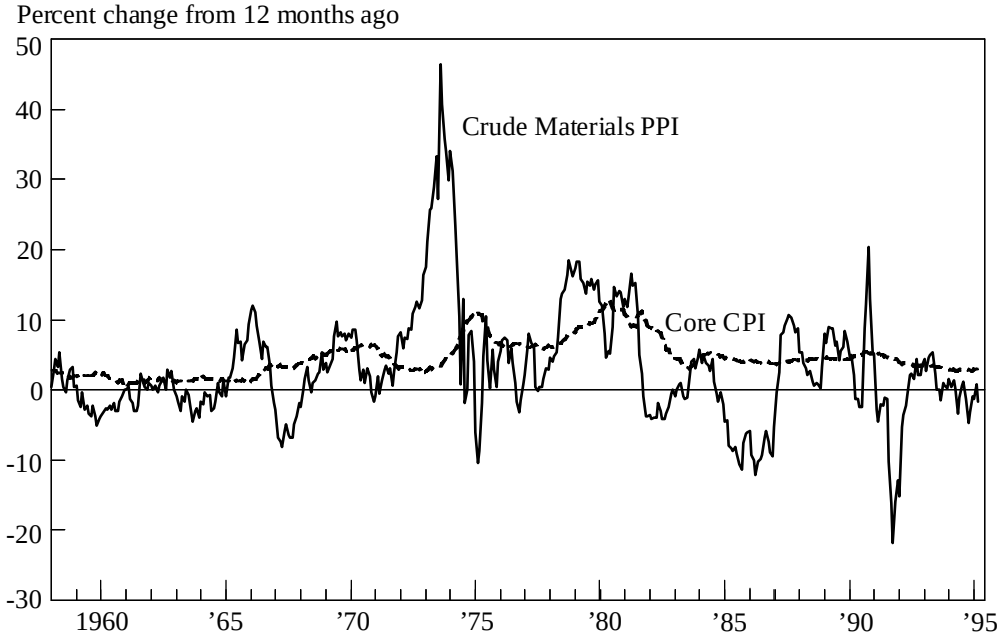
Chart 1 suggests the production chain weakly links the PPI for crude materials to subsequent movements in the core CPI. In some instances, changes in crude materials inflation appear to precede changes in consumer price inflation. For example, as the economy expanded rapidly in 1971-72, crude materials prices accelerated.[11] An acceleration of the core CPI followed in 1973-74.[12] In general, however, the crude materials PPI appears to undergo many large changes that have no bearing on subsequent consumer prices. For example, crude materials inflation rose sharply in 1987 and then dropped in 1988, while consumer price inflation remained relatively steady. In 1987, much as in 1994 and early 1995, the economy had been experiencing strong growth for several years, straining what some analysts consider to be the limits of production capacity.

Chart 2 indicates that movements in the PPI for intermediate goods also have only a weak relationship to subsequent movements in the core CPI. For example, with the economy expanding solidly in 1976, inflation in intermediate goods prices rose. Consumer prices remained steady, however, in both 1976 and 1977.[13] Then, in 1978 and on into 1979, intermediate goods and consumer price inflation moved up together, with no indication of intermediate goods prices leading consumer prices.[14]

Chart 3 shows that changes in the finished goods PPI also have little connection to subsequent changes in the core CPI. Contrary to the implications of the production chain view, finished goods inflation fails to lead changes in consumer price inflation. Rather, the finished goods PPI tends to move with the CPI. In the late 1960s, for instance, finished goods inflation moved up at the same time consumer price inflation moved up, rather than

Chart 1

CRUDE MATERIALS PPI AND CORE CPI



preceding it. Similarly, from 1979 to 1983, finished goods inflation moved together with, not before, consumer price inflation.

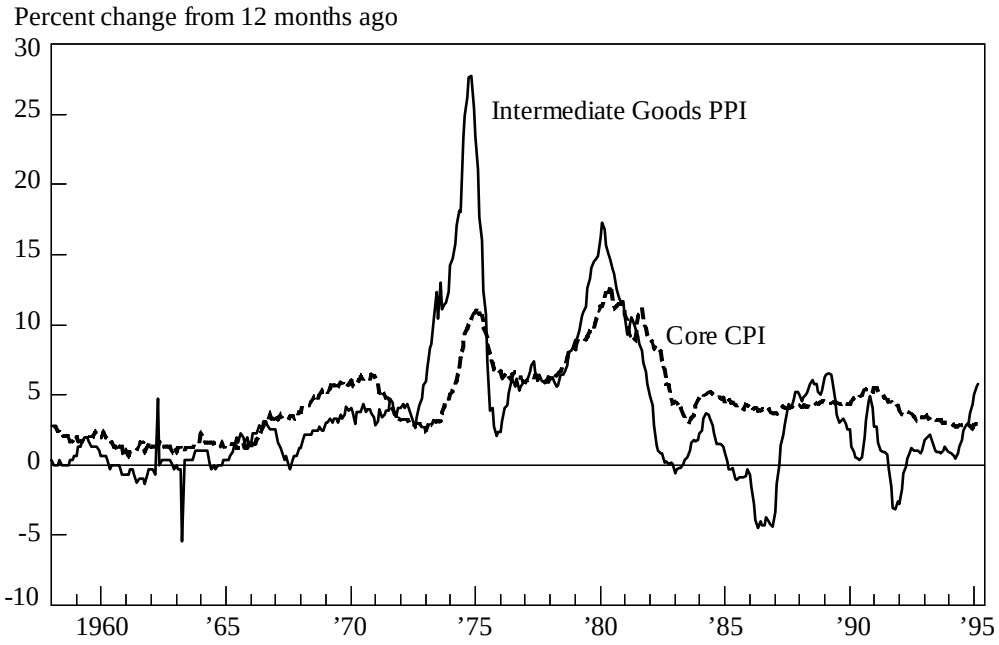
The production chain linkage from producer prices to the core *goods* CPI is as weak as the linkage from producer prices to the total CPI. Chart 4 shows that the core goods CPI moves with the core CPI, which includes both goods and services prices. For example, core goods CPI inflation began trending up in early 1978, consistent with core CPI inflation. Since the core CPI moves together with the core goods CPI, what is true for one is also true for the other. As a result, the relationship between the core goods CPI and producer prices is much like the relationship between the core CPI and producer prices. As the PPI has little tendency to lead the core CPI, it also has little tendency to lead the core goods CPI.

The historical data presented in the charts provide little evidence of a production chain linkage of consumer prices to producer prices. Occasionally, PPI changes lead CPI changes. But overall, movements in producer prices appear to have little bearing on subsequent changes in consumer prices—either the total CPI or the goods component. Thus, at least to the eye, there appears to be little evidence that a production chain links the CPI to the PPI.

Relying on the eye to detect a possibly subtle relationship, however, might be misleading. The large volatility of the PPI might make any pass-through of producer price changes to consumer prices difficult to discern from charts. A simple regression test of the ability of producer prices to explain movements in consumer prices avoids this difficulty. The regression used here relates consumer price inflation

Chart 2

INTERMEDIATE GOODS PPI AND CORE CPI



to lagged values of consumer price inflation and lagged values of producer price inflation. The test examines whether the lagged values of producer price inflation included in the regression explain a significant portion of the historical, or in-sample, variation in consumer price inflation.

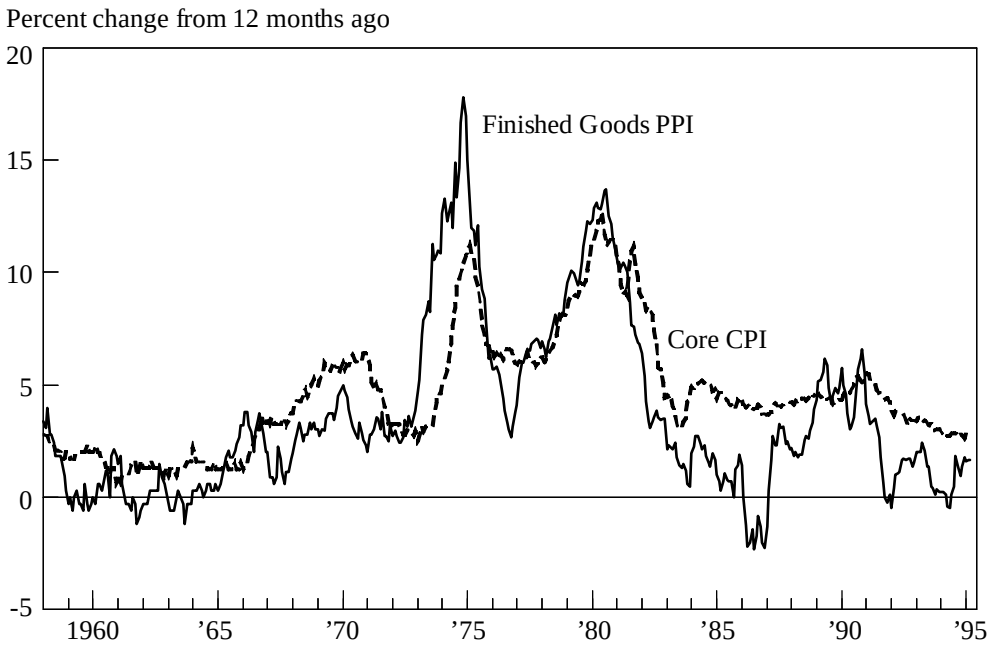
The regression test suggests a stronger linkage from producer to consumer prices than the charts suggest. When estimated with 1959-94 data, the regression test indicates that lagged changes in PPI inflation are statistically significant in explaining variation in core CPI inflation, as well as core goods CPI inflation.[15] While the volatility of producer prices makes any signal difficult to discern, movements in producer prices have some tendency to pass through to consumer prices. When this regression test result is considered in conjunction with the evidence from the charts, the historical record appears to provide some evidence that producer prices lead consumer prices.

Forecast comparisons

While the regression test shows that lagged producer prices help explain the historical movements in consumer prices, it does not necessarily establish the presence of a strong production chain linkage. If the production chain links consumer prices to producer prices, then producer prices should be useful for forecasting consumer prices out of sample, not just for explaining the past. Therefore, examining whether the PPI helps forecast the CPI provides additional evidence on the linkage of consumer prices to producer prices, evidence which may be preferable to that provided by the in-sample

Chart 3

FINISHED GOODS PPI AND CORE CPI



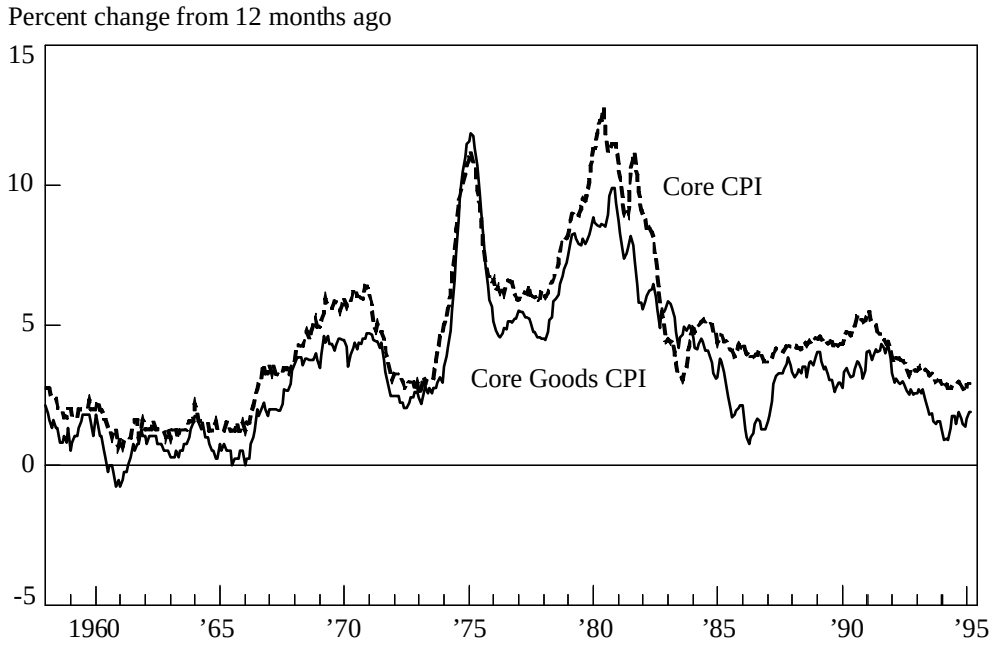
test. This section uses forecasting models to examine whether producer prices help forecast consumer prices. The section describes the models and forecasting procedures used and presents the empirical results.

Models. The ability of producer prices to predict consumer prices is measured by comparing forecasts from a model that includes CPI inflation as the only measure of inflation with forecasts from a model that includes both CPI and PPI inflation. If producer prices lead consumer prices, the model that includes the PPI should predict future CPI inflation better than the model that excludes the PPI. The models also include variables that provide information on the overall state of the economy and on financial and labor market conditions. Specifically, the additional variables include real GDP growth, the 3-month Treasury bill rate, and growth in the average hourly earnings of manufacturing workers.[16] These variables are included because they may be related in different ways to both producer and consumer price inflation. Including these variables helps identify pass-through effects that might otherwise be obscured. The appendix provides additional detail on the specifications of the models.

In estimating the models, food and energy prices are excluded from CPI inflation but not from PPI inflation. The core CPI is used because food and energy prices can sometimes obscure inflation trends. Using the total CPI in place of the core CPI, however, has little effect on the results.[17] Total rather than core PPI series are used because the core data are only available from 1974. Nearly the entire 1974-94 sample of core PPI data would be needed

Chart 4

CORE GOODS CPI AND CORE CPI



for reliable model estimation, leaving only a few years in the 1990s which might be used for forecast evaluation.[18]

In estimating the model that uses producer prices, all of the crude materials, intermediate goods, and finished goods indexes are included. Using any one, rather than all three, of the different PPI inflation rates has little effect on the results.[19]

Forecasting procedures. Forecasts of CPI inflation are computed from 1977 to 1994 using the two models and data beginning in 1959. Forecasting starts in 1977 because a data sample at least as long as 1959-76 is needed for reliable model estimation. As detailed in the appendix, for each quarter, the models are estimated and forecasts of CPI inflation are calculated for the year ahead. These forecasts rely only on data that would have been available contemporaneously to forecasters.[20] For example, for the first quarter of 1977, the models are estimated using data from 1959 to 1976:Q4, and inflation is forecast for the year beginning in 1977:Q1. Then, in the second quarter of 1977, the models are reestimated using data from 1959 to 1977:Q1, and inflation is forecast for the year beginning in 1977:Q2. The process of reestimating the models and forecasting a year ahead continues through 1994:Q1. In that quarter, the models are estimated with data from 1959 to 1993:Q4, and inflation is forecast for the year beginning in 1994:Q1.

The forecasts from the two models are compared for the entire sample period 1977-94, as well as the subperiods 1977-80, 1986-89, and 1991-94. The 1977-94 period permits an evaluation of whether

Table 1

ONE-YEAR-AHEAD ABSOLUTE FORECAST ERRORS, CORE CPI INFLATION

	Model with CPI inflation	Model with both CPI and PPI inflation
1977-80	1.58	1.08
1986-89	.54	.79
1991-94	.30	.80
1977-94	1.51	1.37

one model consistently forecasts better than the other. The short periods are interesting for a variety of reasons. The periods 1977-80 and 1986-89 correspond to periods of rising inflation identified by other researchers (Garner). The current concern that recent PPI increases might generate higher CPI inflation makes such periods particularly relevant. The 1991-94 period corresponds to the expansion which began after the 1990 recession. To the extent the recent past might be viewed as a guide to the near future, this most recent period might be of particular interest.

The forecasting performance of the models is evaluated using the average absolute error of the forecasts.[21] The absolute error is the size of the gap between the forecast and actual rates of inflation. While forecasts of inflation may be above or below the actual inflation rate, the absolute error measures only the size of the gap, without consideration of the direction of the error. For each period over which forecasts are compared, such as 1977-80, the average absolute error equals the average of the absolute forecast errors over the period.

The model that yields a lower average absolute error is the better forecasting model. For example, one model's forecasts might be 2 percent above actual inflation in one year and 2 percent below actual inflation in another year. A second model's forecasts might be 1 percent above actual and 1 percent below actual in the same two years. Each model yields forecast errors which average to zero, since the first year's overestimate offsets the second year's underestimate. But because the size of the forecast errors made by the second model is smaller than the size of the errors made by the first model, the second model is superior. Measuring forecast performance by absolute forecast errors identifies the better model. In this example, the average absolute error is 2 percent for the first model and 1 percent for the second model.

Results. The evidence is mixed on the ability of the PPI to improve core CPI inflation forecasts (Table 1).[22] For the entire 1977-94 period and the 1977-80 subperiod, using PPI information improves forecasts of core CPI inflation. Over 1977-94, the model that includes producer prices yields forecasts with an average absolute error of 1.37 percent, a slight improvement on the 1.51 percent error produced by the model that excludes producer prices. For the 1986-89 and 1991-94 periods, however, using PPI information detracts from forecast performance. Better forecasts are obtained from the model that does not include producer prices. Over

Table 2

ONE-YEAR-AHEAD ABSOLUTE FORECAST ERRORS, CORE GOODS CPI INFLATION

	Model with CPI inflation	Model with both CPI and PPI inflation
1977-80	.96	1.13
1986-89	1.57	1.31
1991-94	.57	1.12
1977-94	1.72	1.49

1991-94, the model without producer prices yields an average absolute error of 0.30 percent, while the model that includes producer prices yields an error of 0.80 percent.

The ability of the PPI to improve CPI inflation forecasts is also mixed when the goods component of the core CPI is used in place of the core CPI (Table 2). For the 1977-94 and 1986-89 periods, using producer prices yields somewhat more accurate forecasts of core goods CPI inflation. Over 1977-94, the model that includes the PPI produces an average absolute forecast error of 1.49 percent, while the model that excludes the PPI produces an error of 1.72 percent. In contrast, for 1977-80 and 1991-94, using PPI information detracts from forecast accuracy. For these periods, the model that does not include PPI information forecasts better. Over 1977-80, the model without producer prices yields an average absolute error of 0.96 percent, while the model that includes producer prices yields an average error of 1.13 percent.

These results indicate the production chain only weakly connects the PPI to subsequent movements in the CPI. At times, producer price changes help predict future movements in consumer prices. Particularly, over the long 1977-94 period, using PPI information yields a small improvement in CPI inflation forecasts. At other times, such as 1991-94, using PPI information reduces forecast accuracy. Overall, the forecast comparisons identify only a weak relationship between changes in producer prices and subsequent changes in consumer prices.

CONCLUSIONS

Some analysts project that recent increases in prices of crude and intermediate goods will pass through the production chain and generate higher consumer price inflation. While simple economics suggests such a pass-through effect may occur, more sophisticated reasoning and careful consideration of the construction of the PPI and CPI data suggest any pass-through effect may be weak. Consistent with this more sophisticated analysis, the empirical evidence also shows the production chain only weakly links consumer prices to producer prices. PPI changes sometimes help predict CPI changes but fail to do so systematically. Therefore, the recent increases in some producer price indexes do not in themselves presage higher CPI inflation.

APPENDIX

This appendix details the specification of the forecasting models and forecasting procedure.

The forecasting models

The forecasting models are vector autoregressions (VARs). Each model relates current values of all variables in the model to previous values of all variables. For example, in the model that includes the PPI, the current quarter's rate of CPI inflation is related to lagged values of CPI and PPI inflation, GDP growth, the Treasury bill rate, and wage growth. Other equations in the model relate current values of PPI inflation, GDP growth, the Treasury bill rate, and wage growth to lagged values of all variables in the model.

The models are estimated with quarterly data beginning in 1959:Q2. The monthly series (all but GDP) are converted to quarterly series by simple averaging within the quarter. Given the quarterly data on the levels of each series, annualized inflation rates and growth rates are computed as 400 times the log of the change in levels. While the underlying data are all available beginning in 1957, models are estimated with data beginning in 1959:Q2 to allow for the computation of inflation and growth rates and a possible maximum of eight lags in the VAR.

The lag lengths of each model are selected using the Akaike information criterion for estimates based on the full 1959:Q2-1994:Q4 sample. This criterion yields lag lengths of 3 for the model that excludes the PPI and 4 for the model that includes the PPI. When the core goods CPI is used in place of the core CPI, the Akaike criterion selects lag lengths of 6 for the model that excludes the PPI and 5 for the model that includes the PPI. While using the Schwarz criterion yields models with much shorter lag lengths, the qualitative results prove to be identical to those presented.

The forecasting procedure

Year-ahead forecasts are computed from quarterly forecasts made on a rolling, out-of-sample basis. At each point in time *t*, data from 1959:Q2 through period *t-1* are used to estimate the model. Forecasts for quarters *t* through *t+3* are then computed using the model estimates and data through quarter *t-1*. The year-ahead forecast for average annual inflation over quarters *t* through *t+3* is the average of the four quarterly forecasts. For the 1977-80 period, for example, the first forecast uses information through 1976:Q4. The first year-ahead forecast of inflation spans 1977:Q1 through 1977:Q4. The second year-ahead forecast, which uses information through 1977:Q1, spans 1977:Q2 through 1978:Q1. Continuing forward, the last year-ahead forecast computed for the 1977-80 period uses information through 1979:Q4 to forecast average inflation for 1980:Q1 through 1980:Q4. In this scheme, there are then 13 individual one-year-ahead forecasts computed for the 1977-80 period.

ENDNOTES

[1] In focusing on whether the PPI and CPI are linked by the chain of production, this article abstracts from the relationship between the finished goods PPI and the CPI created by coverage overlap. Because the finished goods PPI includes the prices of some consumer goods, the PPI and CPI overlap to a limited degree. While overlapping slightly in coverage, the PPI and CPI measure prices at different stages of distribution. The PPI for finished goods tracks prices received by manufacturers. For consumer goods, these might correspond to prices paid by wholesalers. The CPI, however, tracks prices paid by consumers.

[2] The price-setting model sketched here applies to both perfectly competitive and imperfectly competitive markets. The markup equals 1 in perfectly competitive industries, and firms set price equal to marginal cost. The markup exceeds 1 in imperfectly competitive industries, and firms set price above marginal cost. Thus, the simple prediction that the PPI and CPI are linked by a chain of production does not hinge on an assumption about market structure.

[3] This difficulty corresponds to the backflow or imperfect forward flow problem discussed by Mattey. While potentially important in principle, Mattey's results suggest the problem may not be that important in practice. His efforts to construct an improved chain of producer and consumer price equations do little to improve the ability of PPI information to help predict CPI inflation.

[4] As explained by Gaddie and Zoller, the Bureau of Labor Statistics (BLS) began publishing the PPI under a new industry-based system in 1988 in an effort to tighten the production chain links among the components of the PPI. Under the new system, the BLS reports four output price indexes (for the outputs of crude, primary, semifinished, and finished processors) and four input price indexes (for inputs to primary, semifinished, and finished processors, and to final demand).

[5] These difficulties correspond to the leakages problem discussed by Mattey in his input-output analysis of the links between consumer and producer prices.

[6] CPI reports published by the BLS formally refer to the goods component as the *commodities* component of the CPI.

[7] Since firms base prices on the cost of producing gross output, this share of labor and capital is based on gross output rather than value added. Gross output measures the total value of all goods and services produced. Because it includes the value of both final and input goods, gross output double-counts the value of input goods. Value added equals gross output less the value of goods used as inputs, or the value of all final goods and services. Measuring labor and capital shares relative to value added yields much higher labor and capital shares. In particular, measuring labor's contribution relative to value added raises labor's share to roughly two-thirds, which is often cited in discussions of the importance of labor.

[8] If capital is viewed as fixed at a given point in time, as some researchers (such as Mattey and Miron and Zeldes) do, the importance of intermediate materials is slightly higher. In particular, if capital is viewed as a fixed input, roughly two-thirds of variable costs are attributable to intermediate materials. A 1 percent increase in input materials prices might be expected to cause variable production costs to rise by two-thirds of 1 percent.

[9] Cyclicality is greater for less-processed goods (Means; Murphy, Shleifer, and Vishny). The cyclicality of crude materials prices is evidenced by the inclusion of an index of materials prices in the U.S. Commerce Department's Index of Leading Indicators.

[10] Researchers have identified several theoretical reasons that markups might be countercyclical (Rotemberg and Woodford; Basu). However, the empirical evidence on the cyclicality of markups is mixed. While Bils, and Rotemberg and Woodford find the markup to be countercyclical, Chirinko and Fazzari, and Haskel, Martin, and Small find it to be procyclical.

[11] Real GDP grew 4.7 and 7.8 percent, respectively, in 1971 and 1972.

[12] This result does not appear to be driven by the oil price shock of the second quarter of 1973. CPI inflation began to move up shortly before this shock, and the crude materials PPI began to accelerate much earlier.

[13] Real GDP advanced 3.7 percent in 1976 and slightly more than 6 percent in both 1977 and 1978.

[14] The concurrence of the movement in consumer prices and intermediate goods prices is not the result of a major oil price shock. The PPI and CPI began to accelerate in early 1978, while oil prices rose dramatically in 1979.

[15] When the test regression includes four lags of core CPI inflation and four lags of crude materials, intermediate goods, and finished goods inflation, the hypothesis that the PPI inflation rates add no explanatory power is rejected at a statistical confidence level above 99 percent. Less formally,

but consistent with the test outcome, the adjusted R^2 of the regression falls from 81.9 percent to 72.8 when producer prices are excluded. Similar results are obtained when the core goods CPI is used in place of the core CPI and when the lag lengths in the regression and the set of producer price indexes included in the CPI equation are modified. Similar results are also obtained in tests based on vector autoregressive systems which add real GDP growth, the 3-month Treasury bill rate, and wage growth to the inflation variables used in the test.

[16] Real GDP growth and the 3-month Treasury bill rate provide information on the overall state of the economy and financial market conditions, respectively, both of which may impact inflation. For example, a slow economy may reduce inflationary pressures. Growth in average hourly earnings of manufacturing workers provides information on wages, which are an important element of firms' costs and thereby a potentially important determinant of inflation. The manufacturing earnings series is the broadest wage measure available on a quarterly basis back to 1957, the starting point of the analysis.

[17] Forecasting results for the total CPI yield no evidence of a significant link between the PPI and CPI. With the lag lengths of models for the total CPI selected by the Akaike criterion, forecasts from the model which includes PPI information are consistently and sometimes substantially inferior to those from the model which excludes the PPI. With lag lengths selected by the Schwarz criterion, forecasts from the PPI-augmented model are in some cases barely better than forecasts from the model which excludes the PPI, but in most cases inferior.

[18] When forecasts are constructed for 1991-94 using models estimated with data beginning in 1975:Q2, a model that includes core PPI information forecasts slightly better than a model that excludes the PPI.

[19] In addition, over the full 1959-94 period, including all three components of the PPI rather than just one produces a better fit (as measured by the Akaike criterion) of the CPI equation.

[20] Strictly speaking, this statement is not completely accurate because the analysis of this article uses some data—GDP growth and wage growth—which are revised over time. Actual forecasters must rely on the initially reported rather than final, revised figures.

[21] Qualitatively, results are very similar to those presented when the forecast horizon is one quarter or two years, and when forecast performance is measured by the root-mean-squared error.

[22] When the performance measures are gauged against standard errors, the forecasting performances of the models differ very little. There are few statistically significant differences in the performances of the models.

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