AN EMPIRICAL STUDY OF THE RELATIONSHIP BETWEEN CONSUMER AND PRODUCER PRICE INDEX: A UNIT ROOT TEST AND TEST OF COINTEGRATION

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ABSTRACT

Policy makers have been long concerned about finding early indicators of inflation, a continuous rise in aggregate price level measured by the consumer price index (CPI). One of these indicators, which has been a target of many studies and has been supported by the production chain view, is the producer price index (PPI). The production chain view suggests that higher PPI will be passed to consumers through higher prices of finished goods. The purpose of this paper is to investigate the relationship between these two indexes using a unit root test and test of cointegration which are becoming more popular in time series analyses.

REVIEW OF PREVIOUS STUDIES

Many studies have evaluated the link between the producer price index and consumer price index as indicators of inflation. Researchers have investigated different components of these two indices, or in different time periods, and have summarized mixed results. For example, Gordon (1988) analyzed data from 1954 to 1987 and concluded that there is no significant statistical relationship between Consumer Price Index (CPI) and Producer Price Index (PPI). Emery and Chang (1996) used data from the 1990s and indicated that "workers' compensation growth adjusted for productivity has no power to predict inflation." Mehra (1991) and Huh and Trehan (1995) concluded that in the long run CPI leads labor cost, which is a major component of the PPI - a finding that contradicts the production chain view.

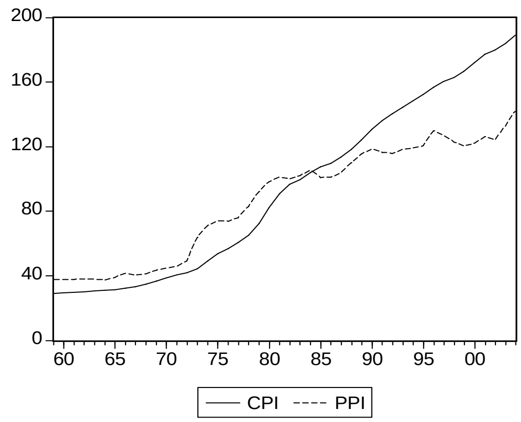
Other studies appear to show a different relationship. For example, Lown and Rich (1997), using data from 1965 to 1996, indicated that labor costs have an important role in predicting inflation. Furthermore, Brauer (1997) demonstrated a link between service sector wages and prices to the overall economy's inflation. However, he also indicates that this link cannot be observed in goods producing sectors. Finally, Clark (1997) graphically represented the link between CPI and PPI and suggested that the CPI should be broken down into three categories: labor-cost-sensitive services, labor-cost-sensitive goods, and other expenditure categories. Using graphs, he concluded that there is only a link from service sector wages and prices to the economy's inflation. Researchers, such as Clark, have not provided objective criteria to show how they have broken down these three categories of CPI indexes, and also their conclusions are heavily depended on observation periods. Other studies done in this area are those of Roth (1986), Garner (1989), Boughton and Branson (1991), Mehra (1993), and Feder (1994).

The purpose of this study is to statistically evaluate the links between CPI and PPI by applying a unit root test and test of cointegration—two tests which are becoming more popular in economic research, especially in time series analyses.

DATA AND METHODOLOGY

All monthly data used in this study (from 1960 to 2005) are drawn from the U.S. Department of Labor, Bureau of Statistics. The classical linear regression model, unit root test, and test of cointegration have been employed in this study. Specifically, this research investigates the relationship between all urban consumer price indices (CPI) and producer price indices (PPI) for finished goods commodities. **Figure 1** represents the monthly data from 1960 to 2005.

Figure 1: CPI and PPI (monthly data from 1960 to 2005)



EMPIRICAL RESULTS

To statistically evaluate the relationship between CPI and PPI, the CPI is regressed on PPI. The estimate model and some descriptive statistics are shown below.

$$CPI = -35.82589 + 1.492671 PPI \qquad \ldots (1)$$

(t-statistics) (-5.775030) (22.51838)

Adjusted R-squared: 0.920156
F-statistic: 507.0776
Prob. (F-statistic): 0.000000
Durbin-Watson stat: 0.127676

The above results show that all estimated coefficients, as well as F-statistics, are statistically significant. The high adjusted R-squared (0.92) is an indicator that there is a strong relationship between CPI and PPI. However, the Durbin-Watson statistic is very low (0.13). Based on Granger and Newbold (1986), whenever the Durbin-Watson statistic is less than adjusted R-squared, there is a good chance that the estimated regression suffers from the problem of spurious regression. In other words, it indicates that we are regressing a nonstationary time series against another nonstationary one.

A stochastic time series process is said to be stationary if its mean and variance are constant over time and that the value of the covariance between any two time periods does not depend on the actual time at which the covariance is computed. **Figure 1** graphically shows that there is the possibility that CPI and PPI are not stationary because both series exhibit an upward sloping time trend. That is, it is possible that there is no relationship between CPI and PPI and the apparent relationship is nothing other than a third factor that causes both CPI and PPI to move in the same direction. To statistically test for this possibility, we employed a unit root test, and the results are shown in **Table 1**. For more information on a unit root test, and other econometric topics used in this study, the readers are referred to any econometrics textbooks such as those of Enders (2004), Green (2005), and Gujarati (2006).

Table 1: Unit root tests of CPI and PPI

	CPI		PPI	
	t-statistic	Prob.	t-statistic	Prob.
Augmented Dickey Fuller Test Statistic	0.172958	0.9676	-0.052847	0.9482
Test Critical Values:				
1% Level	-3.596616		-3.584743	
5% Level	-2.933158		-2.928142	
10% Level	-2.604867		-2.602225	

Based on **Table 1**, at any reasonable significance level, we fail to reject the null hypotheses that CPI and PPI have unit root; that is, both CPI and PPI are nonstationary and the regression of CPI on PPI is a spurious regression - a regression that has a high R-Squared and t-statistics that appear to be very significant but the results do not have any econometric meaning.

Test of Cointegration

Even though the two time series (CPI and PPI) are nonstationary, it is possible that they are cointegrated; that is, it is still possible that there is a long run equilibrium relation between these two indexes. To test whether the two time series are cointegrated, that is, to see whether or not there is a long run equilibrium between these two time series, the following residuals are calculated from a regression of CPI on PPI using equation (1).

$$e_t = CPI + 35.82589 - 1.492671PPI \qquad \ldots (2)$$

Now treating e_t as a time series, a unit root test (Dickey Fuller Test Statistic) can be applied to it. The results of test of cointegration are shown in **Table 2**.

Table 2: Test of Cointegration

	Residuals	
	t-statistic	Prob.
Augmented Dickey Fuller Test Statistic	-1.132370	0..2304
Test Critical Values:		
1% Level	-2.617364	
5% Level	-1.948313	
10% Level	-1.612229	

The results in Table 2 show that CPI and PPI are not cointegrated; there is no long run equilibrium between these two time series. In other words, one cannot look at the PPI to predict the CPI. Therefore, higher costs of production will not necessarily result in a higher inflation rate. To remedy this non long-run equilibrium, there are two possible remedies: (1) use the first difference of these two stochastic processes; or (2) break down these two indices into their different components.

In this study, the first remedy was employed. That is, we conducted a unit root test for the first difference of CPI and PPI. The results of a unit root tests of the first difference of these two time series are shown in **Table 3**. To avoid the loss of first observation, which can adversely affect the results, the following Prais-Winsten transformation is used:

$$CPI_1^* = \sqrt{1-\rho^2}\,(CPI_1)$$
$$PPI_1^* = \sqrt{1-\rho^2}\,(PPI_1)$$

Where ρ is a coefficient of autocorrelation and it is assumed to be 0.5. The coefficient of autocorrelation shows the relationship between the same time-series variables in two consecutive periods.

Table 3: Unit root tests for first difference of CPI and PPI

	Δ CPI		Δ PPI	
	t-statistic	Prob.	t-statistic	Prob.
Augmented Dickey Fuller Test Statistic	-2.159589	0.2234	-4.388383	0.0010
Test Critical Values:				
1% Level	-3.584743		-3.584743	
5% Level	-2.928142		-2.928142	
10% Level	-2.602225		-2.602225	

The first difference of CPI is still nonstationary and has a unit root; however, the first difference of PPI is stationary. In other words, the first difference of PPI does not have a unit root at any reasonable significance level.

The descriptive statistics that regresses the first difference of CPI on the first difference of PPI are shown below.

$$\Delta CPI = -3.021841 + 0.203020\ \Delta PPI \qquad \dots (3)$$

(t-statistics) (-8.436161) (2.562515)

Adjusted R-squared: 0.110082
F-statistic: 6.566483
Prob. (F-statistic): 0.013890
Durbin-Watson stat: 0.397144

The above results show that this estimated model (equation 3) does not suffer from the problem of spurious regression. Thus, it is possible to use changes in PPI to predict changes in CPI. In other words, changes in PPI are good indicators of changes in CPI.

POLICY IMPLICATIONS AND CONCLUSION

Analyzing the link between the Consumer Price Index (CPI) and the Producer Price Index (PPI) has been a target of many studies. The link is important since it allows policy makers to predict future inflation by using PPI data. Through the analysis provided in this study, policy makers may be better prepared to avoid, or at least mitigate, the negative consequences of inflation. This paper is another effort in this area of research which uses a unit root test and test of cointegration in order to statistically analyze the link between CPI and PPI. Overall, the test results indicate that both CPI and PPI are nonstationary, have unit roots, and regression of CPI on PPI is a spurious one.

Even though both time series, CPI and PPI, are nonstationary, the authors have employed a cointegration test to see whether there is still long run equilibrium between CPI and PPI. The result of the cointegration test indicates that there is no long run equilibrium between these two time series. To correct the problem of nonstationary time series, the authors have used the first difference of both CPI and PPI and concluded that regression of the first difference of CPI on first difference of PPI does not suffer from the problem of spurious regression. This finding can help policy makers to rely more on the link between CPI and PPI and use changes in PPI to predict changes in CPI. In other words, it can be concluded that the combined regression-time-series-model, if used with proper care, can be an effective forecasting tool.

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ACKNOWLEDGEMENTS

We appreciate the valuable comments that we have received from an anonymous reviewer. All remaining errors solely belong to the authors.