Zsolt Becsi
Economist
Federal Reserve Bank of Dallas*

Indicators of the General Price Level and Inflation

Price stability has emerged as a key long-term monetary policy goal. In a nutshell, a price stabilization policy seeks to minimize the disruptive effects of aggregate price movements and price uncertainty on economic decisions. This means that a long-run aggregate price level or some low inflation rate is targeted.[1] Consequently, the Federal Reserve's job is to monitor the value of currency. The problem for the Fed practitioner is how to monitor general price movements given that aggregate price data are noisy and imperfectly measured and that there are competing price measures. This article examines whether existing price indexes tell a consistent story about the general price level and its inflation rate.

To answer this question, the coverage of the most-watched price indexes is briefly reviewed.[2] It is shown how these indexes differ and that they may provide conflicting information. Does it then matter which price/inflation index is monitored? In response, alternative notions of the theoretically appropriate price index are discussed. Next, the time series properties of the price indexes are analyzed and compared. For instance, whether a time series is stationary is evaluated because this can determine if the effects of shocks on the series are temporary and will eventually die out. Cointegration tests reveal whether the price indexes have any stable, long-term relationships: cointegrated series have a common trend.

Popular price indexes such as the consumer price index (CPI) and the implicit price deflator for gross domestic product (PGDP) capture prices of currently produced final goods and services, while the producer price index (PPI) captures final goods prices at an early distribution stage. These indexes are found to have a stable long-run relationship (or, are cointegrated) with PGDP. For growth rates, the story is similar. Inflation rates tend to be nonstationary, although the evidence can be ambiguous, and except for the PPI, the inflation rates of the different series have stable long-run relationships with one another. Thus, monitoring any particular price series or inflation rate will capture long-run movements in the other series.

Some economists have argued that central banks should monitor a very general price level that would not only include final goods and services prices but also the prices of assets, intermediate goods, and services. How good are the above price indexes as indicators of a comprehensive aggregate price measure? Price indexes for intermediate goods, the producer price index for all commodities (PPIT), and asset prices, such as the Standard & Poor 500 stock index (S&P 500) and median housing price, are weakly cointegrated in levels with final-goods price indexes (such as the PGDP). In addition, the inflation rates of the

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[1] *See Ireland (1993) and Balke and Emery (1994) for an overview of the issues. Balke and Emery distinguish between long-run price level targeting, or strong price stability, and low (or zero) inflation rate targeting, or weak price stability.*

[2] *See the surveys of Brauer and Wu (1991), Davis (1991), Carlson (1989), Webb and Willemse (1989), and Wynne and Sigalla (1993) on the coverage of the producer price index of finished goods, the consumer price index, and the implicit price deflator for gross domestic product, as well as other indexes. The PPIT referred to below is the PPI for all commodities (seasonally adjusted), not the popular PPI, which only covers finished goods.*

PPIT and the median housing price (but perhaps not the S&P 500) are weakly cointegrated with PGDP inflation. Thus, monitoring final goods prices or inflation indexes may be adequate because shocks to the other series will be reflected in these indexes. However, to the extent the PGDP does not fully capture information about movements of the other price indexes, a more comprehensive price level index may be called for.

Coverage of major price indexes

In theory, the aggregate price level represents the average level of all prices in an economy at a point in time. However, existing price indexes measure the price level for a group of goods and services that is more or less broad. The CPI, PPI, and PGDP are the price indexes that receive the most attention. Of these, the CPI is the most widely watched measure of purchasing power. Not only is the CPI timely because monthly data exist, it is influential because it is used to index federal programs such as Social Security, income tax brackets, and wage contract negotiations.

The PGDP covers the prices of all goods and services included in GDP, so it tends to be the most comprehensive.[3] The CPI covers just the prices of consumption goods and services paid by urban consumers. The CPI includes imported consumption goods, while the GDP deflator covers only domestically produced goods. Thus, the PGDP is less sensitive to factors such as oil price shocks.

The PPIT measures the prices producers charge for goods used to produce other goods (crude materials, commodities, and semi-finished and finished goods). PPIT measures prices of goods at an earlier production and distribution stage than the CPI and PGDP; however, the PPIT does not cover services. The same can be said for the popular PPI, except that it only covers the wholesale prices of final (or finished) goods.

Which index comes closest to measuring the aggregate price level? Obviously, the PPI is too narrow by itself to reflect the general price level. The PPIT is broader and may contain useful information beyond that embodied in the final-goods price indexes. It seems that PGDP is closest to an aggregate measure of the general price level because it has the broadest coverage. However, PGDP has two disadvantages relative to the CPI. It is only measured quarterly and uses current quantity weights that make it an impure measure of price changes.[4]

What price index does theory suggest? Davis (1991) writes that "the CPI can reasonably be considered 'the' measure of inflation, since it is the only one specifically designed to measure the purchasing power of money for the average final consumer of goods and services." However, the price index for measuring the purchasing power of a unit of currency could easily be defined on a broader collection of goods and services than even the PGDP. For instance, the transactions approach of the quantity theory of money, as stated by Fisher (1920) or Friedman and Schwartz (1982), proposes an even broader price index that reflects all money-based market transactions within a time period.[5] The transactions approach suggests targeting a comprehensive price index with the broadest possible coverage of current final goods and services as well as assets and intermediate goods prices.[6] Fisher's quantity equation evokes the long-run link between monetary instruments and objectives: $MV = PT$. Here, M is the money stock, T is the total number of transactions, P is the aggregate price level, and V is the velocity of transactions. Thus, given the velocity and number of transactions, money influences the aggregate

[3] *Note that up to 80 percent of the PGDP is built up from components of the CPI and PPI as well as other indexes. See footnote 2 for references.*

[4] *Because the PPI and CPI are based on a fixed market basket of goods, they reflect price changes only. However, the fixed-base-year quantity weights come from surveys taken at ten-year intervals that become less and less relevant over time. Weights in the PGDP reflect the importance of the various items in the current market basket of goods. Thus, changes to the index reflect changes in the composition of GDP as well as prices. While a fixed-weight GDP price deflator exists, the series covers too short a time span to be useful.*

[5] *See Wynne and Sigalla (1993) and Santoni and Moehring (1994) for further discussion and references.*

[6] *This includes money transactions in the underground economy. For a survey of studies estimating the size of the underground economy, see Bendelac and Clair (1993).*

price level one-to-one in the long run.

As a practical matter, the quantity equation has been narrowed by substituting final goods output for total transactions, which are difficult to observe. In this income-based approach, the price index is the aggregate price level for final goods and services (or PGDP), and velocity is defined as the velocity of final goods and services transactions. It requires strong assumptions to presuppose that the price of final goods captures all movements of the aggregate price of money transactions. In essence, it must be true that within a period, total transactions are a constant multiple (or cointegrated in the long run) to the output of final goods; and similarly for the velocity of total transactions and output. If this is not the case, final-goods price indexes may imperfectly reflect sustained general price changes that are due to monetary policy and may make aggregate price targeting more difficult.

Definition of inflation

The rate of inflation is defined as the percentage rate of change in a price index from one period to the next. Policymakers are interested in sustained changes of the economy's aggregate price level. This is because the trend, or average rate, of money growth (relative to real potential output growth) is the main determinant of these changes. When central bankers speak of inflation, they are concerned with sustained aggregate price changes or price movements that are primarily determined by monetary policy.

However, many other factors can affect price statistics. For example, short-term price shocks to a small number of goods may cause one-time jumps in the price level that are not sustained. Also, and perhaps simultaneously, as sectors allocate resources, the relative price changes of some goods over time may be picked up as persistent effects on many price indexes. Because price data are very noisy, the public and policymakers may have trouble distinguishing all of the different sources of change. Thus, they may overreact to short-term movements in the published price indexes and make suboptimal economic choices.

To get a reliable measure of sustained aggregate price changes, policymakers try to sift out the noise from the aggregate price changes they can influence. The crudest attempts to factor out short-term variability were the core rates of inflation. These indexes subtract food and energy indexes from the PPI and CPI. Except for the volatility of the food and energy markets in the 1970s, there really is no basis for throwing away the information that may be contained in these series.[7]

Recently, more sophisticated attempts to filter out noise have been studies that estimate common factors in the subindexes of the major aggregate inflation indexes. These studies use the inflation rates of components of the price indexes as separate but noisy observations on common price changes. Bryan and Cecchetti (1993b) use subindexes of the CPI, while Dow (1993) uses components of both the PPI and CPI to estimate common factors. The time-varying common factor may be attributed to monetary policy.

Although this second approach comes closer to what policymakers want measured, it may not adequately capture sustained price movements. Capturing these movements requires focusing on long-term price and inflation series movements and good knowledge of the series' dynamic properties over long periods. A common trend (or common long-run factor) across different price series—if one exists—would capture the long-term price growth that is of interest to policymakers. The next section explores whether the PPI, CPI, and PGDP have common trends despite differences in coverage. It also explores the links between the PGDP and price indexes of assets and intermediate goods to determine whether final goods prices are satisfactory indicators of the general price level as suggested by the transactions version of the quantity equation. For instance, the information contained in the dynamics of final-goods price indexes may be insufficient to capture price movements of intermediate goods, financial assets (such as equities and bonds), and real assets

[7] *Golub (1993) cites studies in the early 1980s that find relative price variability due to food and energy prices caused inflation in the 1970s. However, there do not seem to be similar studies for the 1980s. Bryan and Cecchetti's (1993a) median estimator approach is a more subtle attempt to derive a core rate of inflation that does not exclude any particular sector as a source of temporary variability.*

Table 1a
Contemporaneous Correlation Among Quarterly Price Indexes

	PGDP	CPI	PPI	PPIT	SP500	HMP
PGDP		.998	.995	.991	.912	.995
CPI			.997	.993	.898	.993
PPI					.872	.989
PPIT					.856	.985
SP500						.877
HMP						

(such as the stock of residential and commercial real estate, land, art, and so on).

Empirical properties of existing price series

This section examines the time series properties of price statistics to see how well they capture sustained or money-induced price movements. As Table 1a shows, the quarterly price series for the *CPI*, *PPI*, and *PGDP* exhibit high correlations between 1947:2 and 1994:1; the same is true for inflation rate indexes between 1947:3 and 1994:1, as can be seen in Table 1b. This suggests that any series may be a reliable indicator of movements in the others. However, targeting any one of these series will not necessarily produce equivalent movements in those that remain. Simple correlations do not necessarily imply a stable long-run relationship that a central bank can exploit. In particular, such correlations do not distinguish between persistent or temporary movements and their sources.

Since the transactions approach of the quantity equation suggests that the general price level may differ from final goods prices, this section also looks at the prices of assets and intermediate goods to see whether final goods prices (as represented by the *PGDP*) capture general price level movements. Convenient asset price indexes are the median sales price of housing (available starting in 1963:1) and the S&P 500 index. Tables 1a and 1b include correlations of a broad final-goods price index, the *PGDP*, with *PPIT*, the *S&P 500* index, and the median home price (*HMP*). Despite the broader coverage of the *PPIT*, correlations of the *PPIT* in levels and differences are similar to that of the *PPI*. Both asset price series are also highly correlated with the final-goods price indexes in levels. However, they are only weakly correlated in differences; the *S&P 500* index shows a negative correlation and the housing price exhibits a positive correlation with *PGDP* inflation. Also, as Figures 1a and 1b show, the price series appear to trend together even though movements of these indexes can deviate over short horizons. Below, we investigate to what extent there exist common long-term trends (which are presumably due to common factors such as monetary policy).

Before looking at common long-term trends, this section looks first at the properties of the different time series in isolation. In particular, tests reveal whether a series is nonstationary or stationary. These tests estimate the persistence of prices and their growth rates. Stationarity implies that the effects of shocks are temporary and will eventually die out. Whether a series is stationary or not also gives a measure of the price uncertainty facing economic decisionmakers. Finally, this section examines whether pairs of different price series are cointegrated—that is, whether they have a stable long-run relationship. Cointegration tests tell us whether it matters which price index we monitor and if a stable long-run relationship exists between the various indexes that could be capitalized on by policy. Shared stochastic trends, or cointegration, reveal shared underlying pro-

Table 1b
Contemporaneous Correlation Among Quarterly Inflation Indexes

	ΔPGDP	ΔCPI	ΔPPI	ΔPPIT	ΔSP500	ΔHMP
PGDP		.81	.74	.704	–.081	.205
CPI			.862	.804	–.213	.017
PPI					–.236	.117
PPIT					–.232	.181
SP500						–.07
HMP						

cesses and imply that permanent shocks to the trend of one series will be transmitted to the trend of the other series.

Stationarity tests determine the importance of a deterministic trend relative to a stochastic trend within a variable's long-run dynamics. Loosely, a (trend) stationary time series contains a deterministic trend but not a stochastic trend.[8] This means that shocks to the series cause temporary fluctuations. Because the series always reverts to its trend, there is no long-run uncertainty about the series. Therefore, one can forecast the series' long-run component with complete certainty or zero forecast variance. In contrast, a nonstationary series contains a stochastic trend. Instead of trend-reverting fluctuations, shocks cause permanent changes to the series. As a result, the series never completely returns to its original trend. For such a series, there is a great deal of uncertainty about its long-run behavior that increases with time. This uncertainty is reflected by an increasing forecast variance. Strong versions of price stability attempt to eliminate this uncertainty by making price levels and inflation rates stationary.

To determine whether a series is stationary or not requires a battery of tests.[9] The first of these is the augmented Dickey–Fuller (ADF), which tests the null hypothesis that the variable is nonstationary (or difference stationary). Additional information is available from the KPSS test by Kwiatkowski et al. (1992), which directly tests the null hypothesis that the series is stationary.[10] The ADF and KPSS tests may have difficulty in establishing whether a series is stationary or not. This is because it takes a very large sample to distinguish between stationarity and nonstationarity, and the postwar quarterly sample used in this article may be too small. Finally, the variance-ratio test of Cochrane (1988) compares the size of the permanent (or stochastic trend) component relative with the temporary (trend-reverting) component in a series by calculating the ratio of the components' variances. The variance ratio tends toward zero (or one) the smaller (or larger) the stochastic

[8] *For a trend stationary process, the deterministic trend is linear and can be written as* (a + bt). *A mean stationary process is a trend stationary process with* b = *0. The important issue of nonlinear deterministic trends and structural breaks will not be explored here. For more on this, see, for instance, Balke (1991) and Hamilton (1994).*

[9] *The tests are further described in the summary tables. In the spirit of Nelson and Plosser (1982), the ADF and KPSS (nonstationarity) tests define difference stationary by focusing on unit-root processes. In the spirit of Beveridge and Nelson (1981), McCallum (1993) argues for allowing more general nonstationary (or difference stationary) processes and that time series combine trend and difference stationary components with one or the other dominating. The variance ratio below agrees with this view.*

[10] *Difference stationary processes can be either trend or mean stationary.*

Figure 1a
Movements of *PGDP*, *PPI*, and *CPI*

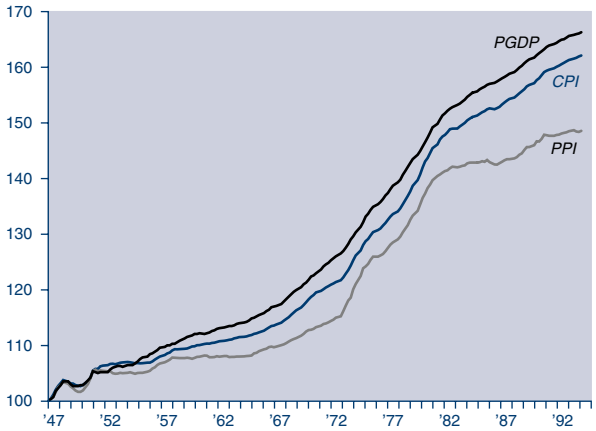
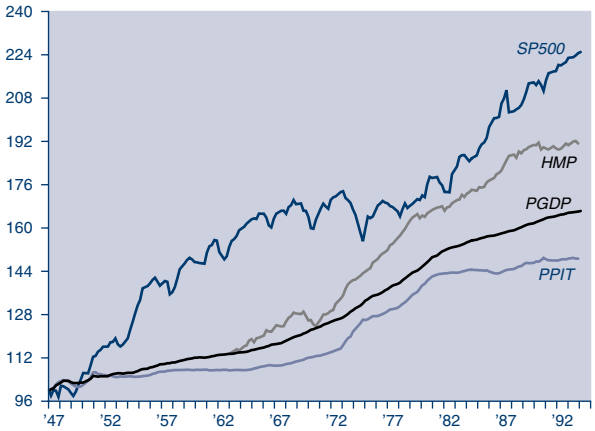


Figure 1b
Movements of *PGDP*, *PPIT*, *SP500*, and *HMP*



trend component in the series. However, if there is positive (or negative) serial correlation, the variance ratio will have an upward (or downward) bias from one. Differences in this ratio across price series indicate possible heterogeneous trends resulting from the different coverage of the indexes.

Results of the ADF and KPSS stationarity tests are summarized in Tables 2 and 3. The tests agree that *PGDP*, *CPI*, and *PPI* are nonstationary in levels. However, the tests on the stationarity of the series' inflation rates disagree and are sensitive to the lag specification.[11] The ADF test fails to reject nonstationarity for the growth rates of all three series. The results for the KPSS test tend to be less crisp. For the *PGDP* and *CPI* inflation rates, stationarity is (weakly) rejected, while stationarity fails to be rejected for the *PPI*. Thus, the ADF and KPSS give weak or conflicting results for the inflation series (especially for the *PPI*) but indicate that the levels of the price series are nonstationary.

The variance ratios of the price level series in Table 4 are large and growing, which suggests a large permanent component with positive serial correlation. The results agree with the above finding of nonstationary price level series. Thus, unexpected shocks to the price level cause the series to diverge from its initial path. By contrast, the variance ratios for the inflation rate series are small and falling. This is evidence that the inflation rates are stationary or that the permanent (or stochastic trend) component is dominated by the temporary (or trend-reverting) component over longer horizons. A large temporary component may distort the finite sample critical values of the ADF and KPSS tests and may explain why the test results are ambiguous (Schwert 1987). Furthermore, as the variance ratios differ from one index to another, the size of the stochastic trend component relative to the temporary component differs too. At long horizons, the *CPI* and *PPI* inflation rates have similar variance ratios, while *PGDP* tends to have the lowest. This suggests that shocks to the *CPI* and *PPI* inflation rates are more persistent than shocks to the growth rates of *PGDP*.

What about the price indexes for intermediate goods and assets? Despite the broader coverage of the *PPIT*, ADF and KPSS tests reveal that the *PPIT* in levels behaves similar to the *PPI* in terms of nonstationarity. However, in contrast to the *PPI*, these tests suggest that the *PPIT* inflation rate is stationary. This conclusion is supported by the variance ratios (which in levels and differences

[11] *The discussion of the ADF and KPSS tests considers the optimal lag length that comes closest to eliminating serial correlation for the ADF test statistic. The results for other lag lengths are in Tables 2 and 3.*

Table 2

Augmented Dickey–Fuller Unit-Root Test Statistics[1]

		With trend			Without trend		
Variable	**Sample**	**Lags = 4**	**Lags = 8**	**Lags = 12**	**Lags = 4**	**Lags = 8**	**Lags = 12**
PGDP	1947:1–94:1	–2.365 (.072)	–1.941 (.414)	–2.153 (.048)	1.114 (.088)	–.276 (.472)	–.701 (.105)
CPI	1947:1–94:1	–2.197 (.001)	–1.448 (.151)	–1.875 (.003)	1.337 (.002)	.564 (.228)	–.193 (.009)
PPI	1947:2–94:1	–1.965 (.04)	–1.5 (.101)	–1.877 (.010)	.528 (.044)	–.031 (.144)	–.189 (.023)
PPIT	1948:2–93:4	–1.904 (.005)	–1.424 (.019)	–1.756 (.0003)	.376 (.008)	–.10 (.032)	–.365 (.001)
SP500	1947:1–94:1	–2.153 (.088)	–1.716 (.002)	–1.705 (.007)	–.899 (.075)	–.88 (.004)	–.805 (.012)
HMP	1963:1–93:4	–1.21 (.169)	–1.628 (.243)	–1.398 (.147)	–1.109 (.226)	–.822 (.435)	–0.959 (.194)
Δ*PGDP*	1947:2–94:1	**–4.122***** **(.08)**	–1.453 (.2)	–1.229 (.03)	**–3.729***** **(.1)**	–1.86 (.29)	–1.755 (.04)
Δ*CPI*	1947:2–94:1	**–3.908**** **(.003)**	–2.411 (.19)	–2.166 (.14)	**–3.494***** **(.005)**	2.471 (.23)	–1.865 (.02)
Δ*PPI*	1947:3–94:1	**–4.134***** **(.02)**	–2.705 (.07)	–2.166 (.14)	**–3.975***** **(.3)**	**–2.798*** **(.099)**	–2.054 (.18)
Δ*PPIT*	1948:3–93:4	**–4.388***** **(.002)**	**–2.80***** **(.004)**	**–2.034***** **(.8)**	**–4.297***** **(.004)**	**–2.893***** **(.007)**	**–2.072***** **(.8)**
Δ*SP500*	1947:2–94:1	**–6.73***** **(.075)**	**–5.23***** **(.004)**	**–4.32***** **(.013)**	**–6.749***** **(.11)**	**–5.223***** **(.007)**	**–4.33***** **(.022)**
Δ*HMP*	1963:2–93:4	**–3.926**** **(.09)**	–2.823 (.52)	–2.522 (.22)	**–3.865***** **(.13)**	**–2.72***** **(.59)**	–2.472 (.32)

* Significant at the .10 level.
** Significant at the .05 level.
*** Significant at the .01 level.

Significance denotes that the null hypothesis of nonstationarity is rejected. Numbers in parentheses are the significance level determined by the Ljung-Box Q statistic for whether serial correlation is eliminated for a given lag length.

[1] The ADF test is determined by the regression: $y_t = \alpha + \beta_t + \rho y_{t-1} + \sum_{j=1}^{n} \gamma_j \Delta y_{t-j} + e_t$,

where y_t is the variable in period t, $\Delta y_{t-j} = y_{t-j} - y_{t-j-1}$, and n is the lag length. The null hypothesis that y_t is nonstationary is rejected when $\hat{\rho}$ differs significantly from one. The critical values are found in Fuller (1976) and Hamilton (1994).

Table 3
KPSS Unit-Root Test Statistics[1]

		With trend			Without trend		
Variable	**Sample**	**Lags = 4**	**Lags = 8**	**Lags = 12**	**Lags = 4**	**Lags = 8**	**Lags = 12**
PGDP	1947:1–94:1	.47***	.258***	.183**	2.128***	1.159***	.811***
CPI	1947:1–94:1	.485***	.266***	.188**	2.092***	1.14***	.8***
PPI	1947:2–94:1	.42***	.231***	.165**	2.05***	1.114***	.780***
PPIT	1948:2–93:4	.40***	.221***	.157**	2.03***	1.104***	.722***
SP500	1947:1–94:1	.254***	.147**	**.108**	1.959***	1.09***	.781***
HMP	1963:1–93:4	.14*	**.089**	**.077**	1.447***	.8***	.571**
Δ*PGDP*	1947:2–94:1	.244***	.174**	.125*	.574**	.383*	**.272**
Δ*CPI*	1947:2–94:1	.181**	.141*	**.116**	.527***	.377*	**.297**
Δ*PPI*	1947:3–94:1	.172***	.138*	**.112**	**.3**	**.233**	**.186**
Δ*PPIT*	1948:3–93:4	.163**	.143*	**.115**	**.242**	**.206**	**.165**
Δ*SP500*	1947:2–94:1	**.098**	.411***	.236***	**.098**	.411*	**.237**
Δ*HMP*	1963:2–93:4	.127*	**.108**	**.107**	**.166**	**.140**	**.137**

* Significant at the .10 level.
** Significant at the .05 level.
*** Significant at the .01 level.

Significance means that the null hypothesis of stationarity is rejected.

[1] The test statistics are derived by computing the test statistic $\left(1/T^2\right)\sum_{t=1}^{T}\left(S_t^2/\sigma^2(l)\right)$, where T is the sample size, $S_t=\sum_{i=1}^{T}e_t$ and e_i is the residual from a regression of the variable in question, y_t, on an intercept and a time trend. Also, $\sigma^2(l)$ is a consistent estimator of the long-run variance of y_t and is constructed as in Kwiatkowski et al. (1992). Critical values for the above test statistics can be found in Kwiatkowski et al. (1992).

appear to be very similar to those of the *PPI*). ADF and KPSS tests reveal that the *S&P 500* is nonstationary in levels. The evidence is mixed for the growth rates. ADF and KPSS tests seem to imply stationarity, and variance ratios show that the temporary component tends to dominate in differences, which is evidence for stationarity. Finally, the ADF and KPSS tests indicate that median home prices are nonstationary in levels and possibly stationary in differences.

Finally, cointegration tests of various price series are depicted in Tables 5a and 5b. Essentially, the cointegration test is a test for common trends and indicates whether the same processes underlie the different price indexes, even if the indexes cover different goods and services. The method proposed by Johansen (1988, 1991) and Johansen and Juselius (1990) was chosen to determine whether various price indexes share a common stochastic trend.[12] The evidence is that the *PGDP* is cointegrated with the *PPI* and weakly cointegrated with the *CPI*, but the *PPI* and *CPI* are not cointegrated. Because coverage of the *PGDP* comprises components of both *CPI* and *PPI*, it is not surprising that *PGDP* shares a trend with these indexes. Surprisingly, *PPI* and *CPI* do not share a trend. Transitivity would imply that

[12] *See Campbell and Perron (1991) and Gonzalo (1994) for comparisons of methods.*

Table 4
Cochrane's Variance-Ratio Statistics*

Variable	Sample	$k = 4$	$k = 8$	$k = 12$	$k = 24$	$k = 36$	$k = 48$
PGDP	1947:1–94:1	2.76	4.35	6.06	12.114	18.38	24.43
		(.046)	(1.03)	(1.76)	(4.985)	(9.26)	(14.21)
CPI	1947:1–94:1	3.18	5.13	6.69	11.73	17	21.96
		(.53)	(1.22)	(1.95)	(4.83)	(8.57)	(12.78)
PPI	1947:2–94:1	2.82	4.25	5.29	8.02	10.66	12.524
		(.48)	(1.01)	(1.54)	(3.31)	(5.39)	(7.31)
PPIT	1948:2–93:4	2.72	3.81	4.53	6.54	8.56	9.82
		(.46)	(.91)	(1.32)	(2.698)	(4.32)	(5.73)
SP500	1947:1–94:1	1.4	1.16	.93	1.16	1.29	1.27
		(.23)	(.28)	(.27)	(.48)	(.65)	(.74)
HMP	1963:1–93:4	1.3	1.64	1.84	2.07	2.88	4.01
		(.27)	(.48)	(.66)	(1.05)	(1.79)	(2.88)
Δ*PGDP*	1947:2–94:1	.393	.215	.154	.094	.075	.068
		(.066)	(.051)	(.045)	(.039)	(.038)	(.04)
Δ*CPI*	1947:2–94:1	.55	.398	.258	.134	.111	.098
		(.093)	(.095)	(.075)	(.055)	(.056)	(.057)
Δ*PPI*	1947:3–94:1	.658	.43	.276	.134	.108	.095
		(.11)	(.103)	(.081)	(.055)	(.055)	(.056)
Δ*PPIT*	1948:3–93:4	.583	.377	.223	.108	.087	.078
		(.098)	(.09)	(.065)	(.044)	(.044)	(.045)
Δ*SP500*	1947:2–94:1	.365	.187	.113	.068	.037	.024
		(.062)	(.045)	(.033)	(.028)	(.019)	(.014)
Δ*HMP*	1963:2–93:4	.269	.146	.086	.048	.026	.019
		(.056)	(.043)	(.031)	(.024)	(.017)	(.014)

* Cochrane's (1988) variance-ratio statistics for the difference horizon k are estimated as the following ratio of variances: $\frac{Var(y_{t+k} - y_t)}{kVar(y_{t+1} - y_t)}$. Bartlett standard errors are given in the parentheses and are computed as $(4k/3T)^{1/2}$, where T is the sample size.

the *CPI* is cointegrated with *PPI*. This may, in fact, be the case; however, cointegration tests may have insufficient strength to yield consistency. An alternative explanation is that *PGDP* and *CPI* are not cointegrated. In addition, the inflation rates of the *PGDP* and the *CPI* are cointegrated. However, the cointegration tests with the *PPI* inflation indicate that there are as many cointegrating relationships as there are series included in the test regression. This result implies that the inflation series are stationary. Thus, the tests with *PPI* inflation are inconclusive and contradict the findings from ADF and KPSS tests (although they are consistent with the variance ratios).

What about the price indexes for intermediate goods and assets? The *PPIT* is cointegrated with *PGDP* in levels. Despite the earlier finding of stationarity, *PPIT* inflation is cointegrated with *PGDP* inflation. Thus, monitoring any of the final-goods price or inflation indexes (as represented by the *PGDP*) is sufficient because those price or inflation indexes for total intermediate goods will not

Table 5a
Cointegration Test Statistics for Price Levels

		With trend				Without trend			
Variables	Sample size	Eigen-values	Null hypothesis	λ-max test	Trace test	Eigen-values	Null hypothesis	λ-max test	Trace test
CPI, PPI	1947:2–94:1	.027	$r = 0$:	4.97	5.85	**.064**	***r* = 0:**	**11.95**	**14.68**
	$T = 188$	.005	$r = 1$:	.89	.89	**.015**	***r* = 1:**	**2.73**	**2.73**
						0			
PGDP, CPI	1947:1–94:1	**.071**	***r* = 0:**	**13.42****	**14.05****	.112	$r = 0$:	21.51***	24.06***
	$T = 189$	**.003**	***r* = 1:**	**.63**	**.63**	.014	$r = 1$:	2.56	2.56
						0			
PGDP, PPI	1947:2–94:1	.032	$r = 0$:	5.84	8.57	**.101**	***r* = 0:**	**19.35*** **	**23.39*** **
	$T = 188$	.015	$r = 1$:	2.73	2.73	**.022**	***r* = 1:**	**4.05**	**4.05**
						0			
CPI, PPIT	1948:2–93:4	.03	$r = 0$:	5.45	5.95	**.067**	***r* = 0:**	**12.42**	**14.51**
	$T = 183$	.003	$r = 1$:	.496	.496	**.012**	***r* = 1:**	**2.09**	**2.09**
						0			
PGDP, PPIT	1948:2–93:4	.02	$r = 0$:	3.69	6.45	**.077**	***r* = 0:**	**14.52****	**18.01****
	$T = 183$	.015	$r = 1$:	2.76	2.76	**.019**	***r* = 1:**	**3.49**	**3.49**
						0			
PGDP, HMP	1963:1–93:4	.107	$r = 0$:	13.52**	15.62***	**.109**	***r* = 0:**	**13.85****	**19.98****
	$T = 124$	.015	$r = 1$:	2.16	2.16	**.05**	***r* = 1:**	**6.13**	**6.13**
						0			
PGDP, SP500	1947:1–94:1	.049	$r = 0$:	9.31	11.38	**.141**	***r* = 0:**	**28.03*** **	**33.22*** **
	$T = 189$	.011	$r = 1$:	2.07	2.07	**.028**	***r* = 1:**	**5.19**	**5.19**
						0			

** Significant at the .10 level.
*** Significant at the .05 level.

Critical values are from Johansen and Juselius (1990) Table A1 for the model estimated with a trend and Table A3 for the model without. After looking at the graph of the price level series, it was determined that the vector error-correction model should be estimated with a trend. To test whether the null hypothesis of a trend or the alternative of no trend fit the data better, a likelihood-ratio test was performed. The test statistic, $-T\sum_{i=r+1}^{p} ln\frac{1-\lambda_i^{trend}}{1-\lambda_i^{no\ trend}}$, is distributed $x^2(p-r)$ where $p = 2$ is the number of variables, r is the number of cointegrating vectors, and the eigenvalues, λ_i, are arranged in descending order (or, $\lambda_1 > \lambda_2$). Note that this test statistic is conditioned on the r found to be significant in the model with a trend. Finally, the bold-faced statistics in the table indicate which model passes the likelihood-ratio test.

move independently in the long run. This cointegration result suggests a stable long-run link between final-goods price indexes and the general price level. Also, the *S&P 500* and *PGDP* are cointegrated in levels. However, the relationship is inconclusive for the growth rates of the *S&P 500* and *PGDP*, which is in line with the univariate evidence that the *S&P 500* is stationary in differences. The median home price series is also cointegrated with *PGDP* in levels and weakly cointegrated in growth rates (which contradicts the univariate evidence of stationarity). Thus, there is evidence that asset prices share common trends with final goods prices. Since the general price level may comprise intermediate goods and asset prices, and *PGDP* tends to share common trends

Table 5b
Cointegration Test Statistics for Inflation Rates

		With trend				Without trend			
Variables	Sample size	Eigen-values	Null hypothesis	λ-max test	Trace test	Eigen-values	Null hypothesis	λ-max test	Trace test
ΔCPI, ΔPPI	1947:3–94:1	.109	$r = 0$:	20.99***	31.41***	**.110**	**$r = 0$:**	**21.03*** **	**31.52*** **
	$T = 187$	.056	$r = 1$:	10.43***	10.43***	**.056**	**$r = 1$:**	**10.49*** **	**10.49*** **
						0			
$\Delta PGDP$, ΔCPI	1947:2–94:1	.165	$r = 0$:	32.54***	39.43***	**.165**	**$r = 0$:**	**32.64*** **	**39.53*** **
	$T = 188$	.037	$r = 1$:	6.89***	6.89***	**.037**	**$r = 1$:**	**6.89**	**6.89**
						0			
$\Delta PGDP$, ΔPPI	1947:3–94:1	.142	$r = 0$:	27.72***	37.2***	**.142**	**$r = 0$:**	**27.73*** **	**37.74*** **
	$T = 187$	.054	$r = 1$:	10***	10***	**.054**	**$r = 1$:**	**10*** **	**10*** **
						0			
ΔCPI, $\Delta PPIT$	1948:3–93:4	.102	$r = 0$:	19.46***	26.1***	**.103**	**$r = 0$:**	**19.54*** **	**26.2*** **
	$T = 182$	.036	$r = 1$:	6.65***	6.45***	**.036**	**$r = 1$:**	**6.65**	**6.65**
						0			
$\Delta PGDP$, $\Delta PPIT$	1948:3–93:4	.152	$r = 0$:	29.69***	37.04***	**.152**	**$r = 0$:**	**29.71*** **	**37.08*** **
	$T = 182$	.04	$r = 1$:	7.36***	7.36***	**.04**	**$r = 1$:**	**7.38**	**7.38**
						0			
$\Delta PGDP$, ΔHMP	1963:2–93:4	.182	$r = 0$:	23.93***	27.51***	**.182**	**$r = 0$:**	**23.93*** **	**27.51*** **
	$T = 123$	.03	$r = 1$:	3.58**	3.58**	**.03**	**$r = 1$:**	**3.58**	**3.58**
						0			
$\Delta PGDP$, $\Delta SP500$	1947:2–94:1	.218	$r = 0$:	45.19***	58.6***	**.218**	**$r = 0$:**	**45.2*** **	**58.71*** **
	$T = 188$	.07	$r = 1$:	13.4***	13.4***	**.07**	**$r = 1$:**	**13.5*** **	**13.5*** **
						0			

** Significant at the .10 level.
*** Significant at the .05 level.

Critical values are from Johansen and Juselius (1990) Table A1 for the model with a deterministic trend and Table A3 for the model without a trend. After looking at the graph of the inflation rate series, it was determined that the vector error correction model should be estimated without a linear trend. To test whether the null hypothesis of no trend or the trend alternative fit the data better, a likelihood-ratio test was performed. The test statistic, $-T\sum_{i=r+1}^{p} ln\frac{1-\lambda_i^{no\ trend}}{1-\lambda_i^{trend}}$, is distributed $x^2(p-r)$, where $p = 2$ is the number of variables, r is the number of cointegrating vectors, and the eigenvalues, λ_i, are arranged in descending order (or, $\lambda_1 > \lambda_2$). Note that this test statistic is conditioned on the r found to be significant in the model without a trend. Finally, the bold-faced statistics in the table indicate which model passes the likelihood-ratio test.

with some indexes of assets and intermediate goods prices, one can conclude that final goods prices are valid indicators for the general price level. However, this conclusion does not necessarily hold true for the inflation rates of intermediate goods and assets, which tend to exhibit weak or mixed evidence of stationarity and so render the cointegration tests inconclusive.

Conclusion

Past measures of sustained movements in the general price level were based on popular price indexes such as the CPI, PPI, and PGDP. This article extends the search for a general price level measure and money-induced (or sustained) price movements beyond the final goods and

List of Variables

PGDP	Implicit Price Deflator for GDP (seasonally adjusted and in logarithms)
CPI	Consumer Price Index (seasonally adjusted and in logarithms)
PPI	Producer Price Index for Finished Goods (seasonally adjusted and in logarithms)
PPIT	Producer Price Index for All Intermediate Goods (seasonally adjusted and in logarithms)
SP500	Standard & Poor's 500 Index (in logarithms)
HMP	Median Home Price (seasonally adjusted and in logarithms)
Δ	Difference operator

services prices covered by these popular price indexes. Theory suggests expanding the coverage of the popular indexes by adding information contained in asset prices and intermediate goods prices. According to some, such an expansion is necessary for a theoretically satisfactory measure of the aggregate price level and aggregate inflation.

To determine whether price indexes for final goods and services and price indexes for intermediate goods and assets provide similar information, this article investigates the time series characteristics of the above-mentioned popular price indexes, PPIT, and asset price series such as the S&P 500 and the median housing sales index. Because monetary authorities are particularly interested in sustained price changes, I focused on the long-run characteristics of these series. Examining whether the price series and their growth rates are stationary gives an idea of how close we are to price stability. More important is whether the different price series or their growth rates are cointegrated. If so, shocks to the trend of one series will be transmitted to the trends of the others. In other words, cointegration implies a stable long-run relationship between the series—a relationship that simplifies monitoring of the general price level and that a policymaker may exploit. Given cointegration, a specific price index or inflation rate can serve as an effective indicator for the other series. Otherwise, auxiliary information or a more general price measure will be necessary.

Evidence suggests that the different price level series are nonstationary, but evidence is weak or conflicting on whether their growth rates are also nonstationary. Since nonstationarity implies forecast uncertainty and potentially inefficient decision-making, achieving price level stability appears to be a more distant goal than inflation rate stability. While data from the 1980s may reveal that our price stabilizing performance has improved, more work has to be done before we can tell for sure. Tests reveal that the PGDP tends to be cointegrated with a wide range of price indexes. Thus, the PGDP is an effective indicator of the general price level. However, because there is mixed evidence that some inflation series are stationary, evidence is weak that other inflation rates are cointegrated with PGDP inflation. Thus, it is unclear whether final-goods price inflation is a useful indicator for monetary policy decisions. Future work may investigate the information contained in asset price inflation that is not contained in the PGDP and other indexes of final goods prices.

References

Balke, N. S. (1991), "Modeling Trends in Macroeconomic Time Series," Federal Reserve Bank of Dallas *Economic Review*, May, 19–33.

Balke, N. S., and K. M. Emery (1994), "The Algebra of Price Stability," *Journal of Macroeconomics* 16 (Winter): 77–97.

Bendelac, J., and P.-M. Clair (1993), "Macroeconomic Measures of the Hidden Economy" (Paper presented at the 49th Congress of the I.I.P.F., Berlin, Germany).

Beveridge, S., and C. R. Nelson (1981), "A New Approach to Decomposition of the Economic Time Series into Permanent and Transitory Components with Particular Attention to Measurement of Business Cycles," *Journal of Monetary Economics* 7 (January): 151–74.

Brauer, D., and L. Wu (1991), "In Brief: An Overview of Inflation Measurement," Federal Reserve Bank of New York *Quarterly Review*, Summer, 25–29.

Bryan, M. F., and S. G. Cecchetti (1993a), "Measuring Core Inflation," NBER Working Paper Series, no. 4303 (Cambridge, Mass.: National Bureau of Economic Research).

———, and ——— (1993b), "The Consumer Price Index as a Measure of Inflation," Federal Reserve Bank of Cleveland *Economic Review* 29(4): 15–24.

Campbell, J. Y., and P. Perron (1991), "Pitfalls and Opportunities: What Macroeconomists Should Know About Unit Roots," in *NBER Macroeconomics Annual* (Cambridge, Mass.: MIT Press for National Bureau of Economic Research).

Carlson, K. M. (1989), "Do Price Indexes Tell Us About Inflation? A Review of the Issues," Federal Reserve Bank of St. Louis *Review*, November/December, 12–30.

Cochrane, J. H. (1988), "How Big Is the Random Walk in GDP?" *Journal of Political Economy* 96(5): 893–920.

Davis, R. G. (1991), "Inflation: Measurement and Policy Issues," Federal Reserve Bank of New York *Quarterly Review*, Summer, 13–24.

Dow, J. P. (1993), "Measuring Inflation Using Multiple Price Indexes," Department of Economics, University of California–Riverside, March, mimeo.

Fisher, I. (1920), *The Purchasing Power of Money: Its Determination and Relation to Credit, Interest and Crises*, 2nd edition (New York: Macmillan).

Friedman, M., and A. Schwartz, (1982), *Monetary Trends in the United States and the United Kingdom: Their Relation to Income, Prices and Interest Rates, 1867–1975* (Chicago: University of Chicago Press).

Fuller, W. A. (1976), *Introduction to Economic Time Series* (New York: Wiley).

Golub, J. E. (1993), "Inflation, Inflation Uncertainty, and Relative Price Variability: A Survey," Federal Reserve Bank of Kansas City, Working Paper no. 93–15 (Kansas City, Mo., August).

Gonzalo, J. (1994), "Five Alternative Methods of Estimating Long-Run Equilibrium Relationships," *Journal of Econometrics* 60 (January/February): 203–33.

Hamilton, J. D. (1994), *Time Series Analysis* (Princeton, N.J.: Princeton University Press).

Ireland, P. N. (1993), "Price Stability Under Long-Run Monetary Targeting," Federal Reserve Bank of Richmond *Economic Quarterly*, Winter, 25–45.

Johansen, S. (1991), "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models," *Econometrica* 59: 1551–1580.

——— (1988), "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control* 12 (June/September): 231–54.

———, and K. Juselius (1990), "Maximum Likelihood Estimation and Inference on Cointegration—With Applications to the Demand for Money," *Oxford Bulletin of Economics and Statistics* 52 (May): 169–210.

Kwiatkowski, D., P. C. B. Phillips, P. Schmidt, and Y. Shin (1992), "Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root," *Journal of Econometrics* 54 (October–December): 159–78.

McCallum, B. T. (1993), "Unit Roots in Macroeconomic Time Series: Some Critical Issues," Federal Reserve Bank of Richmond *Economic Quarterly*, Spring, 13–43.

Nelson, C. R., and C. I. Plosser (1982), "Trends Versus Random Walks in Macroeconomic Time Series: Some Evidence and Implications," *Journal of Monetary Economics* 10 (September): 139–62.

Santoni, G. J., and H. B. Moehring (1994), "Asset Returns and Measured Inflation," *Journal of Money, Credit, and Banking* 26 (May): 232–48.

Schwert , G. W. (1987), "Effects of Model Specification on Tests for Unit Roots in Macroeconomic Data," *Journal of Monetary Economics* 20 (July): 73–103.

Webb, R. E., and R. Willemse (1989), "Macroeconomic Price Indexes," Federal Reserve Bank of Richmond *Economic Review*, July/August, 22–32.

Wynne, M. A., and F. Sigalla (1993), "A Survey of Measurement Bias in Price Indexes," Federal Reserve Bank of Dallas, Research Paper no. 9340 (Dallas, October).