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The cyclical behavior of prices*

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The procyclical behavior of prices has been a staple of business cycle lore since the work of the early NBER business cycle researchers. This paper reexamines that empirical fact. The aggregate data do not support procyclical price movements as a stable feature of the business cycle. The only episode where it is a robust feature of the data is the period between the two world wars, particularly the period of the Great Depression.

1. Introduction

One of the central goals of modern business cycle theory is to explain the important empirical features of cycles using simple models that are consistent with the principles of optimizing behavior and equilibrium. Determining those important empirical features has been a subject of economic research for a much longer time. Burns and Mitchell (1946) and Friedman and Schwartz (1963, 1982) are among the pioneers in the careful exegesis of empirical regularities and comovements among variables that are used to characterize the business cycle. Most of these features are familiar, uncontroversial, and can be captured in fairly simple model economies. This paper is concerned with the positive correlation between prices and output, a feature of the business cycle that has not been regarded as controversial but has not been easy to explain in the context of equilibrium model economies populated by optimizing agents. It seems fair to say that this particular empirical feature has motivated a lot of the business cycle research of the past twenty

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years whether empirical or theoretical. We look at price and output data from the 1820s to the present and conclude that procyclical behavior of prices is not a consistent feature of the data. For the post-WWII U.S. economy prices are countercyclical, and this finding is not simply an artifact of the oil shocks of the 1970s. In fact, with the important exceptions of the inter-war years and part of the late nineteenth century, we find relatively little evidence of procyclical prices over the last century and a half.

Early chroniclers of business cycles found a strong positive association between price levels and business activity. That they did so was considered by them quite remarkable. As Mitchell (1951, p. 170) noted:

> We know that increases in supply tend to depress prices while increases in demand tend to raise them; but how will prices behave in a cyclical expansion when both supply and demand rise, or in a contraction when both supply and demand shrink? It is in this theoretically indeterminate form that price problems confront students of business cycles. What to expect we learn from experience: most prices rise and fall with the cyclical tides of business activity most of the time – not always.

And Mitchell himself quoted Harrod (1936, p. 41):

> This fact, that prices rise when goods are turned out in greater abundance and fall in the opposite situation, is a striking paradox and requires to be seen to be believed. It is one of the very few generalizations vouchsafed by empirical observation in economics: and it is probably the best established of any.

The reason this great paradox seemed so firmly established is that it was intensely studied and documented. Kuznets (1930) explored the relation between production and prices at a very disaggregated level over the 19th and early 20th century. He found a great deal of conformity in the movements of prices and output both over short-term contractions and longer-term cycles.[1] Mills (1927, 1936, 1946) also studied the behavior of prices during recessions and recovery. He was concerned with the movements of aggregate price indices (primarily the wholesale price index) over contractions and expansions. Mills was also concerned with the similarity of price cycles across countries and for different periods of recessions and recovery. He tried to relate the behavior of prices to movements in the important components of the wholesale price index and to fluctuations in productivity over the business

[1] Long-wave cycles, particularly the Kondratieff cycle, were explicitly long cycles marked off in terms of prices, usually wholesale prices. These cycles were thought to be related to gold discoveries, changes in monetary institutions, and the like.

cycle. For Mills the importance and strength of the procyclical behavior of prices was such that significant expansions and contractions could be virtually defined by the behavior of prices.

Burns and Mitchell (1946) also studied in close detail the behavior of wholesale price indices and the behavior of many individual prices over all of the contractions and expansions from 1854 to 1933. Although the conformity of price movements with expansions and contractions was not as great as for some of the other series they studied (such as bank clearings), it was surprising nevertheless. The index of wholesale prices rose in 13 of 20 expansions and fell in 17 of 20 contractions. Most individual commodity prices exhibited slightly less conformity. Mills (1946) and Mitchell (1951) further updated this research, again with similar findings: prices exhibit a strong but not perfect conformity to output movements during expansions and contractions.

The research just cited, by the National Bureau of Economic Research's business cycle pioneers, is remarkable for its thoroughness and dogged attention to detail. It is also notable for the fact that the perspective of these researchers was so heavily conditioned by the economic history of the late 19th century and especially the great contraction that began in 1929. The features of the post-war U.S. economy appear to have been very different from those of either the inter-war economy or the pre-WWI economy. Among other things, the post-war contractions appear less prolonged and less severe [although the recent reinterpretation of Romer (1989) casts doubt on this view]. Nevertheless, much post-WWII thinking about the economy has been strongly influenced by views of the business cycle that were formed on the basis of this much earlier experience.

The notion that prices are procyclical has, if anything, assumed greater stature in the post-WWII era. This is due not only to the continuing influence of the Burns–Mitchell view of business cycles, but also, and perhaps more importantly, to the widespread acceptance of the Phillips curve as an empirical regularity that macroeconomic theory must account for.[2] It was (and still is in many quarters) widely accepted as a regular feature of the U.S. economy and it was considered to be consistent with the Burns–Mitchell view of the relation between prices and output over the cycle. Lucas (1972a, p. 103), who as much as anyone was responsible for the demise of the output–inflation correlation as an exploitable phenomenon, still regarded it as:

> ...the central feature of the modern business cycle: a systematic relation between the rate of change of nominal prices and the *level* of real output. (emphasis added)

[2]Perhaps the most substantial challenge to this view is by Friedman and Schwartz (1982).

Lucas (1972b, p. 50) clarified this view of the relationship:

> It is an observed fact that, in U.S. time series, inflation rates and unemployment are negatively correlated. This remains true (with the obvious sign change) if unemployment is replaced with de-trended real output, if price inflation is replaced by money wage inflation, and so forth.

Because of its central place in business cycle theory and its acceptance as a statistical fact by the critics of post-WWII Keynesian economics, the positive correlation between real output and inflation has remained a central feature that even neoclassical models must attempt to explain. Examples of models deliberately designed to capture this feature are in Lucas (1972a, 1977). The clarity and elegance of those papers belies the difficulty of constructing equilibrium models that were capable of delivering this phenomenon while preserving the assumption that individuals act rationally and exploit the information available to them. All of the models developed in that vein, however, have the implication that the inflation–output correlation is the result of a positive relationship between *unexpected* inflation (or prices, depending on the author) and real output.

Recent reappraisals have, again, shifted their position on what the important relation between prices and output is. One view is suggested by Mankiw (1989, p. 88) who claims:

> It is a well documented fact that, in the absence of identifiable real shocks such as the OPEC oil price changes, inflation tends to rise in booms and fall in recessions.

This is a curious assertion since it clearly implies that supply shocks are aberrations that are easily identified while demand shocks are the rule. More importantly it suggests that it is the first derivative of inflation that is positively correlated with output.[3]

Our goal in this paper is to re-examine the correlation between prices and output. We begin by discussing this as purely an empirical issue. But, in order to treat this as an empirical issue, one has to take a stand on what to measure. For the early NBER researchers, who explored this issue at the microeconomic level, the issue seemed to be correlation between levels of variables. At the aggregate level there seem to be three distinct views about

[3]It is possible, but unlikely, that the change in inflation could be positively correlated with output even when inflation is negatively correlated. We discuss this further below.

what the appropriate 'stylized fact' is:

1. Inflation is correlated with the level of (detrended) output.
2. Unexpected inflation is correlated with (detrended) output.
3. The change in inflation is correlated with (detrended) output.

We focus most of our attention on interpretations 1 and 3 since they can be addressed empirically without taking a stand on how best to model expectations. We don't directly address interpretation 2 except insofar as vector autoregressions that provide correlations between output and inflation *conditional* on the time path of money and interest rates capture the empirical substance of that idea.[4]

The empirical assertions above also require one to take a stand on how to deal with trends. While there are alternative ways of modeling the trend – deterministic, stochastic, and so on – we adopt the view that growth rates is the natural metric for studying this question, and that suggests using log differences. We also report the results for other ways of filtering out the trend component in the series. Most – not all – of the results are robust to the choice of filter.

In the next section we take as given the definitions of cyclical contractions and expansions. For the period from 1822 to 1859 we define a contraction to be any period in which real GNP declined. For the period from 1869 to the present we use the definitions presented by Burns and Mitchell and subsequent National Bureau of Economic Research datings. With those definitions, we present a visual tour of the behavior of prices and output for both contractions and expansions from just after the 1820s to the present. One conclusion that seems to emerge from this tour is that the relation between inflation and real output is not the same over time and can differ rather dramatically across cycles.

In the third section of the paper we take the issue to be one of comovements between prices and output, leaving aside the exogenous definitions of the cycle provided by NBER dating. Accordingly, we look at some simple atheoretical summaries of the relation between real output and inflation. We consider both simple cross-correlations and vector autoregressions for the pre-WWI period, the inter-war period, and the post-WWII period. In general the data do not indicate a stable pattern of comovement between output and inflation. With the exception of the inter-war period, however, the relation seems to be predominantly negative, and is not sensitive to the method of detrending. These results are consistent with earlier empirical evidence

[4]Previous efforts to detect a significant positive correlation between unexpected inflation and output have had mixed success [Sargent (1976), Fair (1979), Gray and Spencer (1990)].

presented by Kydland (1987) for the post-war U.S., by Backus and Kehoe (1990) for post-war Europe, and by Friedman and Schwartz (1982) for earlier periods.

Some economists associate procyclical prices with the Phillips curve, and may be tempted to interpret this work as an empirical evaluation of that relationship. We do not attempt to estimate Phillips curves, nor is the relevance of our findings limited to this relation. The Phillips curve is a 'structural' relation, requiring the usual identifying restrictions. The purely statistical analysis presented in this paper simply estimates the average historical relationship between prices and output in the United States, an association that was of interest to economists long before the work of Phillips. The empirical results of this paper do have important implications for determining what set of business cycle 'facts' should be explained by theoretical models, and for the type of restrictions used to achieve identification in empirical macroeconomic analysis. The assumption that prices and output co-vary positively has led many researchers to impose as an identifying restriction that aggregate supply schedules are stable in response to fluctuations in aggregate demand. Our finding of no consistent positive relationship between prices and output is strikingly different from the assumed correlations that motivate the identifying restrictions of many aggregate demand-driven business cycle models.

2. Prices and output

We begin by presenting the data that will be the focus of our analysis. In this paper, we want to determine whether the positive comovement of prices and output exists in aggregate data. The aggregates we use are different from the data that formed the basis for the conclusions of the early investigators of the relation between prices and output. Accordingly, it is of some interest to see if our data support the observations of those researchers at a simple level. Our data for the period before the Civil War, 1822–1859, come from a variety of sources. For real GNP we use the data of Robert E. Gallman as extended by Thomas Berry.[5] The price index is the Warren–Pearson wholesale price index. The money stock for this period is taken from Temin (1969), while interest rates are taken from Homer (1977). Our primary data source for the period from the Civil War to WWII is Friedman and Schwartz (1982). We have also looked at alternative sources. One is Balke and Gordon (1986), who have constructed annual and quarterly series for real GNP and the GNP deflator based in part on the Friedman and Schwartz series.[6] In addition,

[5]These data are discussed in Goldin and Margo (1989) and were provided to us by Bob Margo.

[6]Balke and Gordon (1986) construct a GNP series by adding estimates of capital consumption from Kuznets to the Friedman–Schwartz income series. They construct the quarterly data by interpolating the annual data using the procedure of Chow and Lin (1971) and relating GNP and

Balke and Gordon (1989) and Romer (1989) present alternative estimates of GNP and the deflator for the period from 1869 to 1929. For our purposes these do not contain any information not already apparent in the Friedman and Schwartz data, so we will present only the results using the latter.[7] Initially, we simply want to ask if prices and output appear to move together over the expansions and contractions as defined by Burns and Mitchell and reported in Mitchell (1951) and in Citibank.

Figs. 1 and 2 show the behavior of real GNP and the wholesale price index over the pre-Civil War expansions and contractions, respectively. From these there is relatively little evidence of a consistent pattern although during the few contractions the evidence seems to favor a negative comovement. One thing that could be clouding the picture is the presence of trends. These variables are dominated by trends over many of the sample periods we examine, and it is well known that trending data may exhibit spurious relationships [see Granger and Newbold (1974) or Stock and Watson (1988a)]. While there are many ways of modeling trends, recent econometric research has focused on two particular trend specifications: integrated or difference-stationary processes and trend-stationary processes or deterministic trends [see Nelson and Plosser (1982) and Stock and Watson (1988a, b)]. For the current exercise we assume a stochastic trend. The pictures change somewhat using deterministic trends or the Hodrick–Prescott filter, but the general visual impressions remain the same.

Figs. 3 and 4 show the movements of the series discussed above after they have been log-differenced. In some of the expansions detrended income and prices appear positively related, in many they do not. Figs. 5 and 6 show the behavior of real income and its implicit deflator over the pre-WWI expansions and contractions, respectively.[8] During several of these expansions, particularly those prior to 1895, the behavior of the price deflator is at best ambiguous and it often seems to be moving in the opposite direction to output. The behavior of these variables in fig. 6 is quite puzzling. First, many of the contractions do not seem to be contractions in terms of real income, in particular the contraction from 1873 through 1878 seems to be an expansion. Further, during some of the contractions where output falls, the implicit deflator is rising.

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the deflator to independent series. Calomiris and Hubbard (1989) use more disaggregated data on pig iron production and so on to gain more observations. It is worth noting that they find positive relationships between prices and output.

[7]We have repeated some of the analysis using Romer's (1989) data without observing any significant change in the results.

[8]Measured from trough to peak as reported in Mitchell (1951). Since we are using annual data, we are forced to use the annual dating of the cycle that Mitchell presents. Some of the ambiguity that we note may stem from the fact that annual data is too coarse to capture the exact timing of the cycles, especially those that peak or bottom out near mid-year.

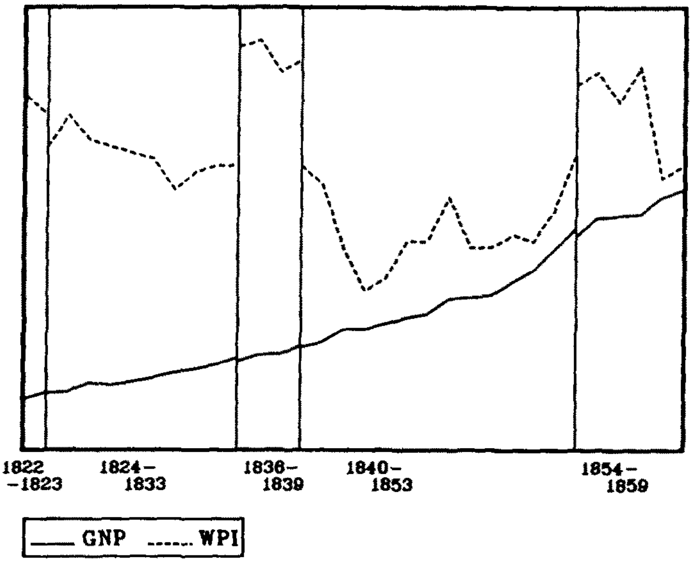

Fig. 1. Real GNP and wholesale price index, pre-Civil War expansions, Gallman-Berry data.

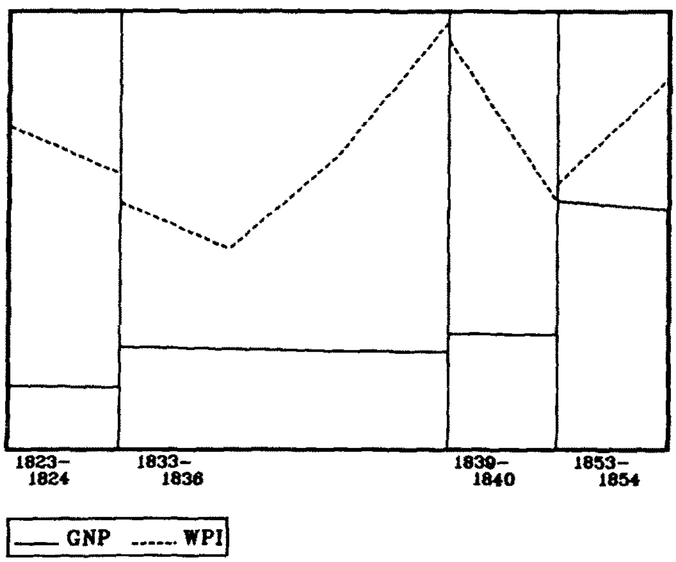

Fig. 2. Real GNP and wholesale price index, pre-Civil War contractions, Gallman-Berry data.

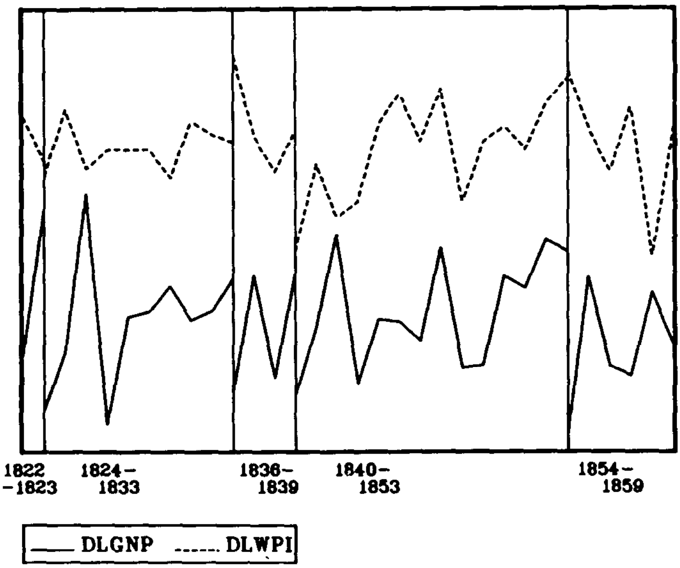

Fig. 3. Log-differenced real GNP and wholesale price index, pre-Civil War expansions, Gallman–Berry data.

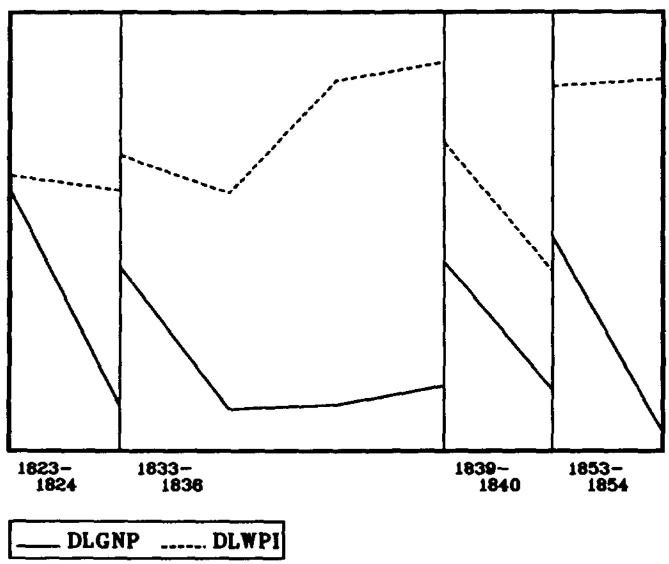

Fig. 4. Log-differenced real GNP and wholesale price index, pre-Civil War contractions, Gallman–Berry data.

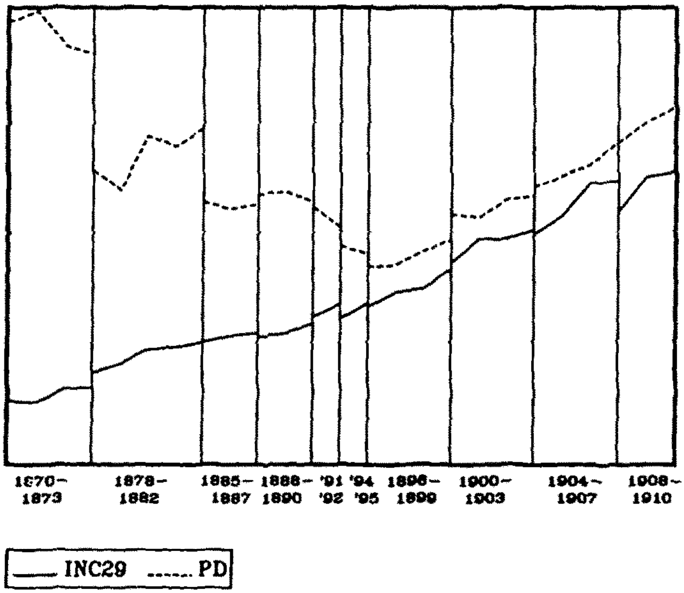

Fig. 5. Real income and implicit price deflator, pre-WWI expansions, Friedman–Schwartz data.

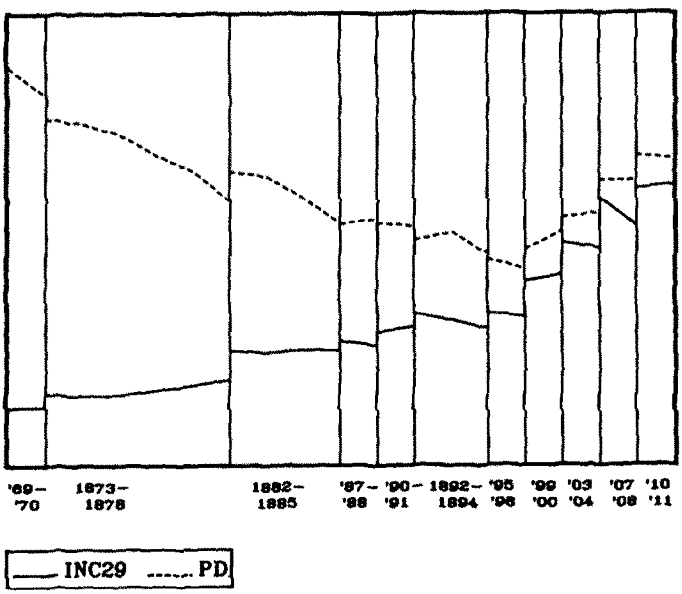

Fig. 6. Real income and implicit price deflator, pre-WWI contractions, Friedman–Schwartz data.

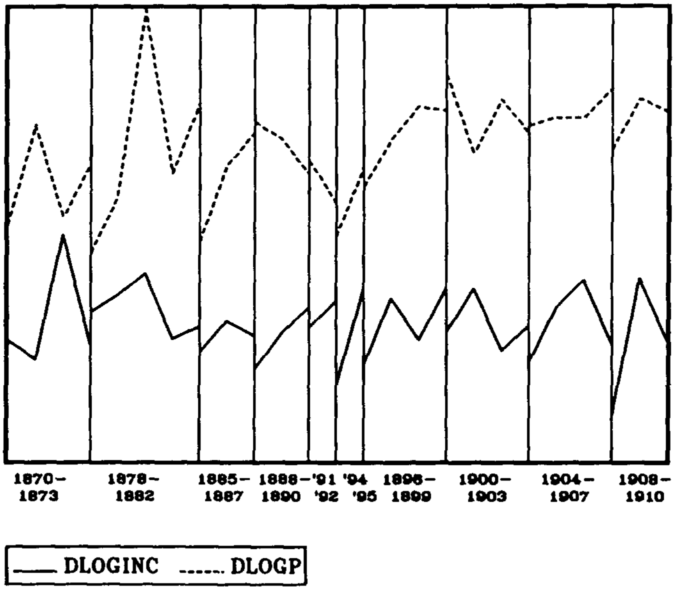

Fig. 7. Log-differenced real income and deflator, pre-WWI expansions, Friedman–Schwartz data.

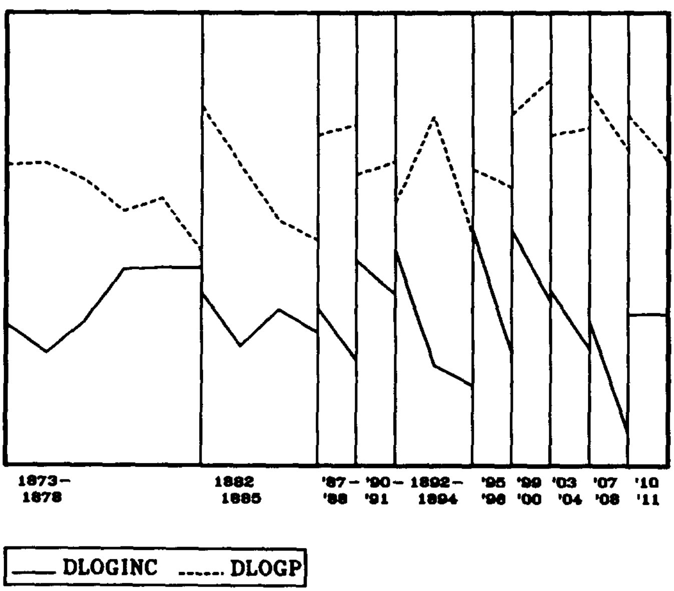

Fig. 8. Log-differenced real income and deflator, pre-WWI contractions, Friedman–Schwartz data.

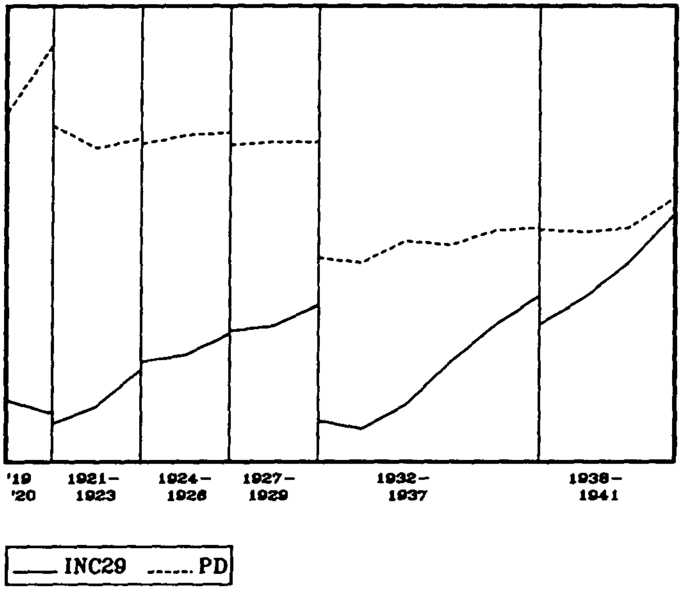

Fig. 9. Real income and implicit price deflator, inter-war expansions, Friedman–Schwartz data.

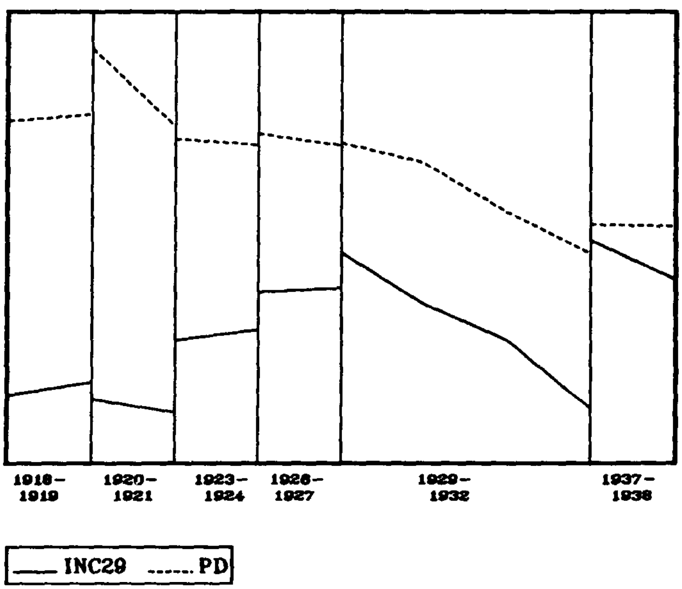

Fig. 10. Real income and implicit price deflator, inter-war contractions, Friedman–Schwartz data.

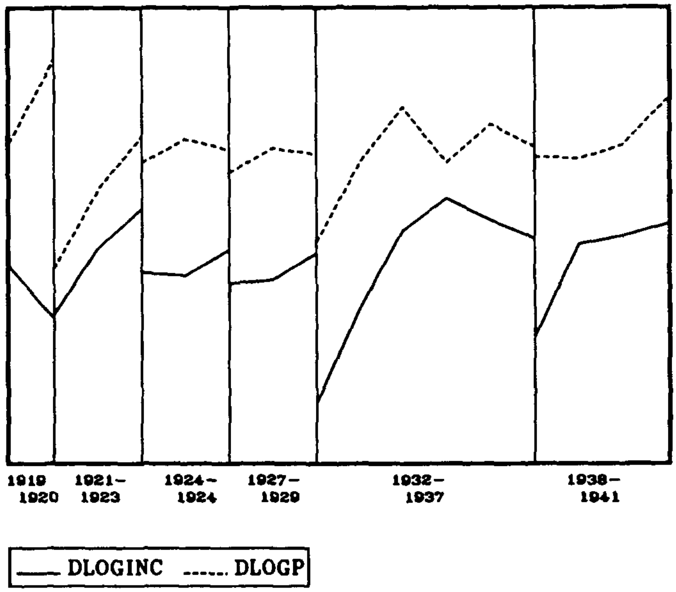

Fig. 11. Log-differenced real income and deflator, inter-war expansions, Friedman–Schwartz data.

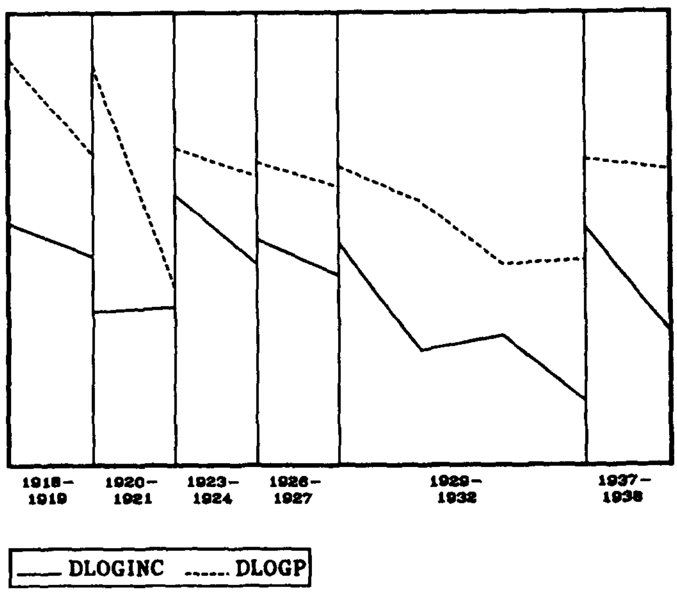

Fig. 12. Log-differenced real income and deflator, inter-war contractions, Friedman–Schwartz data.

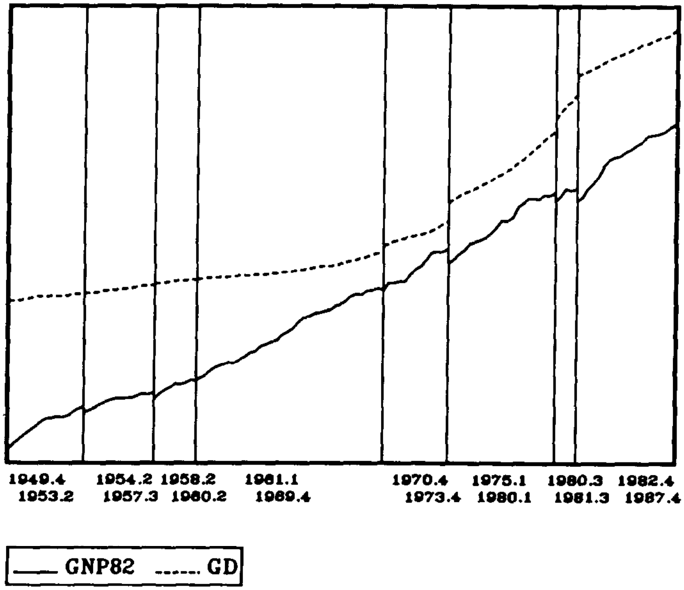

Fig. 13. Real GNP and deflator, post-WWII expansions.

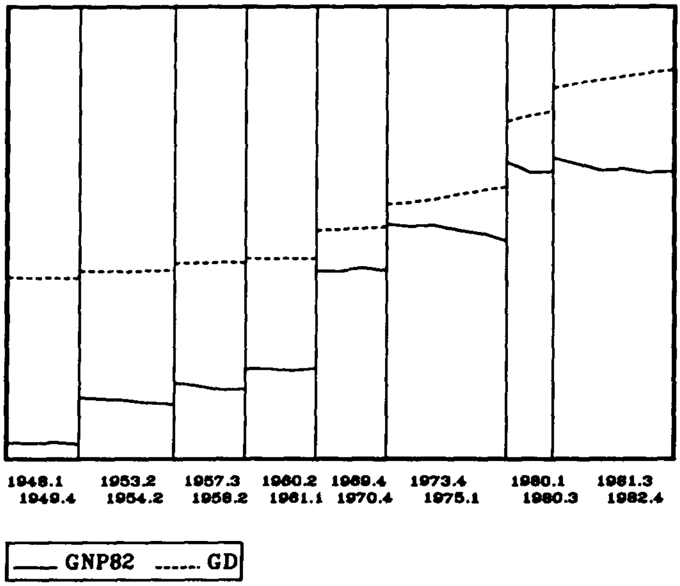

Fig. 14. Real GNP and deflator, post-WWII contractions.

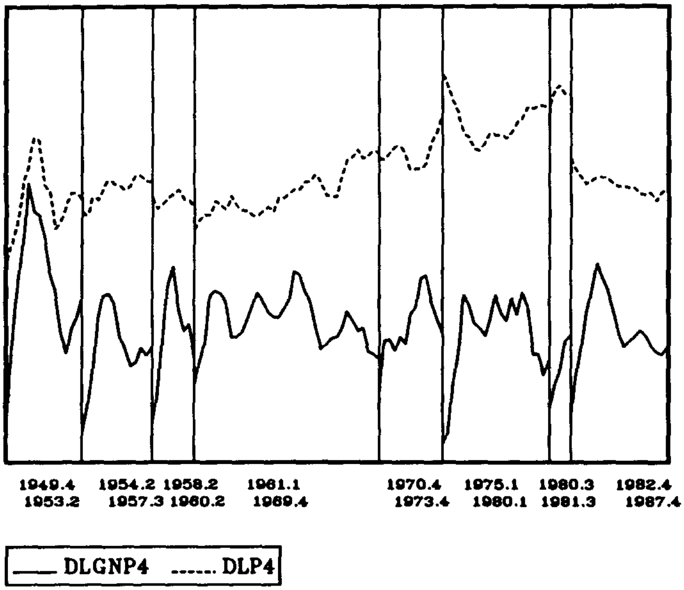

Fig. 15. Log-differenced real GNP and deflator, post-WWII expansions.

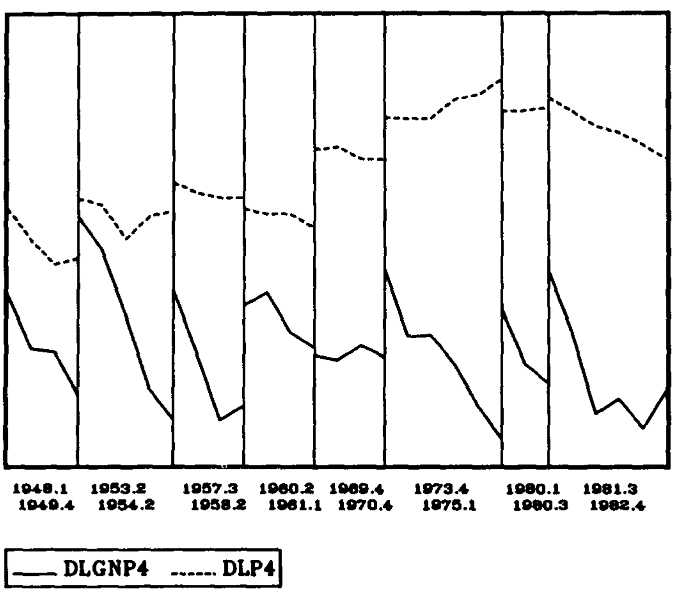

Fig. 16. Log-differenced real GNP and deflator, post-WWII contractions.

There are a number of possible reasons for these anomalies. The dating of business cycle expansions and contractions, discussed in detail in Burns and Mitchell (1946), is based on the behavior of large numbers of series that were known to have some coherence over the business cycle. For the nineteenth century cycles the data were often sparse. Burns and Mitchell did not have access to real output series of the sort used here and, indeed, the data used here may be subject to error. It is also true that among the many series used by Burns and Mitchell to define the cycle were price series, in part because of the belief that they moved positively with output. Of great interest is the fact that for many of the early cycles the majority of series that Burns and Mitchell had to work with were price series – these outnumbered production series. Because Burns and Mitchell did not date the business cycles for the pre-Civil War period, we have defined the contractions to be the periods when real GNP actually declined. In many accounts of the economic history of the period [e.g., North (1961)] the dating of contractions does not conform very closely to the periods we have identified. Again in those accounts there is substantial discussion of what was happening with prices at the same time, with price deflations being associated with economic decline. There is also some controversy over the estimates for GNP during the decade from 1869 to 1879. The Friedman–Schwartz data are based on underlying data from Kuznets (1961) and from Robert Gallman. The Friedman–Schwartz estimates show income higher in 1869 and lower in 1879 than do Kuznets' estimates.[9] This is an issue that bears further investigation, but is beyond the scope of this paper.[10]

Figs. 7 and 8 show the correlations between output and prices for the log-differenced data. Again it is difficult to pick out any single consistent pattern. The pre-war contractions appear very different from one another and do not exhibit a lot of positive correlation between output and prices.

The comovement of prices and output during the inter-war period is captured in figs. 9–12. The levels of the variables are depicted in figs. 9 and 10, while the log-differenced variables are shown in figs. 11 and 12. The inter-war expansions seem generally to depict a positive correlation between the variables of interest, although the expansions of the mid-twenties seem not to fit the pattern. Removing a stochastic trend (as in fig. 11) seems to strengthen the positive association. The inter-war contractions seem a bit more ambiguous, but certainly the series move together during the major contraction. Detrending again strengthens the conclusion.

[9]For a more detailed discussion of these measurement issues see Gallman (1966).

[10]Related to the fact that the earlier business cycle researchers worked with individual price series rather than aggregate series is the issue of whether there might be composition bias in the latter. A composition bias would lead to this correlation if expensive and inexpensive goods had different weights (relative importance) during expansions and contractions. But composition bias would seem to work in the opposite direction – that is, it would tend to make prices more procyclical if high-priced goods have higher weight during expansions and vice versa.

For the pre-war and inter-war periods one is pretty much constrained to looking at annual observations. For the post-WWII era the data are more abundant and expansions and contractions can be pinpointed more precisely. Figs. 13 and 14 show the comovement of real GNP and the implicit GNP deflator for the post-WWII expansions and contractions. These data are taken from the Citibase file. The post-WWII expansions display an unambiguous positive association, while the post-war contractions again seem quite equivocal. The data in levels show prices continuing to rise during some of the contractions and remaining at best flat during the rest of them. When the data are detrended, in figs. 15 and 16, the picture is, if anything, more varied. The only post-war expansion where prices and output seem clearly positively correlated is the immediate post-WWII and Korean War period, a time period that was dominated by large public finance shocks. The post-war contractions are clearly not all alike. During some of them prices and output seem to move together and during some they do not.

To summarize this excursion, the simple facts about the correlation of prices and output over the business cycle as defined by the NBER dating schemes are not at all clear. Nothing like a reliable procyclical pattern emerges. The one period where the series seem to be most strongly positively correlated is the inter-war period and particularly the period after 1929. In other periods business cycles seem to be different from one another in this dimension. Because visual inspection can be deceiving, in the next two sections we look at the relation between prices and output in more depth.

3. Time series analysis of prices and output

In this section we present statistical evidence on the time series behavior of aggregate prices and output, drawing on quarterly post-war data from the National Income and Product Accounts, annual data extending back to 1870 assembled by Friedman and Schwartz (1982), and the data described earlier as the Gallman–Berry data.[11] We present results from two empirical exercises in this section. We first summarize the data using cross-correlations for various subperiods and we then estimate some unrestricted vector autoregressions.

3.1. Cross-correlations

In this section, we calculate simple cross-correlations between prices and output over several historical periods.[12] Here again, because the variables are

[11]We have repeated the calculations based on the Friedman–Schwartz data using Balke and Gordon's (1989) quarterly distributions of that data. We do no report them here. The results are quantitatively slightly different but qualitatively similar.

[12]Standard errors are calculated under the null that the true correlation is zero. Asymptotic standard errors could be obtained using a mean value approximation (the delta method), but they may be misleading in small samples.

Table 1

Cross-correlations: Real output and lagged prices, post-war quarterly data.[a]

Lag	1948:2–1987:2		1954:1–1973:1		1966:1–1987:2	
	(A) Detrended data					
6	−0.61	(0.09)	−0.77	(0.13)	−0.77	(0.12)
5	−0.64	(0.08)	−0.75	(0.12)	−0.79	(0.11)
4	−0.66	(0.08)	−0.74	(0.12)	−0.81	(0.11)
3	−0.67	(0.08)	−0.73	(0.12)	−0.83	(0.11)
2	−0.67	(0.08)	−0.72	(0.12)	−0.85	(0.11)
1	−0.67	(0.08)	−0.71	(0.12)	−0.86	(0.11)
0	−0.67	(0.08)	−0.69	(0.11)	−0.87	(0.11)
−1	−0.65	(0.08)	−0.65	(0.12)	−0.85	(0.11)
−2	−0.62	(0.08)	−0.61	(0.12)	−0.82	(0.11)
−3	−0.60	(0.08)	−0.57	(0.12)	−0.79	(0.11)
−4	−0.57	(0.08)	−0.53	(0.12)	−0.76	(0.11)
−5	−0.55	(0.08)	−0.50	(0.12)	−0.73	(0.11)
−6	−0.52	(0.09)	−0.46	(0.13)	−0.69	(0.12)
	(B) Log-differenced data					
6	−0.25	(0.09)	−0.09	(0.13)	−0.10	(0.12)
5	−0.38	(0.08)	−0.19	(0.12)	−0.19	(0.11)
4	−0.23	(0.08)	−0.07	(0.12)	−0.18	(0.11)
3	−0.25	(0.08)	−0.22	(0.12)	−0.26	(0.11)
2	−0.14	(0.08)	−0.16	(0.12)	−0.26	(0.11)
1	−0.09	(0.08)	−0.11	(0.12)	−0.26	(0.11)
0	−0.06	(0.08)	−0.05	(0.11)	−0.23	(0.11)
−1	−0.05	(0.08)	0.08	(0.12)	−0.21	(0.11)
−2	−0.06	(0.08)	0.09	(0.12)	−0.19	(0.11)
−3	−0.10	(0.08)	−0.00	(0.12)	−0.04	(0.11)
−4	−0.09	(0.08)	−0.09	(0.12)	−0.02	(0.11)
−5	−0.18	(0.08)	−0.20	(0.12)	−0.06	(0.11)
−6	−0.10	(0.09)	−0.06	(0.13)	0.08	(0.12)
	(C) H-P filtered data (output and prices)					
6	−0.36	(0.09)	−0.27	(0.13)	−0.35	(0.12)
5	−0.51	(0.08)	−0.33	(0.12)	−0.51	(0.11)
4	−0.60	(0.08)	−0.37	(0.12)	−0.63	(0.11)
3	−0.65	(0.08)	−0.46	(0.12)	−0.71	(0.11)
2	−0.65	(0.08)	−0.47	(0.12)	−0.74	(0.11)
1	−0.62	(0.08)	−0.43	(0.12)	−0.73	(0.11)
0	−0.57	(0.08)	−0.36	(0.11)	−0.68	(0.11)
−1	−0.47	(0.08)	−0.10	(0.12)	−0.57	(0.11)
−2	−0.36	(0.08)	0.07	(0.12)	−0.44	(0.11)
−3	−0.23	(0.08)	0.17	(0.12)	−0.28	(0.11)
−4	−0.10	(0.08)	0.22	(0.12)	−0.11	(0.11)
−5	0.02	(0.08)	0.22	(0.12)	0.04	(0.11)
−6	0.16	(0.09)	0.22	(0.13)	0.21	(0.12)

[a] Standard errors in parentheses.

dominated by trends, we filter them to remove the trend component.[13] The postwar data are quarterly from 1948:1–1987:2 and include real GNP measured in 1982 dollars and the implicit price deflator. The Friedman–Schwarz data are from 1871–1975 and include real income and the implicit price deflator. The pre-Civil War data are annual from 1822–1859 as described earlier. All data are logged prior to analysis; the detrended data are produced by differencing the logged data for the case of integrated processes and by taking the residuals from a regression of the logged data on a constant and time for the case of deterministic trends. We also detrend the data by filtering the raw time series using the method developed by Hodrick and Prescott (1980).[14] Hereafter, we refer to 'differenced' data, 'detrended' data, and 'H-P filtered' data as the output from the three types of detrending procedures.

Table 1 presents sample cross-correlations between filtered prices and output in various samples from the post-war period. The estimates include six lags and six leads. The most striking feature of these data is the strong and consistently negative relationship between detrended prices and output. Over the entire post-war period, the simple correlation between detrended output and various lags of detrended prices ranges between −0.52 and −0.68. It is interesting to note that the negative relationship we estimate does not simply reflect the 'stagflation' of the mid-1970s and early 1980s. Calculating correlations beginning immediately after the Korean War and terminating prior to the first oil shock (1954:1–1973:1) also reveals a strong negative relation between output and prices, with estimates varying between −0.46 and −0.77. We also calculate correlations over the 1966:1–1987:2 period, a sample characterized by a relatively high average inflation rate. The correlation between prices and output ranges between −0.69 and −0.87.

Panel B of table 1 presents cross-correlations between differenced output and prices for the same samples. Note that with this method of detrending these are correlations between output growth and inflation. For the full post-war period, the correlations remain negative, varying between −0.05 and −0.38. Estimates for the sample 1966:1–1987:2 are principally negative, as are the correlations over the 1954:1–1973:1 period.

Panel C presents cross-correlations between H-P filtered output and prices over the three samples. These estimates also display a strong negative association between prices and output over the entire post-war sample and

[13]Even though most conclusions do not depend on how the data are detrended, it is worth noting that Dickey–Fuller tests suggest that many of these series can be best represented as integrated processes rather than trend-stationary processes. While the tests have little power against borderline stationary alternatives, recent work by Nelson and Kang (1981, 1984) indicates that imposing the trend-stationary specification may result in spurious relationships.

[14]For a detailed discussion of the Hodrick–Prescott filter and its properties see King and Rebello (1989).

also over the 1966:1–1987:2 period. Several of the correlations between prices and lagged output are positive, but not significantly different from zero, during the 1954:1–1973:1 period. It is interesting to note that Stock and Watson (1990) also find a negative relation between prices and output over the post-war period using much different filters.

Table 2a presents cross-correlations using the Friedman–Schwartz annual data.[15] Irrespective of the filter, we find that prices and output during the inter-war period (1928–1946) are primarily positively correlated. The remaining evidence from these data are mixed. Detrended[16] prices and output are negatively correlated in 1870–1900 and in 1900–1928. A largely acyclical association emerges from the log-differenced data over these two subperiods, while the H-P filtered data reveal a negative correlation between output and lagged prices, but a positive correlation contemporaneously and between prices and lagged output. The strong negative estimates reported for the 1947–1975 period confirm the results of table 1.

The 1879–1913 sample corresponds to the period marking the return of the United States to the gold standard following the Civil War, up to the founding of the Federal Reserve. The correlations during this sample are generally positive, particularly for detrended data, which exhibits a sample contemporaneous correlation of 0.64.

A linear trend specification for these two time series during this subsample, however, appears to be a poor assumption. For example, the R-square from the regression of log price on time is nearly zero (0.06 for Balke–Gordon quarterly data and 0.08 for Friedman–Schwartz annual data), while the Durbin–Watson statistic from this time trend regression is also close to zero (0.05 and 0.14 for the two respective data sets). These statistics suggest that log price is better approximated as an integrated rather than a trend-stationary process. The residuals from a regression of log output on time are also extremely autocorrelated. Dickey–Fuller tests for both series indicate that the null hypothesis of a unit root cannot be rejected in favor of the alternative of trend stationarity.[17] While the trend-stationary results for this period may be suspect, both the log-differenced and H-P filtered data suggest a positive association between prices and output. This finding is important, particularly in light of the commodity money standard in place at the time.

[15]Substituting Balke and Gordon's annual and quarterly data or Romer's data for the Friedman–Schwartz data does not substantially change the conclusions.

[16]It is clear from these data that aggregate prices exhibited different trends over the last century. Consequently, we fitted different trends over the individual periods. Fitting a single trend over the entire sample (1869–1975) produces a stronger negative association between prices and output.

[17]We performed a Monte Carlo experiment to determine the bias that might be induced in the correlation as a consequence of trend misspecification and found it to be potentially sizeable. It is our view that the results of the log-differenced correlations are a more reliable indicator of the correlation between the two series.

Table 2a

Cross-correlations: Real output and lagged prices, Friedman–Schwartz annual data.

Lag	1870–1900	1900–1928	1928–1946	1949–1975	1870–1975	1879–1913
			(A) Detrended data[a]			
4	−0.36 (0.20)	−0.07 (0.20)	−0.65 (0.26)	−0.38 (0.02)	−0.06 (0.10)	0.05 (0.18)
3	−0.39 (0.19)	−0.16 (0.20)	−0.44 (0.25)	−0.45 (0.20)	0.01 (0.10)	0.21 (0.18)
2	−0.28 (0.19)	−0.21 (0.20)	−0.06 (0.24)	−0.54 (0.20)	0.12 (0.10)	0.39 (0.17)
1	−0.21 (0.19)	−0.21 (0.19)	0.41 (0.24)	−0.58 (0.19)	0.23 (0.10)	0.51 (0.17)
0	−0.17 (0.18)	−0.12 (0.19)	0.73 (0.23)	−0.53 (0.19)	0.34 (0.10)	0.64 (0.17)
−1	−0.04 (0.19)	−0.10 (0.19)	0.74 (0.24)	−0.33 (0.19)	0.39 (0.10)	0.66 (0.17)
−2	0.14 (0.19)	−0.21 (0.20)	0.58 (0.24)	−0.18 (0.20)	0.38 (0.10)	0.61 (0.17)
−3	0.09 (0.19)	−0.34 (0.20)	0.37 (0.25)	−0.08 (0.20)	0.33 (0.10)	0.58 (0.18)
−4	0.09 (0.20)	−0.34 (0.20)	0.20 (0.26)	0.05 (0.20)	0.31 (0.10)	0.46 (0.18)
			(B) Log-differenced data			
4	0.10 (0.20)	−0.15 (0.20)	−0.50 (0.26)	0.09 (0.20)	−0.19 (0.10)	0.11 (0.18)
3	−0.18 (0.19)	−0.05 (0.20)	−0.33 (0.25)	−0.05 (0.20)	−0.10 (0.10)	−0.07 (0.18)
2	−0.06 (0.19)	−0.19 (0.20)	−0.04 (0.24)	−0.26 (0.20)	−0.12 (0.10)	0.20 (0.17)
1	−0.12 (0.19)	−0.11 (0.19)	0.45 (0.24)	−0.49 (0.19)	0.05 (0.10)	−0.10 (0.17)
0	0.05 (0.18)	0.12 (0.19)	0.67 (0.23)	−0.07 (0.19)	0.26 (0.10)	0.30 (0.17)
−1	0.25 (0.19)	0.28 (0.19)	0.57 (0.24)	−0.06 (0.19)	0.30 (0.10)	0.21 (0.17)
−2	0.14 (0.19)	0.04 (0.20)	0.29 (0.24)	−0.19 (0.20)	0.09 (0.10)	0.00 (0.17)
−3	0.18 (0.19)	−0.31 (0.20)	0.07 (0.25)	−0.11 (0.20)	−0.05 (0.10)	0.21 (0.18)
−4	−0.13 (0.20)	0.03 (0.20)	−0.08 (0.26)	−0.05 (0.20)	−0.04 (0.10)	−0.19 (0.18)
			(C) H-P filtered data (output and prices)			
4	−0.20 (0.20)	−0.14 (0.20)	−0.59 (0.26)	0.17 (0.20)	−0.34 (0.10)	−0.17 (0.18)
3	−0.28 (0.19)	−0.21 (0.20)	−0.50 (0.25)	−0.09 (0.20)	−0.32 (0.10)	−0.10 (0.18)
2	−0.15 (0.19)	−0.22 (0.20)	−0.10 (0.24)	−0.44 (0.20)	−0.16 (0.10)	0.12 (0.17)
1	−0.03 (0.19)	−0.06 (0.19)	0.45 (0.24)	−0.66 (0.19)	0.13 (0.10)	0.12 (0.17)
0	0.24 (0.18)	0.24 (0.19)	0.77 (0.23)	−0.58 (0.19)	0.39 (0.10)	0.48 (0.17)
−1	0.49 (0.19)	0.35 (0.19)	0.67 (0.24)	−0.37 (0.19)	0.44 (0.10)	0.39 (0.17)
−2	0.44 (0.19)	0.16 (0.20)	0.29 (0.24)	−0.23 (0.19)	0.25 (0.10)	0.25 (0.17)
−3	0.27 (0.19)	−0.12 (0.20)	−0.08 (0.25)	−0.16 (0.20)	0.02 (0.10)	0.13 (0.18)
−4	−0.13 (0.20)	−0.12 (0.20)	−0.23 (0.26)	−0.06 (0.20)	−0.09 (0.10)	−0.13 (0.18)

[a]Trends fit individually to each sample.

Table 2b

Cross-correlations: Real output and lagged prices, Gallman–Berry annual data, 1822–1859.[a]

Lag	Correlation
(A) Detrended data	
4	−0.14 (0.20)
3	−0.08 (0.20)
2	−0.02 (0.20)
1	0.14 (0.19)
0	0.21 (0.19)
−1	0.30 (0.19)
−2	0.50 (0.20)
−3	0.54 (0.20)
−4	0.57 (0.20)
(B) Log-differenced data	
4	−0.13 (0.20)
3	0.00 (0.20)
2	−0.22 (0.20)
1	0.17 (0.19)
0	−0.03 (0.19)
−1	−0.24 (0.19)
−2	0.32 (0.20)
−3	0.00 (0.20)
−4	0.10 (0.20)
(C) H-P filtered data (output and prices)	
4	0.34 (0.20)
3	0.29 (0.20)
2	0.28 (0.20)
1	−0.03 (0.19)
0	−0.08 (0.19)
−1	−0.12 (0.19)
−2	−0.34 (0.20)
−3	−0.31 (0.20)
−4	−0.13 (0.20)

[a]Standard errors in parentheses.

For example, consider a permanent innovation to output. Given that the response of money was ultimately limited by the world gold stock, it seems reasonable to expect a countercyclical rather than the observed procyclical relation during this period.

Table 2b presents cross-correlations using the Gallman–Berry data for the 1822–1859 period. The detrended data indicate a positive relationship between prices and lagged output and a weak negative association between output and lagged prices. The H-P filtered data produce an opposite pattern, with a negative correlation between prices and lagged output and a positive correlation between output and lagged prices. The log-differenced data reveal an acyclical association.

To summarize, with the important exception of the inter-war period, these data are not at all suggestive of the stylized fact of procyclical prices that many macroeconomists hold. The correlation in the post-WWII period is negative and robust. In the inter-war period it is positive and robust. For the 19th century the results are mixed and are sensitive to the assumptions about trends.

As we noted earlier, a more recent view of the correlation between output and prices, as represented by Mankiw's (1989) assertion, implies that the *change* in inflation is positively correlated with the level of output. It is worth considering first whether the finding, just reported, of a negative association between inflation and output growth is inconsistent with this view and, secondly, whether it is supported by the data. Consider for the moment the following simplified representation of this view:

$$\Delta p_t - \Delta p_{t-1} = \beta y_t, \qquad \beta > 0,$$

$$y_t = \rho y_{t-1} + \varepsilon_t, \qquad 0 \le \rho \le 1, \qquad \mathrm{E}(\varepsilon^2) = \sigma_\varepsilon^2, \tag{1}$$

where p is the log of the price level and y is the log of output. Now, if output is not detrended, what sign should we expect for $\mathrm{E}[\Delta p\ \Delta y]$? Rewriting, we have

$$\Delta y_t = (\rho - 1) y_{t-1} + \varepsilon_t, \tag{2}$$

$$\Delta p_t = \Delta p_{t-1} + \beta y_t = \beta \sum_{i=0}^{\infty} y_{t-i}. \tag{3}$$

And this implies that

$$\mathrm{E}[\Delta p \Delta y] = \beta(\rho - 1)\left\{ [1 + 2\rho + \rho^2 + \cdots] \frac{\sigma_\varepsilon^2}{1-\rho^2} + \frac{\sigma_\varepsilon^2}{\rho - 1} \right\}. \tag{4}$$

Now, $\beta > 0$ and $\rho < 1$ implies this correlation is negative, so Mankiw could be correct. Unfortunately, the data imply that $\rho = 1$ so that $\mathrm{E}[\Delta p\ \Delta y] = \beta\sigma_\varepsilon^2$, which is unambiguously positive. Similarly if y represents detrended output, then we can assume $\rho < 1$ and the question concerns the sign of $\mathrm{E}[\Delta p, y]$.

From the above we have that (and this is clearly positive):

$$\begin{aligned}
\mathrm{E}(\Delta py) &= \beta \mathrm{E}\left[y \sum_{i=0}^{\infty} y_{t-i} \right] \\
&= \beta \mathrm{E}[y_t (y_t + y_{t-1} + y_{t-2} + \cdots] \\
&= \beta\sigma_y^2 + \beta\rho\sigma_y^2 + \beta\rho^2\sigma_y^2 + \cdots \\
&= \beta \left[\frac{\sigma_\varepsilon^2}{1-\rho^2} \right] [1 + \rho + \rho^2 + \cdots] \\
&= \frac{\beta\sigma_\varepsilon^2}{(1-\rho^2)(1-\rho)} > 0. \qquad (5)
\end{aligned}$$

Finally, we can ask whether there is any empirical support for the assertion that the change in inflation is positively correlated with detrended output. Table 3 presents these correlations. These results show no empirical support for this proposition in the post-war data. What correlations exist are minuscule and insignificant. In the Friedman–Schwartz annual data the evidence is more ambiguous. There appears to be a positive contemporaneous correlation over most of the subsamples. The most pronounced positive correlations appear in the period from 1928 to 1946.

3.2. Conditional correlations: Unrestricted VARs

The results just discussed are simple correlations not conditioned on any other information. Even though simple correlations between prices and output do not reveal a positive association, it is clear that multivariate time series representations of prices, output, and other macroeconomic variables may reveal a positive relation between prices and output. Stated differently, one can often find a set of conditioning variables (lags of the variables in question, lags of other variables) such that the conditional correlations between prices and output may be positive.

We extend our analysis by estimating four-variable VARs over a variety of sample periods using both quarterly post-war data, the Friedman–Schwartz data, and the Gallman–Berry data. In addition to prices and output, the VARs include a narrow measure of the money stock and a short-term interest rate. This specification reflects three important considerations. First, complete observations on money and interest rates are available in the Friedman–Schwartz and Gallman–Berry data sets, as well as in the post-war

Table 3

Cross-correlations: Differenced output and differenced inflation.[a]

Lag	(A) Quarterly post-war data 1948:2–1987:1		1954:1–1973:1		1966:1–1987:1	
8	−0.14	(0.09)	−0.08	(0.13)	−0.19	(0.12)
7	−0.12	(0.09)	−0.06	(0.13)	−0.02	(0.12)
6	−0.07	(0.09)	0.03	(0.13)	−0.04	(0.12)
5	−0.15	(0.08)	−0.08	(0.12)	−0.12	(0.11)
4	0.18	(0.08)	0.15	(0.12)	0.03	(0.11)
3	−0.01	(0.08)	−0.10	(0.12)	−0.12	(0.11)
2	0.13	(0.08)	0.06	(0.12)	0.00	(0.11)
1	0.06	(0.08)	0.00	(0.11)	0.00	(0.11)
0	0.03	(0.08)	−0.03	(0.12)	0.05	(0.11)
−1	0.02	(0.08)	0.13	(0.12)	0.06	(0.11)
−2	−0.03	(0.08)	0.02	(0.12)	0.01	(0.11)
−3	−0.05	(0.08)	−0.07	(0.12)	0.21	(0.11)
−4	0.01	(0.08)	−0.05	(0.12)	0.02	(0.11)
−5	−0.09	(0.08)	−0.08	(0.12)	−0.02	(0.11)
−6	0.09	(0.09)	0.11	(0.13)	0.17	(0.12)
−7	0.01	(0.09)	−0.02	(0.13)	0.01	(0.12)
−8	0.05	(0.09)	0.08	(0.13)	0.05	(0.12)

Lag	(B) Friedman–Schwartz annual data 1871–1975		1871–1910		1928–1946	
4	−0.10	(0.10)	−0.15	(0.7)	−0.38	(0.26)
3	−0.08	(0.10)	−0.18	(0.7)	0.16	(0.25)
2	0.17	(0.10)	0.26	(0.7)	0.33	(0.24)
1	0.15	(0.10)	0.19	(0.7)	0.64	(0.24)
0	−0.03	(0.10)	−0.13	(0.6)	0.28	(0.24)
−1	−0.01	(0.10)	−0.03	(0.7)	−0.14	(0.24)
−2	−0.04	(0.10)	−0.00	(0.7)	−0.35	(0.24)
−3	−0.03	(0.10)	−0.00	(0.7)	−0.29	(0.25)
−4	0.00	(0.10)	−0.03	(0.7)	−0.20	(0.26)

[a]Standard errors in parentheses.

data, allowing us to specify one consistent model for all the periods we examine. Second, the four-variable VAR that includes prices, output, money, and an interest rate has been analyzed extensively in the empirical macroeconomic literature [Litterman and Weiss (1985), Eichenbaum and Singleton (1986), Runkle (1988), Sims (1980), Stock and Watson (1988a)]. Finally, to many, the important question about the correlation between output and inflation is what happens to that correlation *conditional* on the money supply [Friedman and Schwartz (1982)]. Including money as a conditioning variable thus seems of interest. Our goal, however, is not to draw specific structural conclusions from the VARs, but rather to summarize the time series characteristics of the data.

We present three types of evidence from the VARs on the time series behavior of prices and output. First, we examine whether there is a statistically significant temporal relationship between these variables by conducting Granger-causality tests. It is important to note, however, that the absence of a statistical Granger-causal relationship between prices and output does not imply that these variables are unrelated [see, for example, Cooley and LeRoy (1985)].

We are also interested in the nature of the relationship between prices and output and the extent to which historical movements in the innovations to a reduced form equation for prices (output) account for variations in output (prices). These questions are naturally addressed within the VAR framework with the use of impulse response functions and variance decompositions [see Sims (1980)]. As Cooley and LeRoy (1985) emphasize, the innovations in a VAR are complicated amalgams of the underlying errors. In the absence of identifying restrictions the innovations may represent anything. Accordingly, we present these results as the outcome of a particular parametrization, and we interpret our results as simply providing us with conditional correlations where the choice of conditioning set is motivated primarily by its widespread use and by data availability.

VARs estimated over the post-war period include M1 and the average secondary market rate on 90-day Treasury bills, in addition to output and the implicit price deflator, and include constants and four lags. VARs estimated with the Friedman–Schwartz data include the monetary base and the commercial paper rate, in addition to real income and the implicit price deflator. These regressions also include constants and one lag. Overall, the results were not sensitive to extending the lag length to two years. For the purpose of calculating impulse response functions and variance decompositions, the variables are ordered with the interest rate first, followed by money, prices, and output.

We estimate the VARs using only the log-differenced data. As we noted previously, recent work by Kang and Nelson (1981, 1984) suggests that imposing a trend-stationary specification on arguably integrated processes may result in spurious correlations. This may be an important issue with our sample in that several of the time series appear to contain a unit root after linear detrending. The estimated nonstationary cyclical components seem to indicate that these procedures are failing to remove a substantial fraction of the growth component, or trend, from the time series. This would certainly be the case if, for example, an integrated process was linearly detrended. As a result, the estimated deviations from trend become functions of the underlying misspecified trend. A time series analysis of the data is consistent with all the variables having single unit roots [see Nelson and Plosser (1982)] and none of the variables being cointegrated [see Stock and Watson (1988)]. This evidence suggests a difference-stationary specification for the data.

From a statistical viewpoint, it is worth noting that least squares often is a consistent estimator for systems with integrated regressors. The distributions, however, will only be asymptotically normal in special cases, specifically if the coefficients of interest can be written as coefficients on mean zero stationary variates [see Sims, Stock, and Watson (1987)]. An important example of this is if the data are cointegrated. Given that we are interested in testing restrictions on certain Granger-causal orderings with integrated but apparently not cointegrated variables, we will not be able to appeal to the standard normal theory. Moreover, as Christiano and Ljungqvist (1988) and Ohanian (1988) show, using the normal theory in these types of cases can result in very misleading inferences. We can, however, use the normal theory with differenced data, presuming of course that this transformation yields a stationary time series.

Table 4 presents results from the VAR estimated over the post-Korean War period with log-differenced quarterly data.[18] Over this period, we do not find strong evidence of a Granger-causal ordering between prices and output. Lagged values of output in the price equation are significant at the 85% level (approximate F-statistic = 0.34), while lagged prices in the output equation are significant at the 67% level (approximate F-statistic = 0.59). Similarly, variance decompositions suggest that the relation between prices and output may not be particularly important. Over a 16-quarter horizon, variation in prices accounts for a maximum of less than 5% of output forecast error variance, while variation in output accounts for a maximum of less than 1% of price forecast error variance. It is interesting to note, however, that the impulse response functions suggest a primarily negative association between prices and output that is consistent with the simple correlations presented in tables 1 and 2. A positive shock to the output equation is estimated to reduce inflation in 12 quarters over a 16-quarter horizon, while a positive shock to the inflation equation is estimated to reduce output in every quarter over the 16-quarter horizon.[19,20]

A fairly similar empirical pattern emerges when the model is estimated using log-differenced Friedman–Schwartz annual data over 1871–1975. These results are presented in table 6. Both the Granger-causality tests and the variance decompositions suggest a fairly weak association between prices and

[18] Given the substantial public finance shock associated with the Korean War effort, we focus on the post-Korean War period, rather than the post-World War II period. Using the latter period, however, yields very similar results.

[19] In a recent paper Stock and Watson (1988) suggest that the appropriate trend specification for these post-war quarterly time series is to log-difference the variables and remove a deterministic trend from the log-differenced money. Following this approach yields estimates of the relation between prices and output that are almost identical to those reported in table 4.

[20] Alternative orderings based on the approach of Bernanke (1985) suggest an even stronger negative relation between prices and output. These results are available upon request.

Table 4

Summary results from four-variable VAR, log-differenced post-war quarterly data, 1954:1–1987:1.

(A) Granger-causality tests

	F-value	Marginal significance level
1. Lagged prices predicting output	0.59	0.67
2. Lagged output predicting prices	0.34	0.85

(B) Impulse response functions ($\times 10^{-3}$)

Lag	Price shock on output	Output shock on prices
1	−3.51	0.00
2	−0.92	−1.82
3	−2.07	−11.72
4	−5.23	4.69
5	−2.83	−1.77
6	−3.00	3.05
7	−1.03	2.25
8	−1.53	−0.69
9	−0.69	−1.02
12	−0.87	−3.80
16	−0.65	−5.27

(C) Variance decompositions (%)

Step	Prices explaining output	Output explaining prices
1	1.04	0.00
2	1.04	0.22
3	1.21	0.60
4	2.97	0.60
6	3.74	0.50
9	3.89	0.47
12	4.06	0.50
16	4.18	0.64

output. Neither variable was significant in the relevant equation at the 10% level, nor did either variable account for more than 3% of forecast error variance at any forecast horizon. Similarly, the impulse response functions do not indicate a clear relationship between prices and output. The estimated effect of a shock to the price equation on output in this period is quite similar to the response predicted in the post-war interval, with output declining in 14 of 16 periods, while a shock to the output equation is estimated to have increased inflation over the entire sample.[21]

Splitting the Friedman–Schwartz data into subsamples provides little additional evidence on the correlation between prices and output. Tables 6–8

[21]We also estimated using the detrended Friedman–Schwartz data and the results are quite similar.

Table 5

Summary results from four-variable VAR, log-differenced annual data, 1871–1975.

(A) Granger-causality tests		
	F-value	Marginal significance level
1. Lagged prices predicting output	1.28	0.26
2. Lagged output predicting prices	2.52	0.12

(B) Impulse response functions ($\times 10^{-3}$)		
Lag	Price shock on output	Output shock on prices
1	−7.70	0.00
2	5.30	6.43
3	4.60	3.31
4	−0.00	1.42
5	−0.51	0.70
6	−0.25	0.35
7	−0.12	0.04
8	−0.06	0.08
9	−0.03	0.00
12	−0.03	0.00
16	−0.00	0.00

(C) Variance decompositions (%)		
Step	Prices explaining output	Output explaining prices
1	1.56	0.00
2	2.12	1.61
3	2.61	1.90
4	2.61	1.96
6	2.62	1.97
9	2.62	1.97
12	2.62	1.97
16	2.62	1.97

present results from estimating the model over the 1900–1928, 1928–1946, and 1870–1910 intervals. We do not find a statistically significant relationship between prices and output over any of these intervals at the 10% level, although power considerations and bias are surely important in samples of this size. While the cross-correlations reported in table 2a suggested a positive association between prices and output during the 1879–1913 period, this relationship does not emerge from the four-variable VAR. Table 9 presents the VAR results from this sample, which indicate no significant Granger-causal relationships between prices and output. Moreover, the variance decompositions show virtually no association between the two series, and the impulse responses indicate primarily a negative relationship.

Table 10 presents VAR results using the Gallman–Berry annual data over 1834–1858. This corresponds to the longest sample that includes observations

Table 6

Summary results from four-variable VAR, log-differenced annual data, 1900–1928.

(A) Granger-causality tests	F-value	Marginal significance level
1. Lagged prices predicting output	1.91	0.18
2. Lagged output predicting prices	1.25	0.27

(B) Impulse response functions ($\times 10^{-2}$)

Lag	Price shock on output	Output shock on prices
1	−2.15	0.00
2	1.15	0.87
3	0.37	0.50
4	−0.59	−0.27
5	−0.18	−0.17
6	0.14	0.05
7	0.07	0.06
8	−0.03	−0.00
9	−0.03	−0.02
12	−0.00	0.00
16	0.00	0.00

(C) Variance decompositions (%)

Step	Prices explaining output	Output explaining prices
1	15.85	0.00
2	18.06	2.10
3	17.18	2.53
4	17.64	2.64
6	17.64	2.70
9	17.66	2.70
12	17.66	2.70
16	17.66	2.70

on all the time series. The data on the money stock was drawn from Temin (1969, table A.2, pp. 186–187) and is defined as the dollar value of specie in the United States. The interest rate data was drawn from Homer (1977, table 41, p. 305) and is defined as the annual average yield on City of Boston bonds (Homer notes that between 1835 and 1841 there were no U.S. government bonds outstanding). Although we find evidence that output Granger-causes prices, the estimated impulse response functions do not indicate any strong relationship between the two series.

While we refrain from drawing structural inferences from these reduced form exercises, it is our view that the very weakest interpretation of these facts is that they indicate episodes of countercyclical, acyclical, and procyclical price behavior rather than the consistently procyclical behavior that is part of business cycle lore.

Table 7

Summary results from four-variable VAR, log-differenced annual data, 1928–1946.

(A) Granger-causality tests		
	F-value	Marginal significance level
1. Lagged prices predicting output	1.80	0.20
2. Lagged output predicting prices	0.59	0.45

(B) Impulse response functions ($\times 10^{-2}$)		
Lag	Price shock on output	Output shock on prices
1	0.80	0.00
2	2.86	0.71
3	1.79	0.86
4	0.11	0.71
5	−0.53	0.51
6	−0.55	0.33
7	−0.47	0.19
8	−0.37	0.08
9	−0.26	0.02
12	−0.03	−0.03
16	0.01	−0.00

(C) Variance decompositions (%)		
Step	Prices explaining output	Output explaining prices
1	1.09	0.00
2	10.34	1.56
3	12.40	3.22
4	12.10	4.28
6	12.45	5.05
9	12.70	5.15
12	12.72	5.15
16	12.72	5.15

Characterizing the time series behavior of prices and output with cross-correlations and four-variable unrestricted VARs provides little support for a positive relation between prices and output. There are few statistically significant patterns between these variables, and the estimates are predominantly negative. Taken together, it seems difficult to reconcile these estimates with traditional views of the price–output relation.

4. Conclusions

It might be tempting to conclude that the empirical results of this paper are simply directed against a straw man: that no one these days seriously maintains the view that prices and output are positively correlated. But

Table 8

Summary results from four-variable VAR, log-differenced annual data, 1871–1910.

(A) Granger-causality tests	F-value	Marginal significance level
1. Lagged prices predicting output	0.85	0.36
2. Lagged output predicting prices	0.09	0.77

(B) Impulse response functions ($\times$ 10^{-2})		
Lag	Price shock on output	Output shock on prices
1	−1.49	0.00
2	−0.56	0.13
3	0.60	−0.20
4	−0.20	0.00
5	0.00	0.00
6	0.00	0.00
7	0.00	0.00
8	0.00	0.00
9	0.00	0.00
12	0.00	0.00
16	0.00	0.00

(C) Variance decompositions (%)		
Step	Prices explaining output	Output explaining prices
1	6.3	0.0
2	6.6	0.1
3	7.5	0.4
4	7.6	0.4
6	7.6	0.5
9	7.6	0.5
12	7.6	0.5
16	7.6	0.5

consider the following quote from Hall and Taylor's (1986) textbook on macroeconomics:

> There is another important feature of economic fluctuations that is missing from the classical model: the behavior of prices. There is a general tendency for prices to rise when GNP is above potential and to fall when GNP is below potential... (a) fact of the business cycle that is missed in the classical models is the positive correlation between prices and output.

The assertions by Lucas (1972a, b), Hall and Taylor (1986), and Mankiw (1989) help confirm that the positive correlation between output and prices has long been one of the cornerstones of business cycle lore and business

Table 9

Summary results from four-variable VAR, log-differenced annual data, 1879–1913.

(A) Granger-causality tests	F-value	Marginal significance level
1. Lagged prices predicting output	0.61	0.44
2. Lagged output predicting prices	0.23	0.63

(B) Impulse response functions ($\times 10^{-3}$) Lag	Price shock on output	Output shock on prices
1	−4.32	0.00
2	−6.60	1.81
3	5.57	−1.45
4	−2.61	0.27
5	0.49	0.06
6	0.18	−0.12
7	−0.22	0.05
8	0.09	−0.01
9	−0.01	−0.00
12	−0.00	0.00
16	0.00	−0.00

(C) Variance decompositions (%) Step	Prices explaining output	Output explaining prices
1	0.66	0.00
2	2.00	0.30
3	2.87	0.50
4	3.04	0.50
6	3.05	0.50
9	3.05	0.50
12	3.05	0.50
16	3.05	0.50

cycle theory. It assumed a central role in the Keynesian policy discussions of the 1960s and it plays a central role in the neo-Keynesian economics of the 1990s. Moreover, it seems to play a central role in the current discussions of Federal Reserve policy as the financial press tracks the growth of GNP with the view that high GNP growth rates presage inflation and low GNP growth rates imply the Fed may relax its monetary policy. In this paper we have re-examined this central fact about business cycles and found it to be specious.

For the last twenty years, the procyclical behavior of prices has assumed a prominent role in construction of business cycle models, including the equilibrium models of Barro (1978), Lucas (1972), and Sargent (1976) and the nonmarket clearing models of Taylor (1980, 1979), Gordon (1982), and Fischer (1976). The empirical results presented in this paper suggest that

Table 10

Summary results from four-variable VAR, log-differenced annual data, 1835–1858.

(A) Granger-causality tests	F-value	Marginal significance level
1. Lagged prices predicting output	0.41	0.53
2. Lagged output predicting prices	5.04	0.037

(B) Impulse response functions ($\times 10^{-2}$)

Lag	Price shock on output	Output shock on prices
1	−0.00	0.55
2	0.06	−0.14
3	−0.02	0.00
4	−0.01	0.02
6	−0.00	0.00
7	0.00	−0.00
8	0.00	−0.00
9	−0.00	0.00
12	0.00	−0.00
16	−0.00	0.00

(C) Variance decompositions (%)

Step	Prices explaining output	Output explaining prices
1	0.00	0.00
2	1.17	15.66
3	1.28	15.35
4	1.32	15.90
6	1.32	15.90
9	1.32	15.90
12	1.32	15.90
16	1.32	15.90

much of the emphasis on developing models that feature a positive relationship between output and prices may have been unnecessary.

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