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Working Paper No. 188
May 1989

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Rochester Center for Economic Research
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May 1989

First Draft: February 4, 1989

Preliminary: Do Not Cite or Quote

We have benefitted from discussions with Stan Engerman, Charles Plosser and Edward Prescott. Marianne Baxter, Adrian Pagan, Neil Wallace, Randy Wright and participants in the University of Rochester Macro Working Group have offered helpful comments on an earlier draft. The above named individuals should not be implicated. The first author acknowledges financial support from the John M. Olin Foundation and the Bradley Policy Research Center.

ABSTRACT

The procyclical behavior of prices has been a staple feature 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 evident is the period between the two world wars, particularly the period of the Great Depression. Theoretical models which are consistent with this empirical fact are discussed.

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. Just what those important empirical features are has been a subject of economic research for a much longer time. Burns and Mitchell (1946), 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. Some others are either controversial or difficult to explain with existing business cycle models, an example being the procyclical behavior of productivity and real wages. 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 years whether empirical or theoretical. We look at price and output data from the 1860's 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 1970's. The bulk of the evidence suggests that prices were also countercyclical in the late 19th century. In fact, with the exception of the interwar years, we find little evidence of procyclical price behavior over the last century. We also argue that theoretical models do not easily imply procyclical behavior of price movements. In those that are capable of displaying such movements the final resolution of the correlation between prices and output depends on the relative importance of supply shocks and monetary shocks in the economy.

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 Wesley Mitchell 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."(p.170)

And Mitchell himself quoted Roy Harrod (1936):

> 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 vouschafed by empirical observation in economics: and it is probably the best established of any. (p.41)

The reason this great paradox seemed so firmly established is that it was intensely studied and documented. Simon 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] Frederick Mills (1927,1936,1946) also studied the behavior of prices during recessions and recovery. Mills was concerned with the movements of aggregate price indices (primarily the wholesale price index) over contractions and expansions. He was also concerned with the similarity of price cycles across countries and for different periods of recessions and recovery. Mills 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 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

[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.

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 twenty contractions. Most individual commodity prices exhibited slightly less conformity. Frederick Mills (1946) and Wesley 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 it's 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 nineteenth 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 the those of either the inter-war economy or the pre World War I economy. Among other things, the post war contractions appear less prolonged and less severe (although the recent reinterpretation of Christina Romer (1989) casts doubt on this view). Nevertheless, our thinking about the economy still seems to be dominated 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 and 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] The Phillips curve relation was originally a relation between the rate of change of nominal wages and the unemployment rate. But this implies, with some additional fairly innocent assumptions, a corresponding relation between

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

the rate of change of prices and output. As an aside, it is worth noting that the bulk of the data offered in support of the Phillips relation extended back to the mid 19th century. It was (and still is in some quarters) widely accepted as a regular feature of the U.S. economy and it was consistent at least with the Burns and Mitchell view of the relation between prices and output over the cycle. Robert Lucas (1972), who as much as anyone was responsible for the demise of the Phillips curve 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." (p.103,emphasis added)

Lucas was referring to the evident robustness and statistical validity of this correlation. 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 (1972) and Lucas (1979). 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.

Our goal in this paper is to re-examine the correlation between prices and output over the business cycle. 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. Is it a relationship between levels of variables, between growth rates or, as Lucas stated it, between a level and a growth rate? We take the interesting question to be one of the correlation between deviation from trend of real output and deviations from trend of the price level or implicit deflator. Unfortunately, this puts a fly in the ointment because 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 that we should use log differences to remove the trends. But, 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 definition of cyclical contractions and expansions presented by Burns and Mitchell and subsequent National Bureau of Economic Research datings. Taking those definitions as given we present a visual tour of the behavior of prices and output for both contractions and expansions from just after the civil war 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 predominately negative. These results are consistent with earlier empirical evidence presented by Kydland (1987) for the post war period and by Friedman and Schwartz (1982) for the earlier periods.

The final section of the paper looks at the theoretical evidence in the context of several different models. The theoretical models we examine all imply that there can exist a negative correlation between output and inflation. In general, this result is a consequence of endowment or supply shocks, but in models with a cash-in-advance constraint and endogenous labor-leisure choice it can result as a consequence of monetary shocks. These theoretical models simply illustrate two channels through which shocks to the economy can result in countercyclical price behavior. They also make clear the importance of interpreting these correlations in terms of an explicit theoretical model.

To us the evidence suggests that macroeconomics will continue to be led astray if it is based on the presumption that there is a positive correlation between output and prices. Neither empirical nor theoretical evidence supports this as a central and stable feature of economic fluctuations. The central finding is that, with the important exception of the interwar period, the correlation between prices and output is predominately negative. If we interpret this in the context of models like those discussed in section 4 it suggests that supply shocks may be an important source of fluctuations. We do not take this evidence to imply that economists should only contemplate models with supply shocks as the driving force of cyclical fluctuations. We do think it suggests fairly clearly that models driven solely by demand shocks, the sort of models that dominated thinking for several decades, are not very useful.

2. **Prices and Output.**

We begin by presenting the data that will be the focus of our analysis. In this paper, we are concerned with whether the positive comovement of prices and output exists in aggregate data. The aggregates we use are quite 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 primary data source for the prewar and inter-war period is Friedman and Schwartz (1982) annual data on real income and the implicit deflator. 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.[3] In addition Balke and Gordon (1989)

[3] 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 the deflator to independent series. Calomaris and Hubbard (1988) 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.

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. 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.

Figures 1 and 2 show the behavior of Real Income and its implicit deflator over the Pre WWI expansions and contractions respectively.[4] 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 Figure 2 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.

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 was 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 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. It seems possible that the heavy reliance on price series to define the cycle led to these being defined as

[4] 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.

contractions precisely because prices were declining! Some of these early business cycles may have been price cycles and prices declined substantially during the latter half of the nineteenth century. Further, there is 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.[5] This is an issue that bears further investigation but is beyond the scope of this paper.[6]

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)]. In this paper, we use both trend specifications, and most of our results are not particularly sensitive to the choice of trend. For the current exercise we assume a stochastic trend. The pictures change somewhat using deterministic trends or the Hodrick-Prescott filter but the general results remain the same.

Figures 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. The prewar contractions appear very different from one another and do not

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

[6] 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.

exhibit a lot of positive correlation between output and prices.

The comovement of prices and output during the inter-war period is captured in Figures 5-8. The levels of the variables are depicted in Figures 5 and 6 while the log differenced variables are shown in Figures 7 and 8. 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 figure 7) 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.

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 is more abundant and expansions and contractions can be pinpointed more precisely. Figures 9 and 10 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 postwar 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 the picture is, if anything, more varied. The only postwar 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 issues. The postwar 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. 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. But visual inspection can be deceiving, so in the next section we look at the relation between prices and output in a little 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 postwar data from the National Income and Product Accounts, and annual data extending back to 1870 assembled by Friedman and Schwartz (1982). Our motivation is simply to summarize the data using atheoretic time series procedures; the characteristics of the data are discussed within the context of some theoretical models in the following section.

We first calculate simple cross-correlations between prices and output over several historical periods. Here again, because the variables are dominated by trends we filter them to remove the trend component.[7] The postwar data are quarterly from 48:1 - 87:2 and include real GNP measured in 1982 dollars and the implicit price deflator. The Friedman-Schwartz data are from 1871-1975, and include real income and the implicit price deflator. 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).[8] Hereafter, we refer to "differenced" data, "detrended" data, and "H-P filtered" data as the output from the three types of detrending procedures.

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[7] Even though the bulk of 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. Accordingly, we view the trend stationary results with caution.

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

Table 1 presents sample cross-correlations between filtered prices and output in various samples from the postwar period. The most striking feature of these data is the strong and consistently negative relationship between detrended prices and output. Over the entire postwar period, the simple correlation between detrended output and various lags of detrended prices ranges between -.48 and -.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 (54:1-73:1) also reveals a strong negative relation between output and prices, with estimates varying between -.73 and -.78. 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 -.57 and -.88.

Panel B of Table 1 presents cross-correlations between differenced output and prices for the same samples. For the full postwar period, the correlations remain negative, varying between -.01 and -.38. Estimates for the sample 66:1-87:2 are principally negative, as are the correlations over the 54:1-73:1 period. Panel C presents cross correlations between H-P filtered output and prices over the three samples. The results are qualitatively similar to the estimated patterns from the detrended and differenced data, and are consistent with the findings of Kydland (1987) who looked at the same issue using the H-P filter.

Table 2 presents cross-correlations between prices and output using the Friedman-Schwartz annual data set. Our main finding is that prices are positively associated with output during the inter-war period (1929-1946); but there is little correlation between prices and output over the full sample (1871-1975), and early subperiods tend to be characterized by a negative correlation. Given the estimated negative correlations in the postwar period and in the 1869-1910 period, it seems reasonable to conclude that the positive contemporaneous correlation that emerges from the full sample using log-differenced data and H-P filtered data primarily reflects the strong positive association during the interwar years.

To summarize, with the important exception of the inter-war period, these data provide remarkably little support for positively correlated prices and output. The relation between detrended and differenced prices and output appear to be predominantly negative both contemporaneously and with a lag.

The results just discussed are simple correlations that are 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. That a judicious choice of conditioning variables can produce the desired result is illustrated by the results of DeLong and Summers (1986) and Gordon (1982).

We extend our analysis by estimating four-variable VARs over a variety of sample periods using both quarterly postwar data and the Friedman-Schwartz 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 data set, as well as in the postwar 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 (1980a,b), 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. Including money as a conditioning variables 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)], and we also report results from these two exercises. 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 parameterization, 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 postwar 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. [The data appendix contains a complete description of the data and sources.] These regressions also include constants, and one lag. For the purposes 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) suggest 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 or even an explosive root after linear detrending or after H-P filtering. 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 3 presents results from the VAR estimated over the postwar period with log-differenced quarterly data. 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

11 percent level, while lagged prices in the output equation are significant at just the 18 percent level. 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 seven percent of output forecast error variance, while variation in output accounts for a maximum of 5 percent of price forecast error variance. It is interesting to note, however, that the impulse response functions suggest a 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 every quarter over a 16 quarter horizon, while a positive shock to the inflation equation is estimated to reduce output in 14 out of 16 quarters.[9]

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 5. Both the Granger-causality tests and the variance decompositions suggest a fairly weak association between prices and output. Neither variable was significant in the relevant equation at the 10 percent level, nor did either variable account for more than three percent 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 remarkably similar to the response predicted in the postwar 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.[10]

Splitting the Friedman-Schwartz data into sub-samples provides little additional evidence on the correlation between prices and output. Tables 6-8 presents results from estimating the model over

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[9]In a recent paper Stock and Watson(1988) suggest that the appropriate trend specification for these postwar 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 3.

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

the 1870-1910, and 1928-1946 intervals. We do not find a statistically significant relationship between prices and output over any of these intervals at the 10 percent level, although power considerations and bias are surely important in samples of this size.

The estimated negative relationships between prices and output seems to suggest a potentially important role for supply shocks in the evolution of aggregate prices and output. In a recent paper Shapiro and Watson (1988) conduct a restricted VAR analysis and conclude that a variable they represent as technology shocks accounts for a significant fraction of cyclical fluctuations but that there is a positive relation between technology shocks and inflation and a negative correlation between technology shocks and the real interest rate. To see if this is born out here, we extend our VAR analysis by replacing output with "Solow residuals" , and estimating the model over the postwar period. Although a regression of this sort is difficult to motivate theoretically the idea is that one should expect supply shocks, as captured by the Solow residuals, to be negatively correlated with prices even conditional on money and interest rates. The Solow residuals are defined as the percentage change in output, less the percentage change in labor weighted by labor's share, less the percentage change in capital weighted by capital's share:

$$\%_D Q(t) - \%_D L(t)*LSHARE - \%_D K(t)*KSHARE$$

Following Prescott (1986), labor's share of output is set at .64. [See the Data Appendix for a complete description of the data and sources.] To calculate variance decompositions and impulse response functions, the interest rate is ordered first, followed by money, prices and the Solow residual. This represents the same ordering as in the previous VARs, with the Solow residual replacing GNP. This is also a conservative ordering, since by listing the Solow residual last, we have minimized the extent to which it can explain other variables in the system.

Table 9 presents results using log-differenced quarterly data between 1951:2 and 1984:4. While we were unable to find a significant Granger-causal relationship between prices and output, it is interesting to note that Solow residuals Granger-cause prices at less than the one percent level. Moreover, the impulse response functions indicate that a positive shock to the Solow residual (positive technology shock) results in lower inflation in every quarter over a 16-quarter horizon. Similarly, the contemporaneous correlation between the residuals from the price equation and the residuals from the Solow residual equation is -13. Variation in the Solow residual is estimated to account for about 13 percent of inflation forecast error variance at the 12-16 quarter horizon.

Characterizing the time series behavior of prices and output with cross-correlations and four-variable 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. Whatever the reduced form errors that are driving prices are, they do not have much role in driving output. Similarly, the reduced form errors driving output do not have much role driving prices. We do find, however, a negative, statistically significant relationship between prices and a measure of technological change [Solow residuals] over the postwar period. Taken together, it seems difficult to reconcile these estimates with traditional views of the price-output relation.

IV. Theoretical Implications

To this point we have tried to capture the empirical facts of the correlation between prices and output. The very weakest interpretation of those facts would be that they indicate episodes of countercyclical and procyclical price behavior rather than the consistently procyclical behavior that is part of business cycle lore. The most compelling evidence of procyclical price movements comes from the inter-war period. In this section we want to return to the question that the early business cycle researchers were acutely aware of and which made their findings of procyclical prices at the microeconomic level so remarkable: what does economic theory predict about the likely correlation between prices and output? The basic supply and demand reasoning of Wesley Mitchell cited in the introduction works well to explain relative prices but needs some amendment to explain movements in the price level in a general equilibrium setting. As is well known, very simple general equilibrium models with money usually have the implication that the price level is a monetary phenomena and one must introduce a constraint on individual actions or information in order to induce a correlation between real and nominal variables.

We summarize below the features of two models. Both incorporate a constraint that induces some correlation between output and prices. The first is a simple variant of Lucas' (1972) island economy that has been suggested by Wallace (1988). Like Lucas' model it produces a positive correlation between output and prices because agents face a signal extraction problem in that they cannot discern real and nominal shocks. Unlike Lucas' model, however, it allows for aggregate supply shocks and, when these shocks are important enough, they will outweigh the effects of the money shocks and produce a negative correlation between output and inflation. The second model is one studied by Cooley and Hansen (1988). It produces a correlation between output and prices through a different mechanism. Agents are constrained to hold cash to purchase consumption goods and in so doing are subject to an inflation tax. But, they can substitute leisure for consumption and anticipated inflation will lead them to do so. This reduces output, producing a negative correlation between output and inflation. In addition, because the quantity theory holds in this model, a shock to output will, *ceterus paribus,* (a supply shock) lead to a decline in prices.

4.1 **Wallace's Economy**

Neil Wallace (1988) describes a model economy that is of particular interest because it delivers the implications of Lucas' (1972) island economy but does so in a very simple elegant way using discrete finite sample spaces. It is a two period overlapping generations model where agents maximize expected lifetime utility

$$E\,[u(c) + v(c')]\ , \tag{4.1}$$

where E is the expectation operator, c represents consumption of leisure when young and c' is consumption of a perishable good when old. The young have an endowment of w units of leisure when young and have access to a constant returns technology that permits units of leisure to be transformed into consumption. The consumption is traded to the current old generation in exchange for money to be carried over to purchase consumption when old.

Wallace's model incorporates two sources of uncertainty - both demand shocks and supply shocks. The supply shocks take the form of random changes in the size of generations N_t. Demand shocks take the form of the fluctuations in the proportional change in the money supply[11] x_t where the latter is defined as

$$x_t = M_t/M_{t-1} \text{ and } x_t \geq 1\ . \tag{4.2}$$

The technology variable N_t and the money supply growth rate x_t are independently and identically distributed random variables. A young agent at t faces the constraints

$$\begin{aligned} c &\leq w - Y_t\ , \\ Y_t &\geq M_t/p_t\ , \\ c' &\leq M_t/p_{t+1}\ , \end{aligned} \tag{4.3}$$

where Y_t is production, M_t is nominal money holdings carried over and p_t and p_{t+1} are the price level at t and t+1 respectively. At date t, c' and p_{t+1} are represented by their distributions. Output in this economy is N_tY_t and a condition of equilibrium is that:

$$N_tY_t = M_t/p_t, \tag{4.4}$$

and

$$u'(w-Y_t) = E[(p_t/p_{t+1})\ v'(Y_tp_t/p_{t+1})]. \tag{4.5}$$

From equation (4.4) it follows that;

$$p_t/p_{t+1} = (N_{t+1}/N_t)\ (Y_{t+1}/Y_t)\ (1/x_{t+1}) = (Y_{t+1}/z_{t+1})(1/N_tY_t), \tag{4.6}$$

[11]Also, equivalently, the nominal deficit.

where $z_{t+1} = x_{t+1}/N_{t+1}$. Wallace assumes that the random variables x_t and N_t have a discrete probability structure and that agents do not observe the contemporaneous realizations. The random variable z_t plays an important role here because it summarizes the agent's information and yet different pairs of (N_t,x_t) can give rise to the same value of z_t. It is this feature that mimics the signal extraction problem faced by the island dwellers in Lucas' (1972) model economy.

An stationary equilibrium for this economy is a function Y such that with,

$$Y_t = Y(z_t), \tag{4.7}$$

$$p_t = z_t \, M_{t-1}/Y(z_t), \tag{4.8}$$

equation (4.5) is satisfied and $z/Y(z)$ is increasing in z. The last condition is needed to insure that people can identify z_t from an observation on p_t. The details of the proof of existence and uniqueness are worth looking at but are not repeated here. What is important is that Wallace's model can be used to study output-inflation correlations in much the same spirit as Lucas (1972). Moreover, because of the simplicity of the structure it is possible to compute examples which Wallace does.

The market clearing condition (4.4) implies that

$$\ln p_t = \ln M_t - \ln (N_t Y_t). \tag{4.9}$$

The log of the gross inflation rate between periods t-1 and t is then

$$\rho_t = \ln p_t - \ln p_{t-1} = Y_{t-1} - Y_t + \ln x_t$$

where $Y_t = \ln(N_t Y_t)$. All we need now is to examine the correlation between output and inflation. Since Y_t and Y_{t-1} are independent, the covariance has the form :

$$\mathrm{Cov}(\rho_t, Y_t) = \mathrm{Cov}(\ln x_t, Y_t) - \mathrm{Var}(Y_t) \ . \tag{4.10}$$

Since x_t and N_t are independent, the covariance between x_t and Y_t depends only on the covariance between x_t and Y_t and that will generally be positive. What tends to make the correlation between inflation and output negative is the contribution of N_t. High realizations of N_t will increase total output and lower prices.[12] Robert Lucas' model treats the inflation output correlation somewhat differently. In his setting an economy consists of several islands or regions of the sort just described and the inflation output correlations are viewed as being based on data aggregated across those regions. Lucas assumes further that there is no aggregate risk. Those assumptions applied to the Wallace model would amount to having the N_t perfectly negatively correlated. With no aggregate contribution from supply shocks the correlation between prices and output would be positive.

4.2 A Cash-in-advance Economy

We also discuss briefly an economy which functions somewhat differently than the one just studied in that aggregate supply shocks and monetary shocks both affect prices and output in the same way. The mechanism by which this happens is the inflation tax which operates through a cash-in-advance constraint. The model is developed in detail in Cooley and Hansen (1988) and we review it only briefly here for its implications about the issue at hand.

The economy is comprised of a continuum of identical households with preferences given by the utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t (\log c_t + A \log l_t) ,$$

where c_t is consumption, l_t is leisure and E_0 is the expectation operator. Households are endowed with one unit of time each period. They sell labor to a firm and accumulate capital which they rent to the firms as well. Consumption in this economy is a cash good, that is, it must be purchased with money. Leisure and investment are credit goods in the sense of Lucas and Stokey (1987).

[12]It is easily shown that the same implications hold when we examine innovations to prices and output.

Household's consumption must satisfy

$$p_t\, c_t \leq m_{t-1} + (g_t\text{-}1)\, M_{t-1} \quad , \tag{4.12}$$

where pt is the price level, m_{t-1} are the nominal money balances a household carries over from the previous period, and $(g_t\text{-}1)\, M_{t-1}$ is the lump sum transfer of money. The growth rate of the money supply, g_t, evolves according to

$$\log(g_{t+1}) = \alpha \log(g_t) + \epsilon_{t+1} \ , \tag{4.13}$$

where ϵ_t is an i.i.d. random variable with mean $\log(\bar{g})(1\text{-}\alpha)$ and variance σ_ϵ^2 where $\bar{g}$ is the unconditional mean of the growth rate.

The firm in this economy produces output using a constant returns to scale technology

$$Y_t = \exp(z_t)\, K_t^\phi \ H_t^{1-\phi} \quad 0 \leq \phi \leq 1 \ , \tag{4.14}$$

where Y_t, K_t and H_t represent aggregate per capita output, capital stock and hours respectively and z_t is an exogenous supply shock that follows a law of motion

$$z_{t+1} = \gamma z_t + \eta_{t+1} \quad 0 \leq \gamma \leq 1 \ , \tag{4.15}$$

where η is an i.i.d. random variable with mean 0 and variance σ_η^2. The firms in this economy maximize profits and the first order conditions for that problem yield expressions for wages and the rental rate on capital:

$$w(z_t,K_t,H_t) = (1\text{-}\phi) \exp(z_t)\, K_t^\phi\, H_t^{1-\phi}, \tag{4.16}$$

$$r(z_t,K_t,H_t) = \phi \exp(z_t)\, K_t^{\phi-1}\, H_t^{1-\phi}. \tag{4.17}$$

The law of motion for the capital stock is,

$$k_{t+1} = (1\text{-}\delta)\, k_t + x_t \quad , \quad 0 \leq \delta \leq 1, \tag{4.18}$$

where x_t is investment and δ is the depreciation rate.

The representative agent in this economy must choose consumption, investment, hours of work and nominal money holdings subject to the constraint:

$$c_t + x_t + m_t/p_t \leq w_t h_t + r_t k_t + (m_{t-1} + (g_t\text{-}1)M_{t-1})/p_t. \tag{4.19}$$

Cooley and Hansen (1988) describe the stationary competitive equilibrium for this economy and describe how to compute an equilibrium even though the competitive equilibrium is not a Pareto optimum. In addition, they describe a set of calibration and simulation exercises that are designed to measure the welfare costs of the inflation tax and study the role of money in real business cycle models. For our purposes, however, we need only consider the implications of this model for the comovements between prices and output.

Consider the decision problem of the representative agent when faced with supply shocks and monetary shocks. The supply shocks in this economy affect prices because the model structure (the cash-in-advance constraint) is one where the quantity equation holds. Consequently, when output increases, *ceterus paribus*, prices will decline. Demand shocks resulting from money supply increases also have real consequences. The representative agent facing a money supply growth rate higher that the Pareto optimal rate will be taxed on the nominal balances he must hold for consumption. His incentive then will be to substitute away from the "cash good", consumption, and in favor of the credit goods, leisure and investment. The latter simply represents future consumption but leisure cannot be taxed. The result is that output will fall when more leisure is consumed so that price level increases and output are negatively correlated.

The importance of this model is really that it indicates another channel of influence that operates to make price and output correlations negative. Moreover, this is a correlation that occurs because of anticipated growth in the money supply. The positive correlation that results from the signal extraction problem inherent in Wallace's model occurs because of unanticipated changes in the money supply.[13]

[13]It is worth noting that very similar implications emerge from a model where money appears in the utility function as in LeRoy (1982) and the economy is subject to real shocks.

V. Conclusions

The positive correlation between output and prices has long been one of the cornerstones of business cycle lore and business cycle theory. It assumed a central role in the Keynesian policy discussions of the 1960's and it plays a central role in the neo-keynesian economics of the 1980's. 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 GNP growth rates that are too high presage inflation. In this paper we have reexamined this central fact about business cycles and found it to be more stylized than real.

Treating the problem from the viewpoint of the NBER cycle analysts as we did in Section II does not provide a convincing picture of a positive correlation between output and inflation. Treating the problem as one of finding the comovements with reliance on the NBER definition of cycles also did not reveal a reliable positive correlation between output and prices. If anything, the empirical evidence suggests a predominantly negative correlation between prices and output. The only period where the correlation appears to be strongly positive is the period between 1929 and WWII. Finally, viewing the problem theoretically suggests at least two important mechanisms which would tend to make the correlation between prices and output negative.

For the last twenty years, different variants of the Phillips curve have assumed a prominent role in construction of business cycle models, including the equilibrium models of Barro (1978), Lucas (1972) and Sargent (1976) and the non-market clearing models of Taylor (1979,1980), Gordon (1982), and Fischer (1976). The theoretical and empirical results presented in this paper suggest that much of the relatively recent emphasis on developing models that feature a positive relationship between output and prices may have been unnecessary. Our estimate of a relatively acyclical relation between prices and output over the last century indicate that the empirical cost of abandoning the Phillips-type relationship may be small. Given the difficulties of incorporating these restrictions in models, however, the potential benefits of relaxing this constraint may be large.

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TABLE 1

CROSS-CORRELATIONS: REAL OUTPUT AND LAGGED PRICES
POSTWAR QUARTERLY DATA

A. DETRENDED DATA

LAG	48:2 - 87:2	54:1 - 73:1	66:1 - 87:2
0	-.67	-.73	-.88
1	-.68	-.74	-.87
2	-.67	-.75	-.86
3	-.67	-.75	-.84
4	-.66	-.75	-.82
6	-.62	-.77	-.77
9	-.53	-.78	-.68
12	-.48	-.77	-.57

B. LOG-DIFFERENCED DATA

LAG	48:2 - 87:2	54:1 - 73:1	66:1 - 87:2
0	-.06	-.05	-.24
1	-.09	-.11	-.26
2	-.15	-.16	-.28
3	-.25	-.22	-.27
4	-.24	-.07	-.18
6	-.25	-.09	-.11
9	.01	.02	.09
12	-.01	.07	.13

C. H-P FILTERED DATA

LAG	48:2 - 86:1	54:1 - 73:1	66:1 - 87:2
0	-.57	-.36	-.68
1	-.62	-.43	-.73
2	-.65	-.47	-.74
3	-.65	-.46	-.71
4	-.60	-.37	-.63
6	-.36	-.27	-.35
9	.14	.00	.16
12	.40	.18	.45

TABLE 2

CROSS-CORRELATIONS: REAL OUTPUT AND LAGGED PRICES
FRIEDMAN-SCHWARTZ ANNUAL DATA

A. DETRENDED DATA

LAG	1869 - 1975	1869 - 1910	1928 - 1946
0	.02	-.65	.75
1	-.02	-.61	.43
2	-.06	-.56	.00
3	-.08	-.46	-.36
4	-.11	-.45	-.57

B. LOG-DIFFERENCED DATA

LAG	1870 - 1975	1870 - 1910	1928 - 1946
0	.26	.05	.67
1	.05	-.11	.45
2	-.12	-.06	-.03
3	-.16	-.12	-.33
4	-.19	.05	-.50

C. H-P FILTERED DATA

LAG	1870 - 1975	1869 - 1910	1928 - 1946
0	.43	.27	.75
1	.29	.01	.44
2	.12	-.14	-.02
3	.00	-.25	-.39
4	-.08	-.28	-.58

TABLE 3

SUMMARY RESULTS FROM 4-VARIABLE VAR
LOG-DIFFERENCED POSTWAR QUARTERLY DATA
1948:2 - 1987:1

A. GRANGER-CAUSALITY TESTS

	F-Value, Marginal Significance Level
1. LAGGED PRICES PREDICTING OUTPUT:	1.58 .18
2. LAGGED OUTPUT PREDICTING PRICES:	1.89 .11

B. IMPULSE RESPONSE FUNCTIONS
($x\ 10^{-3}$)

LAG	PRICE SHOCK ON OUTPUT	OUTPUT SHOCK ON PRICES
1	-.07	.00
2	1.02	-.12
3	.82	-.20
4	-.67	-.75
5	-1.12	-.88
6	-1.00	-.66
7	-.96	-.62
8	-.58	-.55
9	-.39	-.43
12	-.05	-.38
16	-.07	-.35

C. VARIANCE DECOMPOSITIONS (%)

STEP	PRICES EXPLAINING OUTPUT	OUTPUT EXPLAINING PRICES
1	.01	.00
2	1.13	.05
3	1.63	.17
4	2.00	1.63
6	3.78	4.18
9	4.81	5.56
12	4.83	6.12
16	4.83	6.78

TABLE 4

SUMMARY RESULTS FROM 4-VARIABLE VAR
DETRENDED POSTWAR QUARTERLY DATA
1948:2 - 1987:1

A. GRANGER-CAUSALITY TESTS

	F-Value,	Marginal Significance Level
1. LAGGED PRICES PREDICTING OUTPUT	2.61	.04
2. LAGGED OUTPUT PREDICTING PRICES	.79	.53

B. IMPULSE RESPONSE FUNCTIONS
($x\ 10^{-3}$)

LAG	PRICE SHOCK ON OUTPUT	OUTPUT SHOCK ON PRICES
1	-.19	.00
2	.78	.00
3	.15	-.02
4	.07	-.06
5	.00	-.07
6	-.09	-.07
7	-.17	-.06
8	-.24	-.04
9	-.31	.00
12	-.39	.10
16	-.49	.21

C. VARIANCE DECOMPOSITIONS (%)

STEP	PRICES EXPLAINING OUTPUT	OUTPUT EXPLAINING PRICES
1	0.0	0.0
2	0.4	0.0
3	0.9	0.1
4	0.8	0.2
6	0.6	0.2
9	2.9	0.3
12	7.4	0.3
16	14.0	0.4

TABLE 5

SUMMARY RESULTS FROM 4-VARIABLE VAR
LOG-DIFFERENCED ANNUAL DATA
1871 - 1975

A. GRANGER-CAUSALITY TESTS

	F-Value,	Marginal Significance Level
1. LAGGED PRICES PREDICTING OUTPUT	1.28	.26
2. LAGGED OUTPUT PREDICTING PRICES	2.52	.12

B. IMPULSE RESPONSE FUNCTIONS
($x\ 10^{-3}$)

LAG	PRICE SHOCK ON OUTPUT	OUTPUT SHOCK ON PRICES
1	-7.70	.00
2	5.30	6.43
3	4.60	3.31
4	-.00	1.42
5	-.51	.70
6	-.25	.35
7	-.12	.04
8	-.06	.08
9	-.03	.00
12	-.03	.00
16	-.00	.00

C. VARIANCE DECOMPOSITIONS (%)

STEP	PRICES EXPLAINING OUTPUT	OUTPUT EXPLAINING PRICES
1	1.56	.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

TABLE 6

SUMMARY RESULTS FROM 4-VARIABLE VAR
LOG-DIFFERENCED ANNUAL DATA
1900 - 1928

A. GRANGER-CAUSALITY TESTS

	F-Value,	Marginal Significance Level
1. LAGGED PRICES PREDICTING OUTPUT	1.91	.18
2. LAGGED OUTPUT PREDICTING PRICES	1.25	.27

B. IMPULSE RESPONSE FUNCTIONS
$(x\ 10^{-2})$

LAG	PRICE SHOCK ON OUTPUT	OUTPUT SHOCK ON PRICES
1	-2.15	.00
2	1.15	.87
3	.37	.50
4	-.59	-.27
5	-.18	-.17
6	.14	.05
7	.07	.06
8	-.03	-.00
9	-.03	-.02
12	-.00	.00
16	.00	.00

C. VARIANCE DECOMPOSITIONS (%)

STEP	PRICES EXPLAINING OUTPUT	OUTPUT EXPLAINING PRICES
1	15.85	.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

TABLE 7

SUMMARY RESULTS FROM 4-VARIABLE VAR
LOG-DIFFERENCED ANNUAL DATA
1928 - 1946

A. GRANGER-CAUSALITY TESTS

	F-Value,	Marginal Significance Level
1. LAGGED PRICES PREDICTING OUTPUT	1.80	.20
2. LAGGED OUTPUT PREDICTING PRICES	.59	.45

B. IMPULSE RESPONSE FUNCTIONS
(x 10⁻)

LAG	PRICE SHOCK ON OUTPUT	OUTPUT SHOCK ON PRICES
1	.80	.00
2	1.29	.71
3	1.18	.86
4	.11	.71
5	-.53	.51
6	-.55	.33
7	-.47	.19
8	-.37	.08
9	-.26	.02
12	-.03	-.03
16	.01	-.00

C. VARIANCE DECOMPOSITIONS (%)

STEP	PRICES EXPLAINING OUTPUT	OUTPUT EXPLAINING PRICES
1	1.09	.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

TABLE 8

SUMMARY RESULTS FROM 4-VARIABLE VAR
LOG-DIFFERENCED ANNUAL DATA
1871 - 1900

A. GRANGER-CAUSALITY TESTS

	F-Value,	Marginal Significance Level
1. LAGGED PRICES PREDICTING OUTPUT	.95	.34
2. LAGGED OUTPUT PREDICTING PRICES	.17	.68

B. IMPULSE RESPONSE FUNCTIONS
($\times 10^{-2}$)

LAG	PRICE SHOCK ON OUTPUT	OUTPUT SHOCK ON PRICES
1	.00	-1.55
2	.23	-.76
3	-.11	.76
4	-.07	-.30
5	.02	.00
6	-.02	.00
7	.00	.00
8	.00	.00
9	.00	.00
12	.00	.00
16	.00	.00

C. VARIANCE DECOMPOSITIONS (%)

STEP	PRICES EXPLAINING OUTPUT	OUTPUT EXPLAINING PRICES
1	7.6	0.5
2	9.0	0.5
3	10.5	0.5
4	10.7	0.5
6	10.7	0.5
9	10.7	0.5
12	10.7	0.5
16	14.0	0.5

TABLE 9

SUMMARY RESULTS FROM 4-VARIABLE VAR
LOW-DIFFERENCED POSTWAR QUARTERLY DATA
1951:2 - 1984:4

A. GRANGER CAUSALITY TESTS

Level	F-Value,	Marginal Significance
1. LAGGED PRICES PREDICTING SOLOW RESIDUALS:	.84	.500
2. LAGGED SOLOW RESIDUALS PREDICTING PRICES:	4.73	.001

B. IMPULSE RESPONSE FUNCTIONS
(x 10-3)

LAG	PRICE SHOCK ON SOLOW RESIDUALS	SOLOW RESIDUAL SHOCK ON PRICES
1	-1.76	.00
2	-.07	-.83
3	.30	-1.17
4	-.93	-.79
5	-1.20	-.98
6	-.63	-.58
7	-.12	-.56
8	-.08	-.58
9	-.83	-.60
12	-.11	-.50
16	-.08	-.39

C. VARIANCE DECOMPOSITIONS (%)

STEP	PRICES EXPLAINING SOLOW RESIDUALS	SOLOW RESIDUALS EXPLAINING PRICES
1	3.48	.00
2	3.36	3.07
3	3.09	7.97
4	3.76	9.03
6	4.83	11.02
9	4.73	11.44
12	4.84	12.68
16	4.88	13.37

TABLE 10

SUMMARY RESULTS FROM 4-VARIABLE VAR
LOG-DIFFERENCED ANNUAL DATA
1871 - 1910

A. GRANGER-CAUSALITY TESTS

	F-Value, Marginal Significance Level
1. LAGGED PRICES PREDICTING OUTPUT	.85
2. LAGGED OUTPUT PREDICTING PRICES	.09

B. IMPULSE RESPONSE FUNCTIONS
($x\ 10^{-2}$)

LAG	PRICE SHOCK ON OUTPUT	OUTPUT SHOCK ON PRICES
1	-.15	.00
2	-.06	.00
3	-.02	.00
4	.00	.00
5	.00	.00
6	.00	.00
7	.00	.00
8	.00	.00
9	.00	.00
12	.00	.00
16	.00	.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

Figure 1

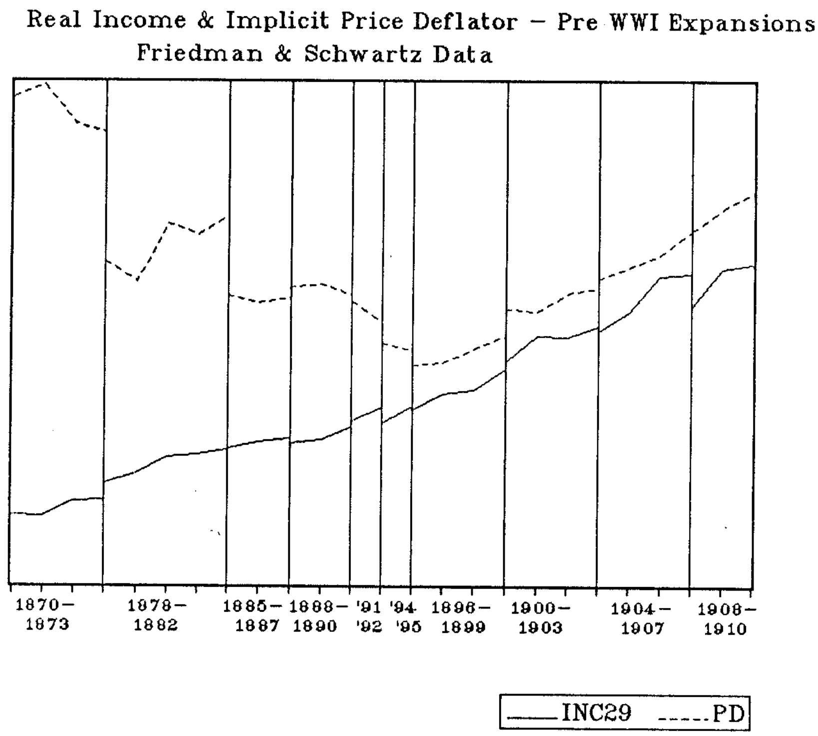

Figure 2

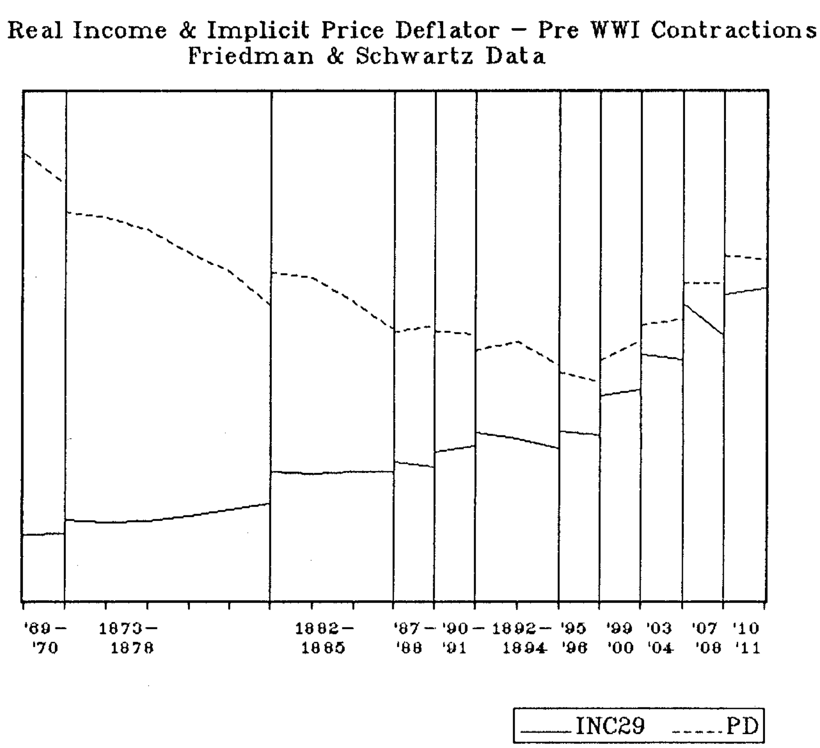

Figure 3

Log Differenced Real Income & Deflator – Pre WWI Expansions
Friedman & Schwartz Data

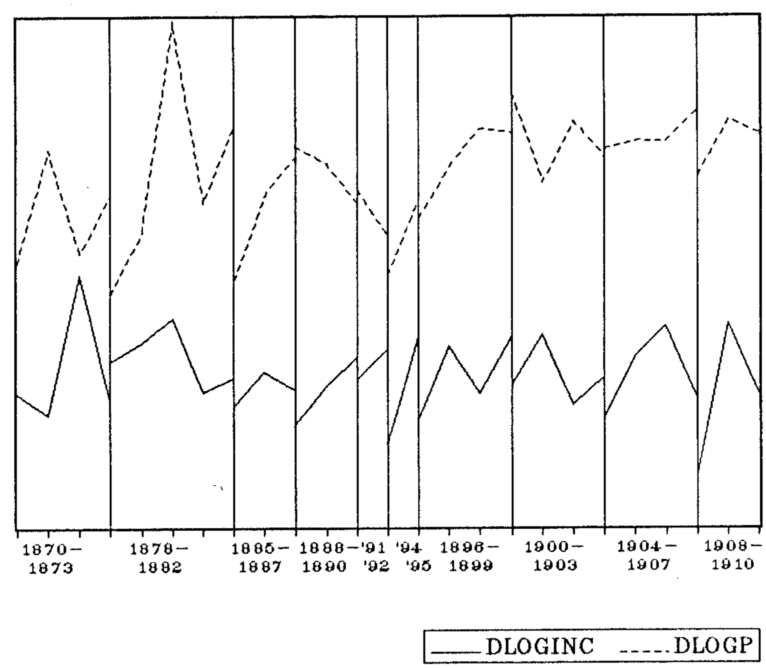

Figure 4

Log Differenced Real Income & Deflator – Pre WWI Contractions
Friedman & Schwartz Data

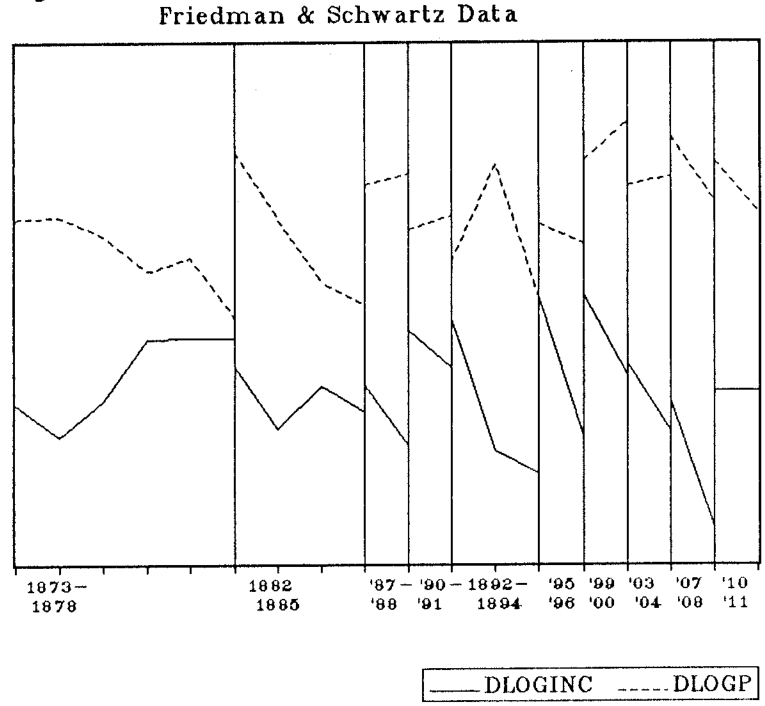

Figure 5

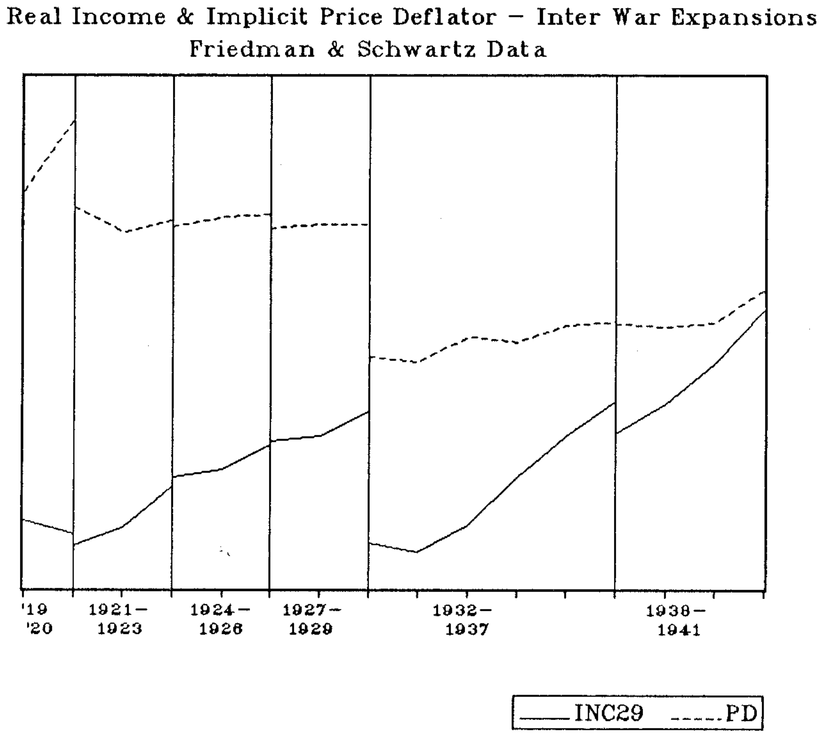

Figure 6

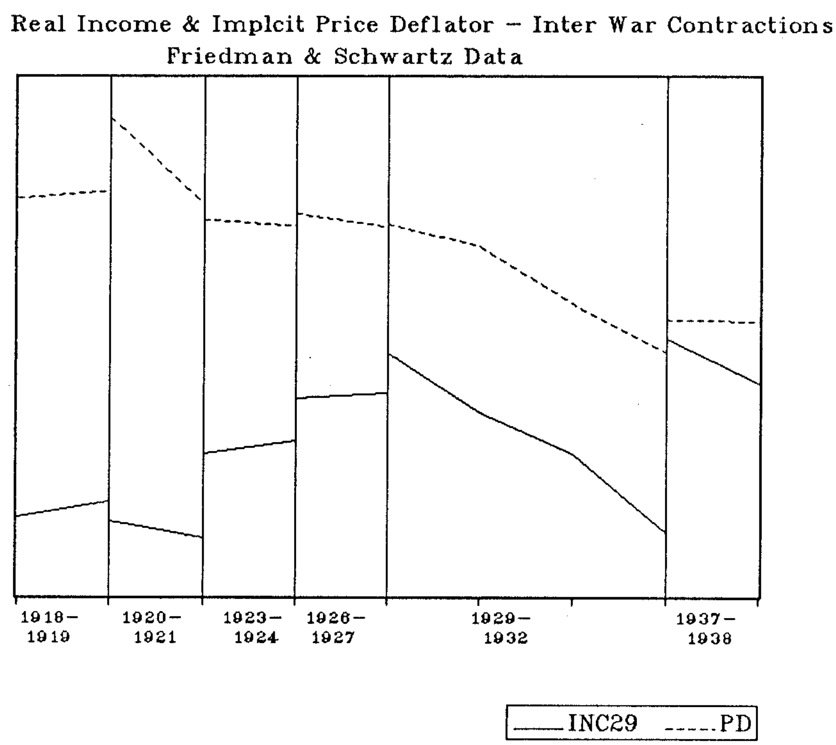

Figure 7

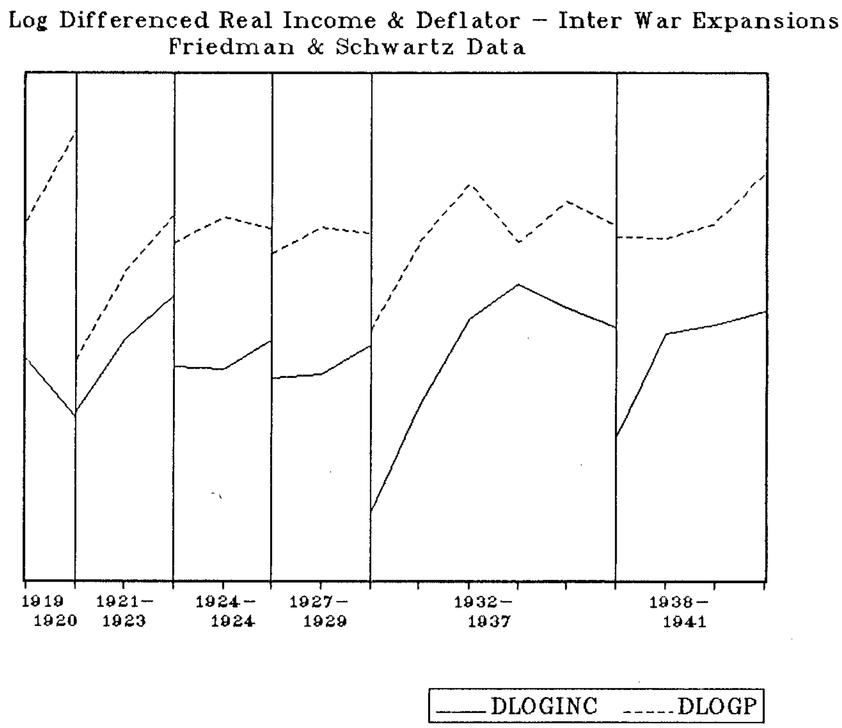

Figure 8

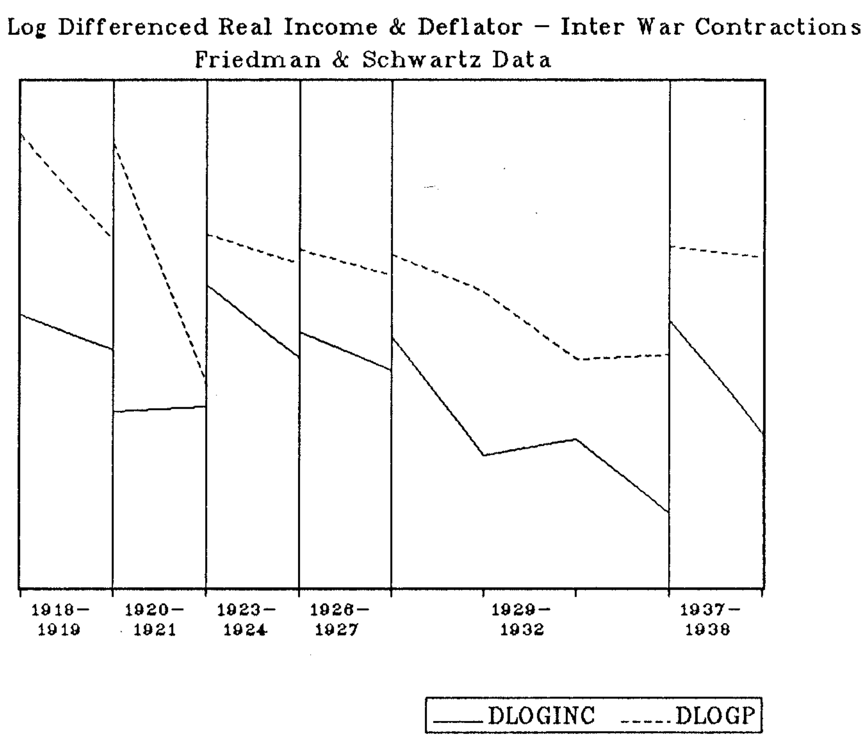

Figure 9

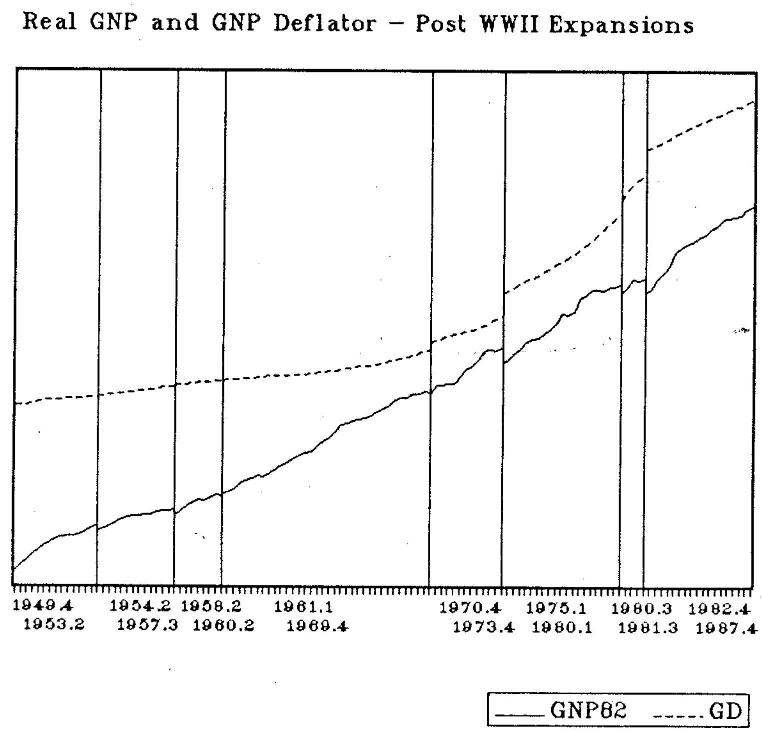

Figure 10

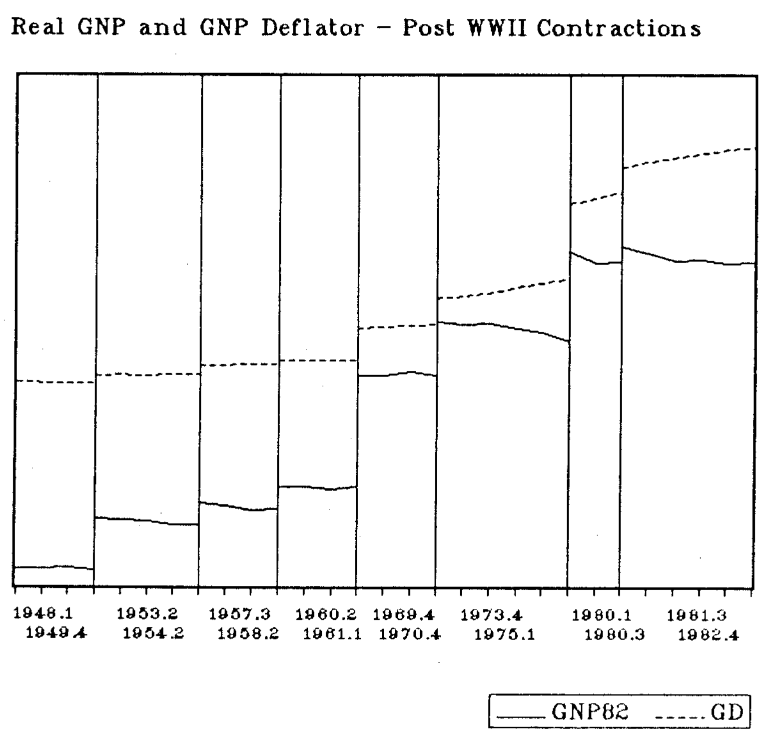

Figure 11

Log Differenced Real GNP & Deflator – Post WWII Expansions

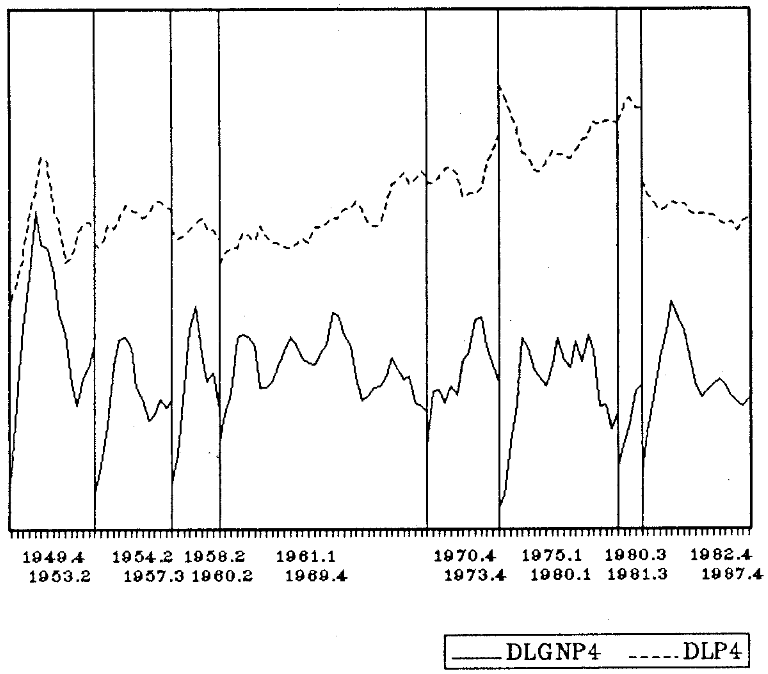

Figure 12

Log Differenced Real GNP & Deflator – Post WWII Contractions