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Non-Monetary Effects on Inflation Within the Price-Gap Model

Leonard Loebach

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Non-Monetary Effects on Inflation Within The

Price-Gap Model

(TITLE)

BY

Leonard Loebach

THESIS

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ABSTRACT

Non-Monetary Effects on Inflation within the Price-Gap model

The purpose of this thesis is to examine some of the various non-monetary effects on inflation within the framework of the price-gap model. Some of the non-monetary shocks that can affect inflation include wage adjustments, changes in basic commodity prices (for example, crude oil), changes in the exchange rates, and shifts in inflationary expectations.

In April of 1989, a study was put out by the Federal Reserve (staff study 157) that examined the relationship between the current price level and an estimate of the long-run equilibrium price level. In the study, an indicator P* (pronounced P-star) was used to estimate what level of prices could be supported by the present money stock. The long-run price level was defined as $P^*=(MV^*)/Q^*$ where M is the money stock, V^* is the long-run equilibrium level of velocity, and Q^* is the potential output level. From this the study relates the acceleration of the price level (or changes in the rate of inflation) to the price gap defined as $(p-p^*)$ where the lower-case variables are the natural logarithms of the upper-case counterparts. The authors were able to show that, in the long-run, the price gap gives a reasonable explaination of the dynamics of inflation.

This thesis builds on the basic framework of the price gap model particularly with respect to short-run variations in the rate of inflation. The Fed study suggest:

> "In the short-run, other characteristics of the economy such as the formation of expectations, lags in wage contracts and in aggregate demand, and the effects of changes in the exhange rate, may affect the inflation process. These factors thus may well affect the estimated dynamics of the model, ... and (we)

have focused instead on tying down the long-run price level."
This thesis examines the effect of these short-run variations.

The basic form of the model is specified as:

change in rate of inflation	=	price gap	+	lagged changes in the rate of inflation	+	series of non-monetary disturbances

The price gap and the lagged dependent variables are the basic form of the price-gap model used in the Fed study. The non-monetary disturbances to be used are basic commodity prices, exchange rates, wage adjustments, and inflationary expectations. The individual commodity prices that are examined are crude oil, lumber, cotton, copper and scrap steel. These commodities are chosen because they are basic industrial commodities that have the greatest effect on the manufacturing sector of the economy. In addition, a commodity price index is developed that incorporates price movements of the mentioned commodities into a single series. The effects of this index are also examined. Variations in a dollar index are used to model exchanges rates. The dollar index used is a trade weighted basket of 10 foreign currencies published by the Fedral Reserve and is a good proxy for the performance of the dollar relative to foreign currencies. The average weekly wage level for manufacturing is used to model wage adjustments and their impact on inflation. Lastly, an adaptive inflationary expectations disturbance is computed and is tested. All significant disturbances are incorporated into a general model a simulation was run to test the predictive power of the model.

The thesis concludes that variations in commodity prices and wage adjustments have a significant effect on inflation in the short-run. Movements in the exchange rates have a milder effect on inflation while the expectations disturbance had no usefulness at all. The explanatory power of the price-gap model from the Fed study to the general model in this thesis was increased from about 33% to about 47% of total variation in inflation. The simulation showed that the model had reasonable predictive power. Overall, the thesis shows that the price-gap model is flexible enough to be adapted to short-run work.

Introduction

Inflation is a widely perceived, yet little understood, phenomenon. Economists know what inflation is, but there is wide disagreement on its causes and dynamics. At the extremes are Keynesians who consider prices the product of oligopolistic trade unions and corporations who have power to set prices where they wish and Monetarists who believe, in the words of Milton Friedman, that "inflation is everywhere and anywhere a monetary phenomenon."

Recently a new model, called the "price-gap′ model, was developed by the Federal Reserve that while fundamentally Monetarist incorporates some Keynesian concepts. The study focuses on the long-run charactistics of inflation. The study shows that the price-gap model has significant explanatory power of the long-run trend of inflation, but it has less explanatory power in the short-run. This thesis builds on the price-gap framework in an attempt to capture some of the short-run variation in inflation.

Acknowledgements

I would like to thank the members of my thesis committee, Dr. Tim Mason and Dr. Bill Weber, for their constructive comments on the contents and structure of this thesis paper. A special gratitude is in order to the committee chairman, Dr. Minh Dao, who guided me through the difficult process that goes into producing a study of this sort. And last, but certainly not least, a special thanks to my mother and father for their continual support.

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Non-Monetary Effects on Inflation Within the Price-Gap Model

I. Introduction

One of the major debates in economics today is the issue of inflation, defined as a sustained increase in the price level. Many different theories about inflation have been developed over the years, each with its strengths and weaknesses. The most recent theory is based on a "price-gap" model that was developed by the staff at the Federal Reserve Board at the request of Alan Greenspan, Chairman of the Federal Reserve system. This model focuses on the long-run nature of inflation as a monetary phenomenon. However, the model lacks some explanatory power in the short-run. This study builds on the basic price-gap model and incorporates non-monetary effects on short-run inflation.

The layout of this paper is as follows: chapter II is a review of literature on inflation, emphasizing the general theoretical paradigms that have been developed over the years. Chapter III gives a critique of the price-gap model and then derives the model examined in this study. Chapter IV explains the sources of data used in this study and the methodology of data analysis. Chapter V presents the results of regressions run in this study and those of some standard statistical tests. Chapter VI examines a simulation of a general model developed in chapter V to test its forecasting power, and chapter VII states the conclusions of this study.

II. Review of Literature

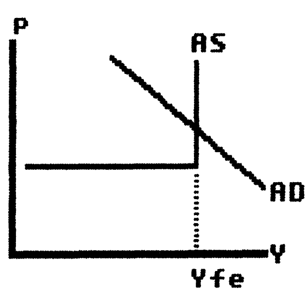
The literature on the causes of inflation reveals that these are as diverse as macroeconomic theories themselves. In fact, the basic concept behind any given inflation theory reflects the macroeconomic paradigm (Keynesian, Monetarist, Rational Expectations, etc.) to which an author adheres. While no mere review can do justice to the large amount of literature on inflation, what follows is an attempt to review the basic theories on inflation and some concepts that other authors have used which are relevant to the present study.

It is widely accepted in economics that equilibrium prices are the results of market supply and demand conditions. At the macro level, the concepts of aggregate supply and aggregate demand are used in the determination of the price level. Early inflation theories fall under the headings of demand-pull or cost-push inflation. Demand-pull inflation is a situation where rising aggregate demand "pulls" prices higher along with increases in output. Cost-push inflation is the complementary situation of rising business costs (materials, wages, etc.) causing a fall in aggregate supply resulting in rising prices and lower output.

Chapter 11 of Makinen (1977) gives a good summary of these early theories. Prior to the Keynesian revolution of the 1930s, the quantity theory of money was the primary analytical tool for studying inflation. Simply stated, from the equation of exchange, $MV = PQ$, and given that velocity was assumed constant and output was considered independent of money, the price level was directly related to the money stock. Of course, this early theory formed the basis for the monetarist theories a few decades later. More on monetarism will be discussed below. Thus the early quantity theory was a demand-pull theory; too much money chasing too few goods.

Early Keynesian theory offered a static view of inflation through the concept of the "inflationary gap" formed when aggregate spending is greater than the full employment level of real income at a given price level. For example, if the full employment level of real income were Y_{fe} and aggregate spending of consumption, business investment, and government purchases (C+I+G) is above this level, then prices would rise to bring real spending and real output back into equilibrium. This assumes a right-angle aggregate supply curve with the vertex being formed at the full employment level of income. Figure 1 illustrates this point.

Figure 1



The events of the late 1950s posed somewhat of a dilemma for economists as the economy experienced rising inflation in an environment with obvious slack; unemployment rates ranged from 6 to 7%. Table 1 shows that unemployment in the 1957-58 period was rather high in comparison to earlier years, yet prices rose faster than what was thought possible.

Table 1

Year	1954	1955	1956	1957	1958	1959
Unemployment	5.5%	4.4%	4.1%	4.3%	6.8%	5.5%
Inflation	0.5%	-0.4%	1.1%	3.6%	2.7%	0.8%

Makinen (1977) remarks "(economists) believed that with (unemployment) rates approaching 6 percent and 7 percent, society ought to have had either price stability or deflation." This phenomenon led to the cost-push theory of inflation. In the Keynesian analysis, in an environment of less than full employment, prices are considered "administered" based on historical precedent or tradition. Therefore, sources of inflation were sought on those agents that presumably had power over the administration of prices; e.g. trade unions and corporations. John K. Galbraith (1967) comments that because unions and corporations operate in oligopolistic markets they have "power over prices--the plenary power to set them within a considerable range..." The terms wage-push and profit-push were used to focus attention on what was the cause of inflation.

Charles Shultze (1959) put forward a slightly different explanation for the inflation of the late 1950s. He theorizes that inflation was possible in an economy not characterized by excess demand, but by sectoral shifts in the composition of demand. Under this approach, those sectors of the economy that do experience excess demand will have price rises while, because of downward rigidity, those sectors that have deficient demand will not have price declines. The net effect is inflation. Not much empirical evidence supports this theory and not much further work has been done on it.

Theories of the causes of inflation were given a major addition by Phillips (1958) with the introduction of the, now famous, Phillips curve. He hypothesizes an inverse relationship between changes in money wages and the level of unemployment. Phillips shows, with not much econometric rigor, a remarkable relationship between wage changes and unemployment in Britain and some evidence for relating changes in the unemployment rate and cost of living increases on wage changes. Curiously, Phillips comments "...that cost of living adjustments will have little or no effect on the rate of change of money wage rates...," thus implying a weak relationship between wages and prices. Lipsey (1960) gives a more detailed econometric examination of Phillips' paper using a theoretical framework within which to base the findings. The theory essentially uses basic supply and demand to establish a relationship between the rate of wage change and employment on a microeconomic level and then aggregate it to the macroeconomic level. In so doing, he brought in the idea of the distribution of unemployment in various markets as a variable explaining money wage changes. Like Phillips, Lipsey finds a weak link between price changes and wage changes but comments that "Until more is known about the causal links between (wage changes) and (price changes), it is very dangerous to argue as if either of these variables were independent of the other." Unlike Phillips, Lipsey leaves open the possibility of a link between wages and prices.

Eventually, the Phillips curve approach evolved into a relationship between price inflation and unemployment through the Keynesians' assumption of markup pricing. In fact, the Phillips curve relationship seemed to hold very well for the United States in the late 1950s and early 1960s. However, the main counterassault on the Phillips curve was put forth independently by Friedman (1968) and Phelps (1967). Friedman reasons that the Phillips curve contains a basic flaw; it relates nominal wages to unemployment rather than real wages. Friedman draws on the natural rate of unemployment, which is that rate of unemployment that will exist when the economy is operating at its long-run potential. Friedman explaines that for a monetary authority to expand employment it must increase its rate of money growth thus causing employment and output to increase. But after this initial effect, commodity prices will begin to rise because of the excess demand and will rise faster than factor prices, or wages. Thus because the real wage has, in effect, declined, more labor will be used. After a time, labor will begin to demand higher nominal wages because of rising commodity prices and expected future rises in commodity prices. This will force the real wage to increase, and employment to decline. Friedman thus concludes that, while there may be a short run tradeoff between inflation and unemployment, there is no long-run tradeoff because of adaptive price expectations. Phelps (1967) essentially comes to the same conclusion as Friedman when he comments that price changes "...shift one-for-one with variations in the expected rate of inflation." While Friedman's explanation is largely qualitative, Phelps develops a theoretically rigorous model which incorporates a dynamic social utility function to determine the optimal unemployment rate and, through adaptive expectations, shows how the Phillips curve will shift so that expected inflation adjusts to actual inflation and the unemployment rate to its natural rate. The Friedman-Phelps framework eventually became known as the Accelerationist theory. The theory received a substantial justification when, in the 1970s, the U.S. economy experienced substantial employment slack (that is, an unemployment level well above anybody's estimate of the natural rate) with stubbornly high inflation and a slow deceleration of price changes--a phenomenon that became known as "stagflation." This led Arthur Okun (1975) to write "Clearly, the short-term Phillips curve has shifted upward. In the sense of recognizing that shift, we are all accelerationists now."

With the advent of the Accelerationist model, there arose a debate among economists on the nature of the long-run Phillips curve. The accelerationists theorized that, in the long-run, the Phillips curve is vertical at the natural rate of unemployment. Any short-run tradeoff between inflation and unemployment would shift, via adaptive expectations, so that unemployment would return to its natural level. On the other hand, defenders of the Phillips curve theory continue to argue that, even in the long-run, there is a definite tradeoff between inflation and unemployment.

A weak long-run relationship between wage changes and unemployment is discussed by R. A. Gordon (1975) where wage changes were regressed against unemployment, changes in unemployment, and price changes. The time period was 1900 to 1970. Though the study was conducted as closely to Phillips' paper as possible, Gordon seeks to modify the unemployment series for the sharp decline in agricultural employment (which tends to have very low unemployment rates) and he studies both manufacturing wages and overall wages. Gordon concludes that there is a loose long-run relationship between wage changes and unemployment and he also concludes that his paper has little support for the accelerationist position. However, upon closer examination of his results, one finds that the inclusion of price changes as a regressor in his model tends to skew the results. In many cases the unemployment variable was not significant. This casts doubt on the wisdom of including both price changes and wage changes in a single equation which has not been pursued by others.

A more typical examination of the long-run Phillips-type relationship is given by Eckstein and Girola (1978) who looks at the wage-price mechanism in the United States from 1871 to 1977. Their model is essentially a two equation structure with a Phillips type wage equation and a markup type price equation. The entire system is then combined to derive an inflation-unemployment relation that represents the long-run Phillips curve. Several particulars should be noted about this paper. Eckstein and Girola use unit labor costs in their wage equation (they felt that including productivity as a regressor gave poorer results) and they also include consumer prices as regressors in the wage equation as well. Though R. A. Gordon came up with poor results when prices were included in his wage equation, Eckstein and Girola develope a quite workable model which includes an unemployment variable. Some reasons for this may be that Eckstein and Girola use two lagged price variables and the inverse of unemployment in their model while R. A. Gordon does not use lags and hypothosizes a negative linear relationship between unemployment and wage changes. Curiously, Eckstein and Girola does not include changes in the unemployment rate as had R. A. Gordon and Phillips. It should also be noted that the coefficients of the price variables in the wage equations in Eckstein and Girola have values close to unity and if they were summed with the lagged price variables, the net coefficient estimates relating prices and wages comes out to between .9 to 1.0. This provides evidence for the very close link between wages and prices shown by R. A. Gordon and hinted at by Lipsey. In the price equation, manufacturer prices are regressed against raw material prices along with a constraint on the weight of labor costs in manufactured prices. The actual regression consisted of the difference between manufactured prices and 60% of unit labor costs being regressed on raw materials prices. The 60% value is chosen because it is consistent with the weight of labor in the Cobb-Douglas aggregate production function. When both the wage and price equations are brought together as a system, a final equation relating consumer prices to manufacturer prices was included to complete the system. Their final results do show a very steep, though not vertical, long-run Phillips curve with non-inflationary unemployment rates between 6% and 7.5% depending on whether consumer prices or manufactured prices are used and the time period involved. In all cases, the curves went nearly vertical at unemployment rates around 4%. One final note is that Eckstein and Girola do not really address the problem of "stagflation" that was becoming more of a problem in the mid to late 1970s except to mention in passing that the phenomenon is caused by shocks and controls which are amplified by the wage-price mechanism of their model.

The experience of "stagflation" in the 1970s led to some interesting studies into its causes and cures. Two such papers on "stagflation" in the Keynesian tradition are put forward by Arthur Okun (1975, 1978). Okun (1975) developes a qualitative mechanism for inflation by stressing non-market clearing factors for both inflation and unemployment. He comments that "Because of the absence of market-clearing mechanisms, quantity adjustments carry the burden for many types of product and factor markets, leading to the observed sluggishness and persistence of inflation and of excessive unemployment. ...I shall stress the cost of information, interpreting it broadly to include costs of prediction, of establishing reliability, and the like." The implications of this analysis for policy to cure "stagflation" are also vintage Keynesian including value-added subsidies and cuts in sales and payroll taxes to stimulate deficient demand and a wage income and price policy. Okun (1978) repeats these recommendations in response to the talk of a gradual-recovery strategy to decelerate inflation. He argues that, though keeping unemployment above the "natural" level would be disinflationary, it is inefficient from the standpoint of lost output. He again argues for the policies mentioned earlier--subsidies and tax cuts.

A third major theoretical advance in the explanation of inflation is the Monetarist movement pioneered by Milton Friedman. Monetarism is a reincarnation of the classical quantity theory of money as put forward by Irving Fisher (reprint 1971). A survey of the basic tenets of Monetarism and some empirical evidence can be found in Friedman (1973) in a lecture given in Israel. Among some of the evidence for Monetarism, Friedman mentions, are the practical experience of Keynesian thought in the late 1940s and late 1960s, advances in scholarly work, and some empirical data. Friedman quotes Emanual A. Goldenweiser, Director of Research at the Federal Reserve Board, as saying in 1945 that inflation in the post-war was not a problem, that employment would be a more serious matter, and that the U.S. would have to adjust itself to 2.5% long term interest rates. Friedman comments:

"Well, it would be hard to find three predictions in the course of a single talk that have been more clearly falsified by subsequent experience. Inflation turned out to be the problem. We did not have a lasting problem of finding jobs, and we certainly did not have to adjust ourselves to a 2.5% interest rate." On the scholarly side, Friedman mentions the work of Pigou, Tobin, and Patinkin (no specific studies) as casting doubt on the Keynesian position that a freely working price system could achieve an underemployment equilibrium. He also cites advances in econometrics and monetary history to reevaluate past events--particularly the Great Depression--within a quantity theory framework. For some empirical evidence, Friedman shows a remarkable high degree of correlation between the levels and rates of change of money stock and nominal income over long periods of time. Of more interest, Friedman also shows a high correlation between price changes and the ratio of the money stock to actual output. This relationship is the antecedent of the theoretical framework of this paper.

An example of a more rigorous model for Monetarism is given by Stein (1978). Stein shows the polar extremes in the debate between Monetarism and the neo-Keynesian (Accelerationist) position. He describes the basic neo-Keynesian position as relating the acceleration of prices to the difference between the actual unemployment rate and the equilibrium unemployment rate. He describes the basic Monetarist position as relating the acceleration of prices to the difference between money supply growth and the current rate of inflation. Stein goes on to develop a general dynamic model from which either position can be derived. Stein comments that "The crucial feature is that a decline in real income and a rise in unemployment: (i) lowers savings relative to investment and (ii) lowers the growth of nominal unit labor costs. The first effect raises, and the second effect lowers, the rate of inflation. If these effects cancel, then the monetarist equation is obtained." He then makes the assumption that the two effects mentioned above do cancel and derives the Monetarist model of inflation. Stein then develops an empirical model and applies it as an explanation for the "stagflation" phenomenon as a result of an erratic stop-go variety of monetary policy.

In an attempt to compare and contrast the three major theories of inflation, Rea (1983) puts forward an interesting paper that compares the three major theories (Keynesianism, Accelerationism, and Monetarism) using the same data over the same time period. Rea uses inflation and unemployment data from 1895 to 1956 to estimate each model and then uses those estimates to predict inflation and unemployment from 1957 to 1979. Rea uses Eckstein and Girola (1978) as the basis for the Phillips curve specification relating price changes to the inverse of the unemployment rate, raw materials prices, productivity, and lagged inflation. For an Accelerationist natural rate model, Rea uses a specification similar to that used by Sargent (1976) where unemployment is related to the difference between actual inflation and expected inflation. Rea uses two forms of this model: one where expectations are formed adaptively and another where they are formed rationally, i.e. given all available information. For the Monetarist model, Rea uses Stein (1978) by relating current inflation to lagged inflation and lagged money growth. Rea also incorporates an unemployment equation, also given by Stein, to complete the model. The basic conclusion of the study is summed up by Rea;

> "During the 1895-1956 subperiod, the trade-off (Phillips curve) model has greatest explanatory power and the monetarist model has the least. Just the reverse is true of the 1957-1979 subperiod where the monetarist model has the greatest and the trade-off model, the least. In both subperiods, the adaptive expectations version of the natural rate (Accelerationist) model outperforms the rational expectations version and, in addition, falls between the trade-off and monetarist models."

Rea concludes that neither model, by itself, can explain the behavior of inflation and unemployment over the eighty year period. He cites two potential obstacles to finding a general theory of prices and unemployment. The first is expectations; how and when are they developed; and the second is gradual changes in the economic structure that may make it impossible to find stable relationships. If some method can be developed that can incorporate these changes, then a general theory may be developed.

One new theory of inflation is derived from the price-gap model that was developed by the Federal Reserve Board Staff. This model is noteworthy, because it seems to incorporate some concepts from both the Monetarist and Keynesian paradigms and has been shown to be remarkably stable over a period of several decades. The next section summarizes the price-gap model and then develops the model examined in this study.

III. Model Development

In the winter of 1988, Federal Reserve Chairman Alan Greenspan requested the Board staff to evaluate the usefulness of M2 as an anchor for the price level. This came in response to some economists who conclude that there is no monetary aggregate on which the monetary authority can rely, notably B. Friedman (1988, 1988). To this end, Hallman, Porter, and Small (1989) developed an estimate of the long-run equilibrium price level P* (pronounced P-star). The logic behind P* is to determine what price level would be supported by the current money stock if output and velocity settled into their long-run equilibria. The value of P* is determined as:

$$P^* = (MV^*)/Q^* \qquad (1)$$

where M is the money stock, Q* is the current value of potential GNP, and V* is the equilibrium value of velocity. M2 is the monetary aggregate used for the money stock because of the relative long-run stability of M2 velocity. Porter and Small (1989) examine the behavior of M2 and V2 and conclude that the relative flexibility of deposit rates paid on M2 components contributes to this stability. The procedure behind the potential GNP estimates is given in Clark (1982). The Q* series from 1952:1 to 1988:4 is provided by Hallman, Porter, and Small.

The discrepancy between the actual price level, P, and the equilibrium price level, P*, is seen as the major factor driving inflation. From the equation of exchange, it can be obtained that $P=(MV)/Q$ and $P^*=(MV^*)/Q^*$. By taking logarithms of both relations and subtracting one from the other, one gets:

$$p - p* = (v - v*) + (q* - q) \qquad (2)$$

where lower-case variables are the natural logarithms of the upper-case counterparts. From this it can be seen that the money stock that supports p* but has yet to be reflected in actual prices can be depressing velocity below its equilibrium, raising output above its potential, or both. As lags in money demand are worked out, it is expected that velocity will rise to V*. Similarly, as wages and expectations adjust, output will move to Q*. Both effects will cause prices to converge to P*.

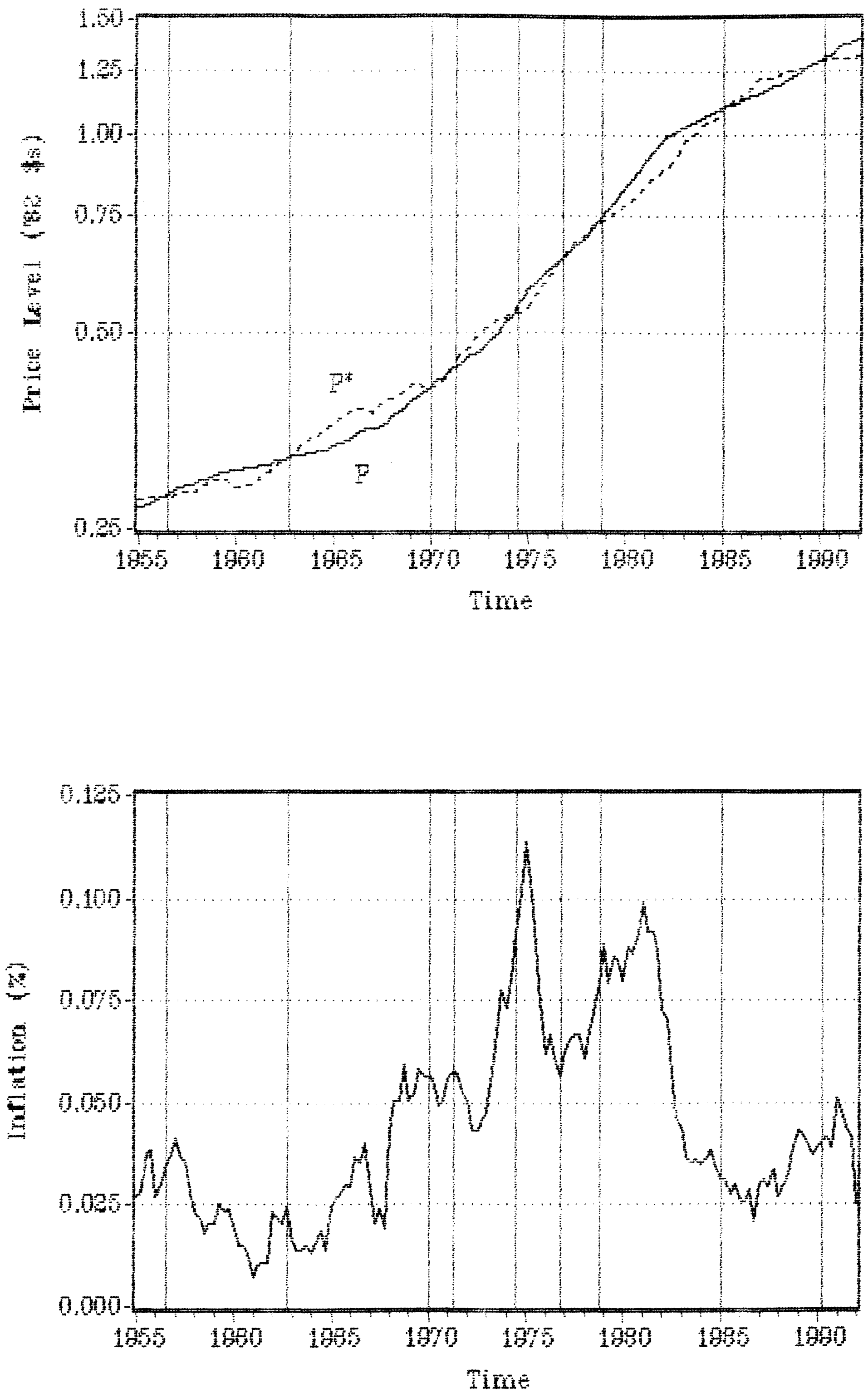
The price-gap (p-p*) is seen as the primary factor driving inflation. Figure 2 (this study's data) illustrates this point. The vertical bars show the points where p and p* cross each other. Notice that when p* is below p inflation tends to decelerate (that is, the rate of price increase will drop) with a lag. Similarly, when p* is above p inflation will tend to accelerate with a lag.

The specification of the price-gap model relates the acceleration of prices, or changes in inflation, to the price-gap and to recent inflationary behavior. The basic price-gap model is specified in equation 3. [Note: The reader should be aware of some special notation used in this and later chapters. The symbol Ε will be used as a summation symbol and a capital "D" will be used as a first difference operator.]

$$Di_t = a(p_{t-1} - p*_{t-1}) + \sum_{j=1}^{4} b_j Di_{t-j} \qquad (3)$$

where i is the quarterly inflation rate and a and b_i are constants.

FIGURE 2



1.50
1.25
1.00
0.75
0.50
0.25
Price Level ('82 $s)
P*
P
1955
1960
1965
1970
1975
1980
1985
1990
Time
0.125
0.100
0.075
0.050
0.025
0.000
Inflation (%)
1955
1960
1965
1970
1975
1980
1985
1990
Time

Statistical tests were conducted by Hallman, Porter, and Small to determine that four lags of the dependent variable are adequate and the inclusion of further lags are not needed.

An empirical estimate of the coefficients from Hallman, Porter, and Small is given Table 2. Note that t-statistics are given in parentheses.

TABLE 2

Dependent Variable: DI_t

Variable	Coefficients
$pgap_{t-1}$	-.031 (3.9)
DI_{t-1}	-.653 (7.7)
DI_{t-2}	-.441 (4.5)
DI_{t-3}	-.326 (3.4)
DI_{t-4}	-.116 (1.5)
Adj. R^2	.317

One of the major motivations behind this study was an examination of the long-run factors of inflation. The quarterly change in inflation is a highly volatile series with the basic model explaining only about a third of the variation. If the series is smoothed by a moving average, the results improve significantly. Table 3 gives a summary of the model from Hallman, Porter, and Small with no smoothing, a four quarter average, and an eight quarter average.

TABLE 3

Frequency	a	t-stat	adj. R^2	St. Error
quarterly	-.031	(3.9)	.317	.0040
4-qtr avg.	-.182	(4.7)	.412	.0098
8-qtr avg.	-.569	(5.9)	.712	.0164

It is interesting to note that the lagged dependent variables are not required for the smoothed series.

The conclusion of the study is that the price-gap model is a useful guide for monetary authorities to evaluate policy. Hallman, Porter, and Small concede that the model misses much in the short-run but that in the long-run the model has explanatory power.

The purpose of this paper is to attempt to capture some of the short-run factors affecting inflation that were not addressed by the Federal Reserve study. Hallman, Porter, and Small admit "In the short-run, other characteristics of the economy such as formation of expectations, lags in wage contracts and in aggregate demand, and the effects of changes in the exchange rate, may affect the inflation process." As was noted, the quarterly change in inflation is a highly volatile series and the basic price-gap model only captures about a third of the variation of the series. The general model of this paper is specified as:

change in the rate of inflation	=	price-gap	+	lagged changes in the rate of inflation	+	series of non-monetary disturbances

Some of the non-monetary disturbances that may have an effect on inflation in the short-run have already been mentioned: exchange rates, wages, and expectations. These three disturbances plus commodity supply shocks form the four major non-monetary disturbances that will be explored by this paper. What follows is a summary of recent literature on how some these disturbances affect inflation and how to properly specify them for empirical purposes.

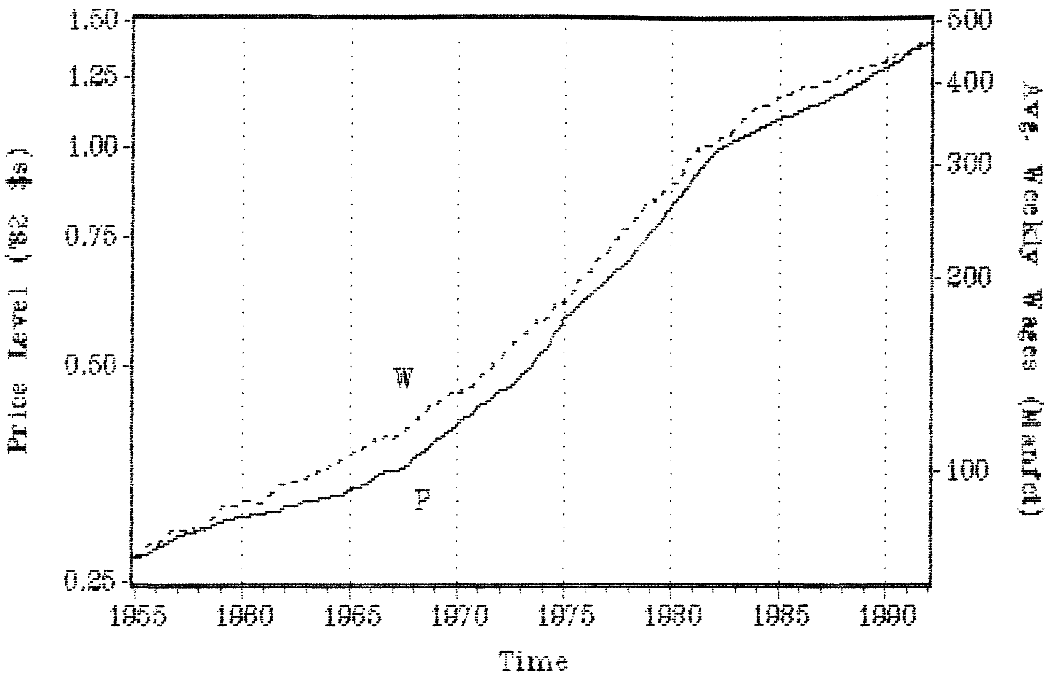
The effect of commodity prices on the general price level comes in the form of "supply shocks." For example, the Arab oil embargo of 1974 almost tripled crude oil prices and was seen as a major contributor to the inflation of the 1970s. Other examples may include the effect of drought on food prices, or miners' strikes. Empirically, these supply shocks can be represented as dummy variables in inflation models.

Hallman, Porter, and Small (1989) used dummy variables to simulate the oil shocks of the 1970s as did Eckstein and Girola (1978). An alternative method of incorporating supply shocks is to actually include a commodity price series in the inflation model. R. J. Gordon (1985 & 1988) does just that by including a vector of supply shocks which includes taxes, exchange rates, a food and energy price index, and price controls. For the food and energy price component, R. J. Gordon constructs the component so that if the relative price (relative to the CPI) is unchanged, the component has a zero value. Thus, R. J. Gordon relates changes in relative commodity prices to changes in the rate of inflation.

The specification of the effect of commodity prices on inflation for this study is to relate the acceleration of inflation to changes in the commodity price level. This seemingly strange specification is not without precedent. From the CRB Yearbook published by the Commodity Research Bureau, Emery (1988) summarizes, in a qualitative way, the impact of changing food and energy prices on the CPI. Emery describes the various factors influencing consumer prices of food and energy products and how shifts in the basic commodities prices effect final consumer prices. He notes "Movement in the overall CRB Futures Price Index can be a valuable aid in forecasting shifts in the rate of change in the CPI." He implies that even in a stable commodity price environment, inflation will remain and be steady. Another example of this specification can be found in two articles from the Monthly Labor Review put out by the Bureau of Labor Statistics: Howell, Burns, and Clem (1987) and Bahr (1987). The two articles show, in a very loose way, how the CPI dramatically decelerated in 1986 and then accelerated through 1987 largely due to changing energy prices. In summary, largely on the basis of empirical evidence, the first difference of commodity prices is specified as a regressor for the acceleration of inflation.

The study of the impact of wages on inflation begins with the Phillips Curve. Due to the assumption of markup pricing, the Phillips curve evolved from a relation between wage changes and unemployment to price changes and unemployment. As was mentioned above, Phillips (1959) and Lipsey (1959) did not feel that a reliable link existed between wage changes and inflation. R. A. Gordon (1972) concluded that a weak link existed, and Eckstein and Girola (1978) incorporated markup pricing directly into their models. More recently, R. J. Gordon (1985) concluded "wage and price markup equations cannot be distinguished as truly structural equations applying to behavior in particular markets." In that paper, R. J. Gordon focuses on price changes because it gave better empirical results. In a later paper, R. J. Gordon (1988) went further by saying "wage changes do not contribute statistically to the explanation of inflation." He did, however, comment that labor costs affect labor's income share. What can be concluded from these studies is that there may be some relation between prices and wages, but the precise link is in doubt. As a graphic illustration, Figure 3 shows the path of the price level and average weekly wages for manufacturing for the 1947 to 1991 period. The two series have a simple correlation of .9986. Because of such a high correlation between wages and prices, the specification for wages on prices is to regress the acceleration of prices on the acceleration of wages. It is felt that this specification will capture the wage adjustments in the short-run. Also, the second order effects have not been explored before (at least this author

FIGURE 3


1.50
1.25
1.00
0.75
0.50
0.25
Price Level ('82 $s)
500
400
300
200
100
Avg. Weekly Wages (Manufct)
W
P
1955
1960
1965
1970
1975
1980
1985
1990
Time

has not seen such an examination), so the results should prove interesting.

The effect of exchange rates on inflation is relatively straightforward. An example of incorporating foreign exchange rates in a study of inflation is given by R. J. Gordon (1985) where exchange rate movements were included in his vector of "supply shocks." R. J. Gordon found that a rising dollar in 1976 helped keep inflation low and a falling dollar helped raise inflation in 1977 and 1979, which is consistent with the impact of changing exchange rates on export and import prices. Without delving too much into the vast area international finance, the specification of exchange rate movements for this study derives from the purchasing power parity identity:

$$E = P_f/P \qquad (4)$$

where E is the exchange rate value of the dollar, Pf is the foreign price level, and P is the domestic price level. After taking the natural logarithm of both sides and two time derivatives, it can be shown:

$$e = p_f - p \qquad (5)$$
$$e' = p_f' - p' \qquad (6)$$
$$e'' = p_f'' - p'' \qquad (7)$$

where lower case variables are the logs of the upper-case counterparts and the primed and double primed variables represent single and double time derivatives respectively. Equation 7 shows that the acceleration of the exchange rate is related to the acceleration of prices. R. J. Gordon (1985) showed that the direction of causality is from the exchange rate to inflation and not vice-versa. Therefore, the specification for this model is to regress the acceleration of prices on the acceleration of the exchange rate.

Inflationary expectations are treated very straightforwardly as well. Rea (1983) uses an adaptive expectations relation derived from Sargent (1976) of the form:

$$i_e = ki_{e(-1)} + (1-k)i_{-1} \quad (8)$$

where expected inflation is dependent on the weighted average of previous expected inflation and previous actual inflation. By taking a first difference, it can be shown:

$$di_e = kdi_{e(-1)} + (1-k)di_{-1} \quad (9)$$

For this study, the change in inflation is regressed upon the change in expectations as derived from equation 9.

IV. Sources of Data and Methodology

Before showing some regression results, a few notes are in order about the nature of the data and the methods used in this study. The price level series is the quarterly series of the GNP implicit price deflator from the Survey of Current Business in 1982 dollars. The GNP figures are also quarterly from the same source as the price series. The money supply series uses the M2 monetary aggregate. It consists of average quarterly levels derived from monthly average figures from the Federal Reserve Bulletin . Prior to the redefinition of the monetary aggregates in 1980, quarterly figures of the old M3 aggregate were computed and then adjusted to correspond to the redefined M2 aggregate to create a continuous series. Long-term series supplied in the Economic Report of the President helped in the adjustment of the money supply series as well as the price and GNP series. The long-run price equilibrium variable, P*, is computed as P*=(MV*)/Q*. The money stock is the M2 aggregate. V* is the average velocity over the period of the study (1955:1 to 1988:4). It was computed as 1.647. Potential output, Q*, is supplied by Hallman, Porter, and Small (1989).

Commodity prices are quarterly averages derived from monthly averages from the Commodity Yearbook published annually by the Commodity Research Bureau (CRB). The five commodities used in this study are crude oil, cotton, copper, lumber, and scrap steel. These five commodites were chosen because they are basic industrial commodities. Each one is close to the beginning of the production chain for many products (lumber for housing and paper, crude oil for energy and chemicals, etc.). Goods production that utilizes these commodities makes up a very high percentage of industrial production in the economy, so it is felt that price movements in these commodities will have the greatest effect on overall inflation. Food commodities (grain, livestock, etc.) were not included because they make up a small portion of the price deflator index and the choice of commodites and their relative importance to the economy is not easily available. All prices are spot prices (as opposed to futures prices). The price data was supplemented by cash quotes from the Wall Street Journal for those periods where price data was lacking. In addition, appendix A describes how these five commodities are combined into a commodity price index (CXI) that is also used. The wage series are quarterly averages of average weekly earnings for manufacturing workers. The data is from Earnings and Employment supplemented by the Monthly Labor Review. The exchange rate series is a trade weighted index of the dollar against ten foreign currencies. The series is from the Federal Reserve Bulletin. An adjustment was made to the series to account for the currency reform of the french franc in 1960.

The method used for the various regressions was ordinary least-squares regressions of the form

$$DI_t = a(p_{t-1} - p^*_{t-1}) + \sum_{j=1}^{4} b_j DI_{t-j} + \sum_{j=0}^{4} c_j Dd_{t-j} \qquad (10)$$

where d is the non-monetary disturbance and a, b, and c are constants. Four lags were chosen for each disturbance to correspond with the number of lags in the basic price-gap model. The fact that most pricing decisions are based on year-over-year comparisons was also motivation for the choice of four lags. A total of nine sets of regressions were run with the first regression being of the form of equation 10 with the concurrent disturbance and four lags used and with a second regression run using only the two most significant lags of the disturbance. Table 4 shows the definitions of variables used in the regressions and how they are computed from the raw data described above.

TABLE 4

1: $Di_t = i_t - i_{t-1}$ where
$i_t = \ln(P_t) - \ln(P_{t-1})$ where P is the price level as measure by the GNP implicit price deflator. (1982 dollars)

2: $Doi_t = \ln(OI_t) - \ln(OI_{t-1})$ where OI is the quarterly average spot crude oil price.

3: $Dlu_t = \ln(LU_t) - \ln(LU_{t-1})$ where LU is the quarterly average spot lumber price.

4: $Dct_t = \ln(CT_t) - \ln(CT_{t-1})$ where CT is the quarterly average spot cotton price.

5: $Dcu_t = \ln(CU_t) - \ln(CU_{t-1})$ where CU is the quarterly average spot copper price.

6: $Dst_t = \ln(ST_t) - \ln(ST_{t-1})$ where ST is the quarterly average price of scrap steel.

7: $Dcxi_t = \ln(CXI_t) - \ln(CXI_{t-1})$ where CXI is quarterly average of a commodity index of 5 spot commodities. See Appendix A for details.

8: $D^2w_t = Dw_t - Dw_{t-1}$ and
$Dw_t = \ln(W_t) - \ln(W_{t-1})$ where W is the quarterly average weekly earnings for manufacturing.

9: $D^2e_t = De_t - De_{t-1}$ and
$De_t = \ln(E_t) - \ln(E_{t-1})$ where E is the quarterly average of the dollar index which is a trade weighted index of 10 foreign currencies.

10: $Di_{*(t)} = ki_{*(t-1)} + (1-k)i_{t-1}$ where
Di_* is the change in expected rate of inflation. See Appendix B for details.

From the results of the nine regression sets, a general model that combines all four major disturbances, (commodities, wages, exchange rates, and expectations) is run. A second general model derived from the first one is also run excluding insignificant factors. The general models also include a dummy variable that accounts for the Nixon price controls. The dummy variable is identical to that used by

Hallman, Porter, and Small (1989). In brief, the dummy variable PC is computed from the difference of two other price control dummy variables PC1 and PC2. The dummy variable PC1 represents phases I and II of the price controls and has value of 1 from 1971:3 to 1972:4 and zero otherwise. Likewise, PC2 represents phase III and has value of 1 from 1973:1 to 1974:4, zero otherwise. The difference, PC=PC1-PC2, takes values of 1 for 1971:3 to 1972:4, -1 for 1973:1 to 1974:4, zero otherwise. Hallman, Porter, and Small use statistical tests to support the specification that the difference between the two dummy variables PC1 and PC2 is the correct specification.

Lastly, the predictive power of the two general models is tested over the time period 1989:1 to 1992:1. Using actual values of the independent variables, a prediction series of price acceleration is computed and the actual series is then regressed against the predicted series to analyze the effectiveness of the prediction. In addition, comparisons are made between the actual and predicted price levels and the levels of inflation.

The next chapter describes in a little more detail the various regressions that were run and their results. In addition to the coefficient estimates, statistical tests were run to check for significance of the individual coefficients, goodness-of-fit of the overall model, existence of autocorrelation and heteroscedasticity, and a Chow test for stability of the coefficients.

V. Regression Results

A summary of the results from the regressions discussed above is given in Table 5. First, for comparison purposes, a duplication of the basic price-gap model used by the Fed study is performed. The next five sets of regressions show the extended price-gap model for five individual commodities. The next four sets of regressions show the extended price-gap model for general non-monetary disturbances of wages, foreign exchange rates, expectations, and a commodity price index. Note that t-statistics for the coefficients are given in parentheses. Summary statistics are given for each regression for various statistical tests. These indicate the explanatory power of the regression (adjusted R^2), the overall significance of the regression (F-statistic), a test for first-order autocorrelation (Durbin's h-statistic), a test for heteroscedasticity, and a test for stability of the coefficients (Chow Test). General observations are given next and a more thorough treatment of the statistical tests follows. It should be noted that the time period under study is from 1955:1 to 1988:4, except for regressions that include foreign exchange rate variables in which case the period is from 1960:1 to 1988:4.

A perusal of the commodity extended price-gap regressions shows that, with the exception of lumber, the explanatory power of the model as measured by the adjusted coefficient of determination was increased somewhat. However, few of the variables were significant at the 5% level. Even in the second-run cases, only the cotton variables and

TABLE 5

Dependent Variable: Di_t

Variable	Fed-study Coefficients	Variable	First-run Coefficients	Second-run Coefficients
$pgap_{t-1}$	-.0312 (3.62)*	$pgap_{t-1}$	-.0351 (3.89)*	-.0350 (4.08)*
Di_{t-1}	-.7332 (8.65)*	Di_{t-1}	-.7531 (8.70)*	-.7602 (9.04)*
Di_{t-2}	-.5449 (5.46)*	Di_{t-2}	-.5843 (5.74)*	-.5872 (5.90)*
Di_{t-3}	-.3577 (3.63)*	Di_{t-3}	-.4051 (4.04)*	-.4061 (4.12)*
Di_{t-4}	-.1121 (1.38)	Di_{t-4}	-.1427 (1.73)	-.1446 (1.79)
- - -	- - -	Doi_t	.0075 (1.34)	.0058 (1.19)
- - -	- - -	Doi_{t-1}	-.0044 (0.70)	- - -
- - -	- - -	Doi_{t-2}	.0142 (2.20)*	.0111 (2.20)*
- - -	- - -	Doi_{t-3}	-.0033 (0.49)	- - -
- - -	- - -	Doi_{t-4}	-.0028 (0.47)	- - -
Adj. R^2	.362	Adj. R^2	.374	.384
F-Statistic	20.12	F-Statistic	9.955	15.05
Durbin's h-stat	-.1640	Durbins h-stat	.0678	1.739
Heteroscedasticity	.1710	Heteroscedasticity	.0679	.1085
Chow Test	0.475	Chow Test	1.666	1.951

Dependent Variable: Di_t

Variable	First-run Coefficients	Second-run Coefficients	Variable	First-run Coefficients	Second-run Coefficients
$pgap_{t-1}$	-.0351 (3.64)*	-.0339 (3.83)*	$pgap_{t-1}$	-.0309 (3.64)*	-.0307 (3.66)*
Di_{t-1}	-.7330 (8.51)*	-.7266 (8.50)*	Di_{t-1}	-.7435 (8.75)*	-.7394 (8.93)*
Di_{t-2}	-.5427 (5.37)*	-.5448 (5.45)*	Di_{t-2}	-.5528 (5.56)*	-.5480 (5.62)*
Di_{t-3}	-.3749 (3.74)*	-.3744 (3.75)*	Di_{t-3}	-.3939 (3.98)*	-.3844 (3.97)*
Di_{t-4}	-.1360 (1.64)	-.1167 (1.44)	Di_{t-4}	-.1053 (1.29)	-.1019 (1.27)
Diu_t	-.0041 (0.87)	-.0044 (0.95)	Dct_t	-.0025 (0.57)	- - -
Diu_{t-1}	-.0044 (0.94)	- - -	Dct_{t-1}	.0087 (1.91)	.0083 (2.00)*
Diu_{t-2}	.0042 (0.88)	- - -	Dct_{t-2}	.0008 (0.17)	- - -
Diu_{t-3}	-.0049 (1.03)	-.0046 (0.99)	Dct_{t-3}	.0006 (0.12)	- - -
Diu_{t-4}	-.0033 (0.70)	- - -	Dct_{t-4}	.0101 (2.25)*	.0106 (2.55)*
Adj. R^2	.358	.361	Adj. R^2	.382	.394
F-Statistic	9.381	13.73	F-Statistic	10.26	15.61
Durbin's h-stat	1.803	1.352	Durbins h-stat	-.7501	-.6253
Heteroscedasticity	.0112	.0024	Heteroscedasticity	.5509	.6159
Chow Test	1.704	1.806	Chow Test	1.644	1.741

Note: $pgap_t = (p_t - p^*_t)$

*: significant at 5% level (critical t-value of 1.98)

Dependent Variable: Di_t

Variable	First-run Coefficients	Second-run Coefficients	Variable	First-run Coefficients
$pgap_{t-1}$	-.0288 (3.21)*	-.0279 (3.24)*	$pgap_{t-1}$	-.0248 (3.00)*
Di_{t-1}	-.7678 (8.84)*	-.7620 (9.00)*	Di_{t-1}	-.8116 (9.46)*
Di_{t-2}	-.5889 (5.76)*	-.5794 (5.76)*	Di_{t-2}	-.6529 (6.45)*
Di_{t-3}	-.4080 (4.07)*	-.4051 (4.08)*	Di_{t-3}	-.4707 (4.73)*
Di_{t-4}	-.1379 (1.67)	-.1253 (1.56)	Di_{t-4}	-.2113 (2.61)*
Dcu_t	-.0030 (0.57)	- - -	Dst_t	-.0062 (2.72)*
Dcu_{t-1}	-3.E-5 (0.00)	- - -	Dst_{t-1}	.0038 (1.65)
Dcu_{t-2}	.0096 (1.41)	.0116 (1.94)	Dst_{t-2}	.0048 (2.09)*
Dcu_{t-3}	-.0061 (0.89)	- - -	Dst_{t-3}	.0083 (3.60)*
Dcu_{t-4}	-.0070 (1.09)	.0084 (1.41)	Dst_{t-4}	.0057 (2.47)*
Adj. R^2	.370	.380	Adj. R^2	.449
F-Statistic	9.814	13.73	F-Statistic	13.24
Durbin's h-stat	1.502	1.352	Durbins h-stat	1.012
Heteroscedasticity	.0036	.0024	Heteroscedasticity	.2274
Chow Test	1.819	1.806	Chow Test	1.299

Dependent Variable: Di_t

Variable	First-run Coefficients	Second-run Coefficients	Variable	First-run Coefficients	Second-run Coefficients
$pgap_{t-1}$	-.0300 (3.53)*	-.0285 (3.66)*	$pgap_{t-1}$	-.0286 (3.50)*	-.0296 (3.60)*
Di_{t-1}	-.8071 (9.41)*	-.7925 (8.93)*	Di_{t-1}	-.7217 (8.33)*	-.7468 (9.09)*
Di_{t-2}	-.6736 (6.53)*	-.6404 (5.62)*	Di_{t-2}	-.5453 (5.50)*	-.5737 (5.95)*
Di_{t-3}	-.4634 (4.58)*	-.4376 (3.97)*	Di_{t-3}	-.3183 (3.26)*	-.3285 (3.47)*
Di_{t-4}	-.2094 (2.50)*	-.1822 (1.27)	Di_{t-4}	-.1088 (1.34)	-.1445 (1.81)
$Dcxi_t$	-.0120 (1.59)	.0126 (1.75)	D^2w_t	.0563 (1.87)	- - -
$Dcxi_{t-1}$	-.0006 (0.07)	- - -	D^2w_{t-1}	.1129 (3.01)*	.0791 (3.00)*
$Dcxi_{t-2}$	.0162 (2.15)*	.0162 (2.20)*	D^2w_{t-2}	.0965 (2.44)*	.0760 (2.47)*
$Dcxi_{t-3}$	.0127 (1.66)	.0146 (1.95)	D^2w_{t-3}	.0976 (2.55)*	.0852 (3.29)*
$Dcxi_{t-4}$	.0100 (1.34)	- - -	D^2w_{t-4}	-.0167 (0.54)	- - -
Adj. R^2	.414	.414	Adj. R^2	.429	.421
F-Statistic	11.59	14.65	F-Statistic	12.28	15.02
Durbin's h-stat	18.84	.5399	Durbins h-stat	N/A	1.592
Heteroscedasticity	.1235	.5723	Heteroscedasticity	.5520	.2886
Chow Test	1.613	1.737	Chow Test	1.898	12.33

Note: $pgap_t = (p_t - p*_t)$

*: significant at 5% level (critical t-value of 1.98)

Dependent Variable: Di_t

Variable	First-run Coefficients	Variable	First-run Coefficients	Second-run Coefficients
$pgap_{t-1}$	-.0296 (3.41)*	$pgap_{t-1}$	-.0287 (3.35)*	-.0289 (3.41)*
Di_{t-1}	-.7387 (8.72)*	Di_{t-1}	-.6692 (7.28)*	-.6777 (7.49)*
Di_{t-2}	-1.051 (2.66)*	Di_{t-2}	-.5280 (4.97)*	-.5387 (5.15)*
Di_{t-3}	-.6047 (2.87)*	Di_{t-3}	-.2700 (2.53)*	-.2739 (2.59)*
Di_{t-4}	-.2197 (1.91)	Di_{t-4}	-.1863 (2.03)*	-.1979 (2.19)*
$Di_{*(t-1)}$	1.173 (1.32)	D^2e_t	-.0086 (0.61)	- - -
- - -	- - -	D^2e_{t-1}	.0077 (0.48)	- - -
- - -	- - -	D^2e_{t-2}	.0055 (0.33)	- - -
- - -	- - -	D^2e_{t-3}	.0265 (1.59)	.0237 (1.72)
- - -	- - -	D^2e_{t-4}	.0243 (1.59)	.0216 (1.54)
Adj. R^2	.365	Adj. R^2	.341	.351
F-Statistic	16.54	F-Statistic	7.60	11.39
Durbin's h-stat	1.567	Durbins h-stat	.1570	.3790
Heteroscedasticity	.0170	Heteroscedasticity	.0026	.0036
Chow Test	2.346	Chow Test	0.626	0.782

Dependent Variable: Di_t

Variable	First-run Coefficients	Second-run Coefficients
$pgap_{t-1}$	-.0289 (3.64)*	-.0280 (3.59)*
Di_{t-1}	-.7983 (8.96)*	-.7853 (9.12)*
Di_{t-2}	-.4664 (0.76)	-.6711 (6.69)*
Di_{t-3}	-.2367 (2.53)*	-.3559 (3.55)*
Di_{t-4}	-.2434 (1.59)	-.3190 (3.77)*
$Dcxi_t$	.0062 (0.83)	.0094 (1.32)
$Dcxi_{t-2}$	.0052 (0.71)	- - -
$Dcxi_{t-3}$	.0113 (1.52)	.0134 (1.87)
D^2w_{t-1}	.0779 (2.70)*	.0824 (2.98)*
D^2w_{t-2}	.0901 (2.64)*	.0862 (2.62)*
D^2w_{t-3}	.0833 (2.93)*	.0791 (2.90)*
D^2e_{t-3}	.0188 (1.42)	- - -
D^2e_{t-4}	.0162 (1.24)	- - -
$Di_{*(t-1)}$	-.5065 (0.36)	- - -
PC	-.0037 (2.95)*	-.0039 (3.21)*
Adj. R^2	.471	.474
F-Statistic	8.32	11.38
Durbin's h-stat	.8122	.2428
Heteroscedasticity	.3478	.5498
Chow Test	1.156	1.298

Note: $pgap_t = (p_t - p*_t)$

*: significant at 5% level (critical t-value of 1.98)

one of the crude oil variables were significant. In many instances, the coefficients had the wrong sign, though most of these had the expected sign with the second run. It was interesting to note that the impact of steel prices was relatively high. The regression had a much higher explanatory power; 45% versus an average of 38% for the others; and all but one of the variables were significant. A possible reason for this is the sensitivity of scrap steel prices to aggregate supply and demand shifts in the economy. This effect is so strong that the Wall Street Journal (April 27,1992) reported that many forecasters have incorporated movements of scrap steel prices into their analysis. It was felt that a second run for this specification was not needed given the better results of the first. It is actually not completely surprising that the individual commodities do not contribute much to the overall explanatory power of the model. Though each commodity was chosen as to be as close to the beginning of the production chain for a wide range of products (lumber for housing and paper, crude oil for energy and chemicals, etc.), individually, they do comprise a small portion of the total output of the economy.

Similar results were also observed for the extended price-gap model for the four non-monetary disturbances. The results were generally better than for the individual commodity cases. The critical t-value for a one-tailed test at 5% significance is 1.66, so many more of the variables were significant. The second-run of the wage extended price-gap regression was particularly noteworthy with very significant variable and a relatively high explanatory power. The expectations regression did not turn out as well as expected. Indeed the coefficient of greater than unity is inconsistent with theory which would suggest that a gradual adaptation of inflationary expectations would be less than actual experience. Also notice that the coefficient on the second lagged dependent variable is significantly different than prior results. It could very well be that the construction of the expectations series is causing more distortion than expected. In fact, it was not possible to include more than a single lag in the regression because it would give a near singular matrix in the computation.

The general model was constructed using the variables from the second-run regressions from the four major disturbances described above. At this point, a price control dummy variable was also included. As before, a second regression of the general model was performed using significant variables obtained after the first run. The results generally turned out very well with most variables being significant and an adjusted R^2 of about 47% for both models. It is interesting to note that the expectations variable lost statistical significance and its coefficient had the wrong sign. Also, the lagged dependent variables did not show significant deviation leading one to conclude that the expectations series is improperly constructed or yields no added benefit to this model specification.

The F-test for overall goodness-of-fit of the models shows that all models are good. The smallest F-statistic for any of the regressions is 7.6 while the critical F-value at a 5% significance level is around 3.9. This situation is expected because even the basic price-gap model has a good fit, therefore any extended model could be expected to perform as well.

The test for first-order autocorrelation was conducted using the Durbin's h-test. The h-statistic can be derived from the

Durbin-Watson statistic. For large samples, the h-statistic is approximately normally distributed with variance of unity. At a 5% level of significance, the critical h-value is 1.64 under a null hypothesis of no first-order autocorrelation. Many of the regressions showed no autocorrelation. The first run of the lumber extended model showed autocorrelation and the first run of the extended model using the commodity index showed definite autocorrelation (with h=18). However, upon respecification, the autocorrelation was corrected. Only the second-run oil extended model showed some autocorrelation, but this may possibly be due to a misspecification. For all models, no autocorrelation was expected due to the use of first and second differences. In fact, Hallman, Porter, and Small (1989) specifically chose the price-gap model specification in order to avoid autocorrelation. It should be noted that for four of the regressions, a shortened sample period had to be used to compute the h-statistic. These were for the first-run commodity models using oil, lumber, copper, and scrap steel. The h-statistic can be approximated from the Durbin-Watson statistic from the formula

$$h = (1 - D/2)\frac{N^{.5}}{(1 - N\,\mathrm{var}(b_J))^{.5}} \qquad (11)$$

where D is the Durbin-Watson statistic, N is the number of observations, and $\mathrm{var}(b_J)$ is the variance of the coefficient of the first lagged dependent variable. A shortend interval (1960:1 to 1988:4) had to be used so the denominator in equation 10 is positive.

The test for heteroscedasticity was done by computing a statistic from the regression residuals and predicted values. The square of the residuals was regressed against the predicted values of the dependent variable. The statistic is then computed as nR^2 where n is the number of observations and R^2 is the coefficient of determination of the auxiliary regression. The statistic has a chi-squared distribution with one degree of freedom, a critical value of 3.84 at the 5% level of significance, under a null hypothesis of no heteroscedasticity. None of the regressions exhibited heteroscedasticity.

An explicit test for multicollinearity is detailed in Appendix C. The appendix shows the correlation matrix for the variables used in the general model and t-values for possible multicollinearity. The t-values show that the expectations variable exhibits collinearity with the first and second lagged dependent variable. This is the source of the distortion mentioned above showing that the expectations variable, as it is presently constructed, is not useful.

A test for stability of the coefficients was conducted using a Chow Test. The regression was run twice over each half of the sample period and the sum-of-squares of the residuals from each subperiod and the entire period was combined to form an F-statistic under a null hypothesis of no structual change. The critical value for this test is about 2.0 to 2.3 depending on the number of independent variables. None of the regressions showed structural change except for the second-run of the wage extended model. The nature of this change is unclear and further research is needed to answer this question.

The next chapter gives the results of a simulation of the general model to test its predictive capability. The first-run version of the general model is not tested due to the presence of multicollinearity. Only the predictive power of the second-run model is tested because it has no statistical shortcommings.

VI. Simulation Results

As was mentioned above, a simulation of the general model was conducted to test its predictive power. Values of the independent variables were known for the time period 1989:1 to 1992:1. This period encompasses the period immediately after the period under study (1955:1 to 1988:4) up through the latest quarter for which data is available. From this data, a predicted series, Di_p, was computed using the coefficient estimates for the general model specification from the preceding chapter. In addition to computing the acceleration series, a quarterly inflation series was computed as:

$$i_{p(t)} = i_{p(t-1)} + Di_{p(t)} \qquad (12)$$

To test the predictive power of both series, the actual values were regressed against the predicted values. It is expected that a good simulation will have a near zero or insignificant intercept and a near unity and significant slope. The results are presented below.

Results of the acceleration and inflation versions of the first-run general model are given below in the form of a table containing actual and predicted values. Note that t-statistics are given in parentheses:

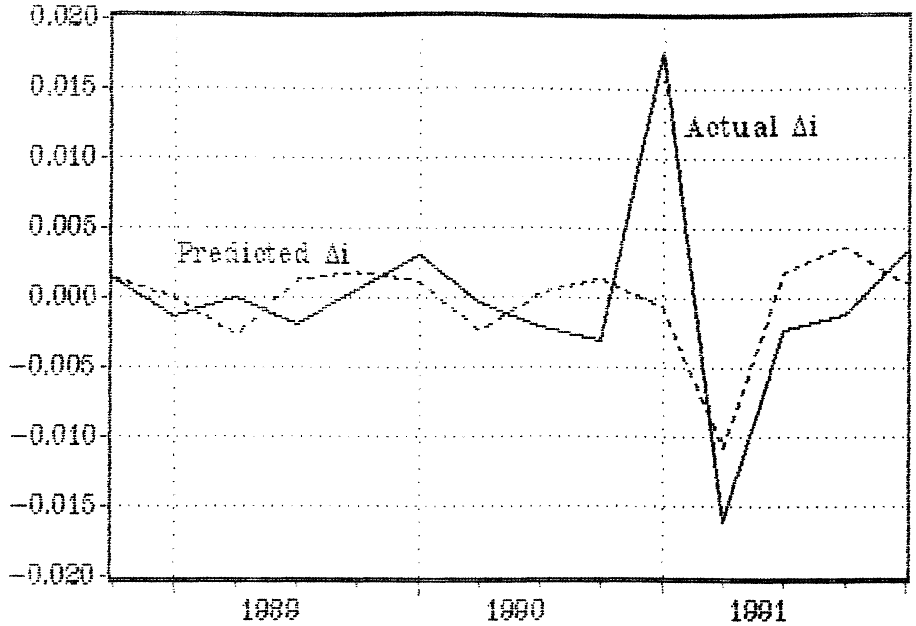
$$Di = -.0004 + .9194Di_p$$
$$(.21) \quad (1.92)$$
$$R^2 = .182$$

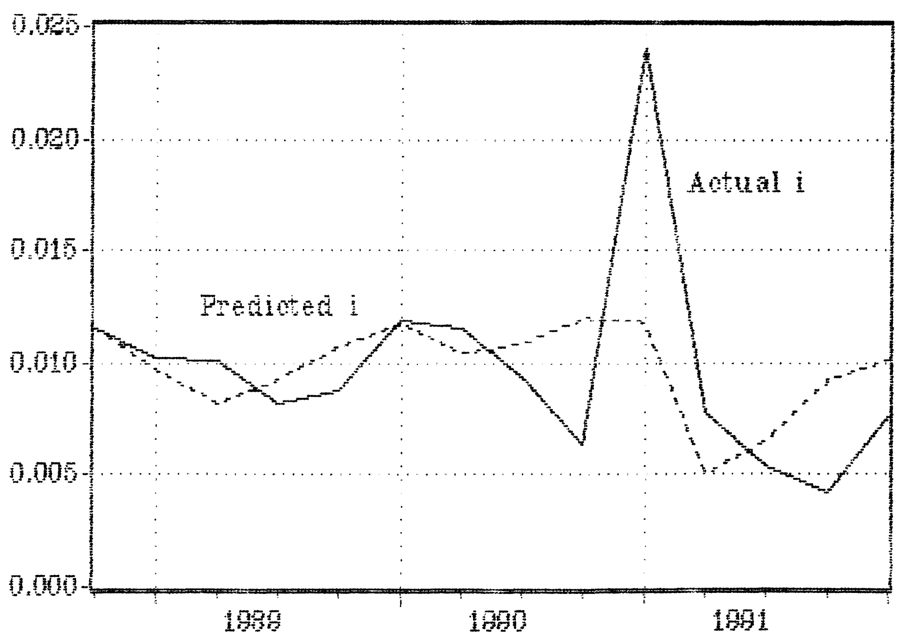
$$i = .0025 + .5998i_p$$
$$(.53) \quad (1.56)$$
$$R^2 = .107$$

T	Actual	Predicted	Error	T	Actual	Predicted	Error
89:1	-.00142	-7.9E-6	-.00141	89:1	.01017	.00971	.00046
89:2	-2.3E-5	-.00271	.00269	89:2	.01015	.00819	.00195
89:3	-.00199	.00125	-.00324	89:3	.00815	.00926	-.00111
89:4	.00064	.00185	-.00122	89:4	.00879	.01072	-.00193
90:1	.00309	.00119	.00191	90:1	.01188	.01175	.00013
90:2	-.00037	-.00246	.00210	90:2	.01152	.01040	.00112
90:3	-.00210	.00029	-.00238	90:3	.00942	.01084	-.00142
90:4	-.00309	.00136	-.00445	90:4	.00633	.01198	-.00565
91:1	.01772	-.00061	.01833	91:1	.02405	.01183	.01222
91:2	-.01624	-.01081	-.00542	91:2	.00782	.00503	.00279
91:3	-.00237	.00188	-.00425	91:3	.00544	.00651	-.00106
91:4	-.00118	.00375	-.00493	91:4	.00426	.00920	-.00494
92:1	.00328	.00099	.00228	92:1	.00754	.01011	-.00257
	RMS error = .005998				RMS error = .00424		

Figure 4 gives graphical representations of the above data. One notices that the acceleraton series gives a reasonably goo approximaton of te actual accelration series with the exception of the inflation spike in 1991:1 caused by an oil "supply shock" brought on by the Persion Gulf crisis. The coefficient from the regression are as expected with an insignificant intercept term and a slope of .92 which is close to unity. The t-value of the slope coefficient of 1.92 is significant at the 8.2% level which is significant given a 10% standard. Also, to test whether the slope coefficent is statistically equivalent to unity, a t-value of .168 can be computed from the standard error of the slope coefficient. This is less than the critical value of 1.66 at 10% significance, so the null hypothesis of the slope equal to unity cannot be rejected. Therefore, one must conclude that the slope is equivalent to unity. Results for the inflation series, however, are not as good. While the intercept coefficient turned out as expected, the slope coefficient of about .60 is much lower than unity to any reasonable approximation. The t-value of the slope coefficient of 1.56 is significant at the

FIGURE 4


0.020
0.015
0.010
0.005
0.000
−0.005
−0.010
−0.015
−0.020
Actual Δi
Predicted Δi
1989
1990
1991


0.025
0.020
0.015
0.010
0.005
0.000
Actual i
Predicted i
1989
1990
1991

14.7% level; these results are inferior to the acceleration results.

It should be noted that because of such a small sample size (13 data points) a detailed statistical analysis is limited. However, some observations can be made. In all simulations, the models fail to capture the inflation spike in 1991:1 brought on by the Persian Gulf crisis. During that time period, oil prices just about doubled which caused a spike in the commodity price index. It was expected that the model would be able to account for the oil shock by the inclusion of the commodity variable. It did not. It may be that the model estimates may respond too slow to sudden surges in some of the variables (i.e. the commodity index) or that uncertainty surrounding the Persian Gulf crisis may yield some non-quantitative effects requiring the use of dummy variables. Further study would have to be done to test this hypothesis. It is conceivable that the presence of the inflation spike could be overwhelming the results of these simulations. As the following table shows, the RMS error values do improve significantly when computed for just the first eight predictions.

	RMS error values	
	all observations	first 8 obs.
acceleration	.005999	.00262
inflation	.00424	.00235

The first eight values were chosen because a significant error would feed through to the later values due to the presence of lagged dependent variables in the model.

More general conclusions concerning the analysis given in this chapter and previous ones are given in the next chapter.

VII. Conclusions

Several conclusions can be drawn from the analysis presented in this study. In addition to those which have already been mentioned, others will be included in this chapter. Also, areas of further research will also be discussed.

The results presented in chapter IV suggest that the basic price-gap model can be improved upon in the short-term by the inclusion of other relevant disturbances. The overall explanatory power of the model was improved from approximately 33% to approximately 47% of total variation. Disturbances which seem to have the most effects are changes in commodity prices and money wage disturbances. Exchange rate disturbances had mild significance while expectations had none.

For commodities, the first difference seems to hold some explanatory power. However, as the simulation results show, this specification may be incorrect or incomplete. It may be that a second difference of commodity prices may be needed in order to capture the "suddeness" of a supply shock. This seems reasonable given that a smoothly trending price path would have small second difference values, except during those times when prices are surging as during a supply shock. Another factor may be that uncertainty surrounding the cause of the supply shock (such as the Persian Gulf crisis) may yield non-quantitative effects on prices requiring the ad hoc use of dummy variables. The significance of the commodity price variable lagged two and three quarters suggest that movements in commodities take about six to nine months to work through the economy and show up as changes in prices. This is reasonable given the time it takes for production and pricing decisions to be formed and passed along from the commodity producers to end users.

The high significance of the acceleration of wages is of particular note. Many studies have shown that wages and prices- both levels and rates of change- are highly correlated. The results here which show a relationship between second differences in wages and prices suggest that the wage-price relationship may be deeper than previously examined in the literature. For this study, it is noteworthy that only wage acceleration lagged one, two, and three quarters, and not the concurrent wage acceleration, was significant in explaining price acceleration. The reverse may also be true, but that was not examined here. This result also shows that wage disturbances take time to work through the economy.

The lack of meaningful significance for the exchange rate disturbances may be explained by the fact that I do not believe that import prices are incorporated into the implicit price index. If this is true, then exchange rate disturbances would have to be of a second-hand variety- showing up in domestic prices for those goods that compete with imports. Exchange rates may have greater impact if a price index that included imports (fixed-weight deflator, consumer price index, etc.) is used. The greater significance of the third and fourth lag suggests an even greater time period for exchange rate disturbances to work through the economy into prices.

The expectations disturbances did not yield good results, and gave more distortion in the results than actual explanatory power. As was mentioned, the construction of the series did yield collinearities with the lagged dependent variables that biased the results. It may be that the lagged dependent variables themselves capture the inertia of short-term changing expectations.

There are many topics for further study. The first is an examination of the effect of commodity supply shocks by including a second difference of the commodity price index. This may help capture some of the inertia displayed by the simulation model. A further examination of the wage-price relationship using the acceleration (second log differences) of the variables as opposed to levels or rates of change (first log differences). Other non-monetary disturbances that could be looked into are changes in sales and excise taxes and rational expectations (that is expectations formed by all available information) as opposed to adaptive expectations. Some or all of these specifications may improve the extended price-gap model to beyond that given in this study.

Overall, this study shows that the price-gap model not only has long-term explanatory power but also is flexible enough to be adapted to short-term work. It may be that the price-gap model is the next step in the evolution of the study of inflation.

Appendix A: Construction of the Commodity Price Index

Construction of a commodity price index can be accomplished by one of two methods: an arithmetic average or a geometric average. An arithmetic average could simply be a weighted or unweighted sum of the index components divided by a divisor. The divisor could be chosen so the index could be a standard value (say 100) in some base year. The major drawback to an arithmetic index is that high priced components tend to dominate the movement of the index over the smaller priced components unless weighted properly. A geometric average would not have this problem as each component would be divided by a base value and then weighted. For this study, the geometric approach was used.

The CXI (commodity index) is a geometrically weighted average of the five spot commodities; crude oil, cotton, copper, lumber, and scrap steel. The index is constructed so that the 1967 average is 100. The index is constructed as:

$$CXI = 100\ P\ (C_i/C_o)^{w_i}$$

where P is a product operator, C_i is the commodity price, C_o is the 1967 average price of the commodity, and wi is the weight of the component in the index. The base prices of the five commodities are:

Commodity	1967 average
Oil	$3.02/barrel
Lumber	$85.53/1000 board feet
Cotton	$.2307/pound
Copper	$.3793/pound
Scrap Steel	$27.96/ton

The weights of the components were derived from their usage in the industrial production index as published by the Federal Reserve. Each major industry group was grouped with that commodity which provides the major source of raw material to that industry. For example, paper products are combined with lumber products to weigh lumber in the index. Below is a list of the major industry groups, their 1967 proportions in the industrial production index, and to which commodity they are attached.

Oil	
Oil and gas extraction	(4.40)
Chemical products	(7.74)
Petroleum products	(1.79)
Rubber and plastic products	(2.24)
Transportation equipment	(9.27)
Total	25.44

Lumber	
Paper products	(3.21)
Printing and publishing	(4.72)
Lumber products	(1.64)
Furniture and fixtures	(1.37)
Total	10.94

Cotton	
Textile products	(2.68)
Apparel products	(3.31)
Total	5.95

Copper & Steel	
Metal mining	(0.51)
Primary metal products	(6.57)
Fabricated metal products	(5.93)
Nonelectrical machinery	(9.15)
Electrical machinery	(8.05)
Total	30.21

Sum of totals = 72.54

unused			
Coal mining	(0.69)	Leather products	(0.86)
Stone and earth minerals	(0.75)	Ordnance	(3.64)
Foods	(8.75)	Instruments	(2.11)
Tobacco products	(0.67)	Miscellaneous	(1.51)
Clay, glass, stone products	(2.74)		

The weights in the index are then computed from the commodity totals divided by the sum of the used proportions. Note that the weight for copper and steel is divided equally between the two.

Commodity	Weight
Oil	.351 = 25.44/72.54
Lumber	.151 = 10.94/72.54
Cotton	.082 = 5.95/72.54
Copper	.208=>
Scrap Steel	.208=> .416 = 30.21/72.54

As can be seen, the CXI is heavily weighted in metals and energy and should accurately reflect the relative importance of each of the commodities in the U.S. economy.

Appendix B: Derivation of Expectations Parameter

As mentioned in the text, the expectations series was derived from the following equation:

$$i_* = k i_{*(-1)} + (1-k) i_{-1} \qquad \text{(B1)}$$

where i_* is the expected rate of inflation, i is the actual rate of inflation, and k is the parameter that will be derived here. The model from which this relationship is derived is an Accelerationist model used by Rea (1983) in his comparison study of inflation models. The Accelerationist model used was derived from Sargent (1976) and consists of equation B1 and

$$U = b_0 - b_1(i - i_*) + b_2 U_{-1} \qquad \text{(B2)}$$

where U is the unemployment rate, and i is actual inflation, and i_* is as computed from equation B1. For empirical purposes i_* is unobservable and some manipulation is required to actually estimate the model. By taking a Koyck transformation of equation B2 and substituting B1, the following can be derived:

$$U = b_0(1-k) - b_1(i - i_{-1}) + (k+b_2)U_{-1} - b_2 k U_{-2} \qquad \text{(B3)}$$

which Rea (1983) estimated as

$$U = .26 - .30(i - i_{-1}) + 1.42U_{-1} - .48U_{-2} \qquad \text{(B4)}$$

From this empirical estimate, a value of k can be derived. A comparison of B3 and B4 will reveal that

$$k + b_2 = 1.42 \qquad \text{(B5)}$$
$$k b_2 = .48 \qquad \text{(B6)}$$

By solving B6 for b_2 and substituting that into B5, the following quadratic can derived.

$$k^2 - 1.42k + .48 = 0$$

The solutions for this equation are $k=.555$ and $k=.865$.

Some value judgement is involved in deciding which parameter should be used. After some experimenting with both values, it was decided that $k=.555$ gave slightly better results, so that is the value used for this study. In addition to the parameter estimate, some initial expectation value must be chosen so that the series can be estimated. It was assumed that Di_e takes a value of zero at 1954:4. This is reasonable given the remarkable price stability in the years prior to that date.

Appendix C: Tests for Multicollinearity

The correlation matrix for the variables used in the general model is given in Table C1. The table gives simple correlation values and t-values in parentheses. The t-values were computed from the following formula:

$$t = \frac{r}{\frac{(1 - r^2)^{.5}}{(n - 2)^{.5}}}$$

An examination of the t-values does reveal several pairs of variables that have t-values that would reject the null hypothesis of no multicollinearity. However, not all of these pairs require the usual cures for multicollinearity- the dropping of variables, differencing, etc. Those variables that have high correlations with their own lagged values can be ignored as one would expect a time series variable to have high correlation with its own lags. All but two of the other variable pairs can, for all intents and purposes, can be considered not to have multicollinearity. Though the t-value cannot reject the null hypothesis, it is not felt that variables with a simple correlation of less .25 to be seriously linearly related to distort the regression results.

The only two pairs of variables that exhibit serious multicollinearity are the expectations variable with both the first and second lagged dependent variables. With correlations of .542 and .883 the expectations variable does have the potential to distort the results. An examination of the expectations extended price-gap model does, in fact, show significant distortion with the wrong sign on the expectations coefficient and significant distortion on the second lagged dependent coefficient.

In summary, the collinearities shown by rigorous hypothesis testing, with the exception of the expectations variable, do not seem to distort the regression results of this study and so will be ignored.

TABLE C1
Variable Correlation Matrix

	di	pgap (-1)	di (-1)	di (-2)	di (-3)	di (-4)	dcxi	dcxi (-2)	dcxi (-3)	d2w (-1)	d2w (-2)	d2w (-3)	d2e (-3)	d2e (-4)	die (-1)
di	1	-.14	-.42	-.10	.11	-.11	.18	.11	.01	.17	-.11	.14	.12	.03	-.06
		(1.51)	(4.93)	(1.04)	(1.18)	(1.19)	(1.94)	(1.14)	(.11)	(1.81)	(1.16)	(1.52)	(1.30)	(.32)	(.64)
pgap-1	-	1.00	-.08	-.07	-.07	-.03	-.15	-.07	.00	-.01	-.02	-.01	.01	.02	-.15
			(.87)	(.79)	(.77)	(.29)	(1.58)	(.77)	(.01)	(.14)	(.17)	(.12)	(.09)	(.21)	(1.59)
di-1	-	-	1.00	-.42	-.10	.11	.03	-.00	.11	-.03	.17	-.11	-.06	.12	-.54
				(4.91)	(1.07)	(1.18)	(.28)	(.04)	(1.14)	(.34)	(1.82)	(1.19)	(.64)	(1.28)	(6.89)
di-2	-	-	-	1.00	-.41	-.10	-.00	.18	-.00	-.05	-.02	-.17	.10	-.06	.88
					(4.86)	(1.13)	(.03)	(1.92)	(.01)	(.56)	(.26)	(1.83)	(1.02)	(.61)	(20.1)
di-3	-	-	-	-	1.00	-.42	-.16	.04	.18	-.08	-.03	-.03	-.15	.08	.00
						(4.90)	(1.75)	(.38)	(1.97)	(.89)	(.34)	(.36)	(1.59)	(.89)	(.00)
di-4	-	-	-	-	-	1.00	.24	.01	.03	.23	-.10	-.03	.01	-.15	-.12
							(2.60)	(.06)	(.32)	(2.53)	(1.09)	(.31)	(.15)	(1.58)	(1.31)
dcxi	-	-	-	-	-	-	1.00	.09	-.10	.15	-.18	.17	.22	.02	-.03
								(.95)	(1.12)	(1.65)	(1.98)	(1.89)	(2.43)	(.25)	(.33)
dcxi-2	-	-	-	-	-	-	-	1.00	.23	.10	-.03	.16	.06	.03	.22
									(2.47)	(1.04)	(.33)	(1.71)	(.62)	(.27)	(2.41)
dcxi-3	-	-	-	-	-	-	-	-	1.00	-.18	.10	-.03	.02	.06	.12
										(2.00)	(1.11)	(.32)	(.18)	(.65)	(1.30)
d2w-1	-	-	-	-	-	-	-	-	-	1.00	-.59	.18	-.03	.08	-.07
											(7.90)	(2.01)	(.28)	(.86)	(.77)
d2w-2	-	-	-	-	-	-	-	-	-	-	1.00	-.58	-.08	-.12	-.06
												(7.66)	(.81)	(1.29)	(.66)
d2w-3	-	-	-	-	-	-	-	-	-	-	-	1.00	.01	-.09	.16
													(.14)	(.93)	(1.72)
d2e-3	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-.33	.04
														(3.77)	(.40)
d2e-4	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-.05
															(.57)
die-1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00

References

Bahr, Richard; "Inflation Fueled by Oil Prices in First 9 Months of 1987", Monthly Labor Review ; December 1987.

Eckstein, Otto; Girola, James, A.; "Long-Term Properties of the "Price-Wage Mechanism in the United States, 1891 to 1977"; The Review of Economics and Statistics , Vol. 60; August 1978.

Emery, Walter; "Food and Energy Prices as Inflation Indicators"; Commodity Yearbook 1988 .

Fisher, Irving; The Purchasing Power of Money ; reprint Augustus Kelley, 1971.

Friedman, Benjamin; "Lessons on Monetary Policy from the 1980's"; Journal of Economic Perspectives , Vol. 2; 1988.

Friedman, Benjamin; "Monetary Policy Without Quantity Variables"; American Economic Review , Vol 78; May 1988.

Friedman, Milton; "The Role of Monetary Policy"; The American Economic Review , Vol. 58; March 1968.

Friedman, Milton; "First Lecture: A Survey of the Evidence for Monetarism"; Money and Economic Development ; Institute for Economic Affairs; 1973.

Galbraith, John, K.; "Administered Prices and Monetary-Fiscal Policy"; reprinted in L. Ritter Money and Economic Activity 3rd Ed. ; Houghton Mifflin, 1967.

Gordon, R., A.; "Wages, Prices, and Unemployment, 1900-1970"; Industrial Relations , Vol. 14; October 1975.

Gordon, Robert, J.; "Inflation, Flexible Exchange Rates, and the Natural Rate of Unemployment"; in Martin Baily Workers, Jobs, and Inflation ; Brookings Institute, 1985.

Gordon, Robert, J.; "The Role of Wages in the Inflation Process"; American Economic Review , Vol. 78; May 1988.

Hallman, Jeffery; Porter, Richard; Small, David; "M2 Per Unit of Potential GNP as an Anchor for the Price Level"; Staff Study 157; Board of Governors of the Federal Reserve System; April 1989.

Howell, Craig; Burns, Roger; Clem, Andrew; "Sharp Drop in Energy Prices Holds Inflation in Check During 1986"; Monthly Labor Review ; May 1987.

Lipsey, Richard; "The Relationship Between Unemployment and the Rate of Change of Money Wages in the United Kingdom, 1862-1957: A Further Analysis"; Economica , Vol. 27; 1960.

Makinen, Gail; Money, The Price Level, and Interest Rates ; Prentice-Hall, 1972.

Okun, Arthur; "Inflation: Its Mechanics and Welfare Costs"; Brookings Papers on Economic Activity ; 1975.

Okun, Arthur; "Efficient Disinflationary Policies"; American Economic Association , Vol. 68; May 1978.

Phelps, Edmund; "Phillips Curves, Expectations of Inflation, and Optimal Unemployment Over Time"; Economica , Vol 34; August 1967.

Phillips, A., W.; "The Relationship Between Unemployment and the Rate of Change of Money Wages in the United Kingdom, 1862-1957"; Economica , Vol. 25; December 1958.

Rea, John, D.; "The Explainatory Power of Alternative Theories of Inflation and Unemployment, 1895-1979"; The Review of Economics and Statistics , Vol. 65; May 1983.

Sargent, Thomas; "A Classical Macroeconometric Model for the United States"; Journal of Political Economy , Vol. 84; April 1976.

Schultze, Charles; "Recent Inflation in the United States"; Joint Economic Committee, Study Paper No. 1; 1959.

Stein, Jerome, L.; "Inflation, Employment, and Stagflation"; Journal of Monetary Economics 4 ; 1978.