PRICES, MONEY
AND
THE REAL ECONOMY

by

John P. Kasperick

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APPROVAL

of a thesis submitted by

John P. Kasperick

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ABSTRACT

This thesis examines the effects of output price surprises, energy price surprises, and money surprises on aggregate real economic activity for the years 1948-1988. Three measures of real activity are utilized; the unemployment rate, the log value of output, and the log value of private employment. Both M1 and M2 definitions of money are employed.

Model 1 is first developed, which is a replication of Gray and Spencer's 1990 study. From this a reexamination of the empirical role of output price surprises, energy price surprises, and a natural rate measure in determining the level of real aggregate activity is undertaken. Next, Model 2 is developed which includes money surprises along with the various other independent variables in determining real economic activity. Non-linear three stage least squares is the estimation technique employed in estimation of both models.

We find that output price surprises are positively and significantly correlated with aggregate real economic activity. Energy price surprises are insignificant in determining real activity. Money surprises, when included with the other explanatory variables, are found to have no direct effect on real activity but operate indirectly through prices. Finally, not much variation in unemployment is explained by the variables of interest.

CHAPTER 1

INTRODUCTION

In the 1980s and now in the early 1990s, business cycles have again become a focus of study in macroeconomics. Recent analysis has stressed real factors such as disturbances to supply, technological shocks, and changes in terms of world trade as sources of business fluctuations. The government can affect real variables by changing its purchases of goods and services or its tax rates, but, at least according to Barro (1989), there is little evidence that these fiscal actions have been major sources of business cycles in U.S. history. Real Business Cycle proponents discount the role of money as a cause of cyclical fluctuations. The correlation between money and economic activity is explained as an endogenous response of money to economic activity, that is, fluctuations in real activity cause fluctuations in money, rather than vice versa (King and Plosser). However, there is also a belief by some economists that monetary fluctuations have been a principal cause of cyclical fluctuations. These monetary disturbances are created mainly by governmental actions. This proposition - that money "matters" for business cycles - has been met with renewed criticism.

The U.S. economy has also experienced several energy crises over the past 45 years. Since the end of World War II there have been at least seven sizeable oil price shocks. All but one of the eight recessions since World War II were preceded by an oil price shock (Hamilton,1983). This has lead some economists to conclude that oil market disturbances have been a prominent cause of post World War II business cycles.

There have been many studies examining the relationships between real and nominal variables in the context of macroeconomic fluctuations. The previous studies have lead to conflicting results. The present study will estimate the relationships between prices, energy prices, and money surprises and aggregate real economic activity. In terms of aggregate real economic activity, measures of output, employment, and unemployment will be utilized.

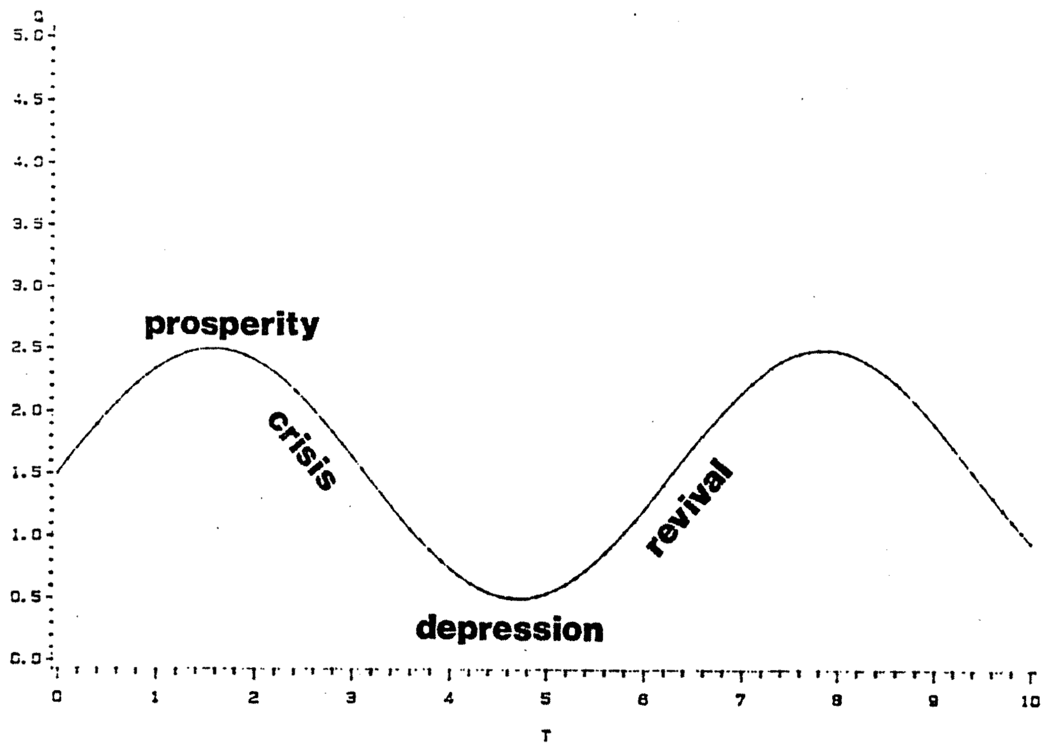
This study is innovative in that it is the first study to incorporate all explanatory variables as explained above. In other words, this study embeds the price surprise, energy shock, and monetary explanations into a single model and allows the data to discriminate among them. Also, if a relationship is found, it will be determined how much of the variation in aggregate real activity can be explained; that is, how important are the price, energy price, and money surprises on real economic activity? Through a more correctly specified and estimated set of empirical models, new light will be shed into the role of price prediction errors, oil price shocks, and money in determining real activity.

Various Views of Business Cycles

What do we mean by the term cycles? In 1922 at a Conference on Cycles, representatives from several sciences analyzed the cyclical nature in their respective fields. The following definition was agreed as being reasonable for all sciences: "In general scientific use, the word cycle denotes a recurrence of different phases of plus and minus departures, which are often susceptible of exact measurement," Kydland and Prescott (1990).

Burns and Mitchell (1946) viewed business cycles as having four phases. These phases are seen to evolve from one into another. The four phases that Burns and Mitchell discuss are prosperity, crisis, depression, and revival. Figure 1, on the following page, illustrates.

Figure 1
General Business Cycle



Source: Burns and Mitchell (1946).

Eugene Slutzky (1937) examined an entirely different way of generating cycles. Slutzky showed that cycles resembling business fluctuations can be generated as the sum of random causes - that is, by a stable, low-order, stochastic difference equation with large positive real roots.

In the 1970s business cycles received renewed attention. Lucas (1977) was the leader of this movement.

He viewed business cycle regularities as "comovements of the deviations from trend in different aggregative time series." The business cycle was defined by Lucas as movements about trend in Gross National Product.

Modern Business Cycle theory was developed in the 1980s and early 1990s. The quantitative research has had difficulty finding an important role for monetary changes as a source of fluctuations in real aggregates. This Real Business Cycle theory discounts the role of money as a cause of cyclical fluctuations. The correlation between money and economic activity is explained as an endogenous response of money to activity; that is, fluctuations in real activity cause fluctuations in money, rather than vice-versa (King and Plosser).

Rational Expectations and Natural Rate

Two assumptions employed in many macroeconomic models, and that will be employed here, are rational expectations and natural rate. These have proven to be powerful analytical tools. The recognition that expectations are extremely important to economic decision making lead in the 1970's to a major revolution in macroeconomic analysis.

The rational expectations assumption simply put states that expectations reflected in market behavior will be optimal forecasts using all available information. Households and businesses invest considerable amounts of time and other resources in monitoring economic activity. Thus, under the rational expectations hypothesis people incorporate their expectations of the future into their decisions. People work hard to form correct and unbiased decisions about future events.

A model obeys the natural rate hypothesis when shifts in aggregate demand have no long-run effect on real GNP. The level of output is always equal to natural real GNP when expectations are accurate. Sooner or later any expectational errors will be corrected, so output cannot remain away from natural real GNP for long. This hypothesis was developed by Milton Friedman (1968) and Edmund Phelps (1972).

In the macroeconomic models employing the rational expectations and natural rate assumptions, output and employment are typically demand driven, with aggregate demand disturbances transmitted to the real sector through price prediction errors.

The Debate

Many economists think that movements in money and prices- that is, nominal disturbances- have a great deal to do with the short-term behavior of real variables, such as aggregate output and employment. In contradiction, real business cycle theory predicts that changes in the monetary base are neutral. In particular, the theory suggests that a one-time shift in the quantity of base money leads to proportional changes in the nominal variables but no changes in the real variables.

Also, macroeconomic models employing the rational expectations and natural rate assumptions have come under scrutiny due to empirical relevance. In these models, output and employment fluctuations are typically demand driven, in which price prediction errors transmit aggregate demand disturbances to the real sector. The view that the models are of questionable empirical relevance appears to be based on a small number of studies which fail to yield evidence of a robust empirical relationship between price level surprises and aggregate real activity. This has lead valuable research to be discarded on the basis of thin and seriously suspect evidence (Gray and Spencer,1990).

Finally, it is enticing to note that all but one of the last eight recessions were immediately preceded by an oil price shock. This has lead some economists to conclude that oil market disturbances have been a prominent cause of post World War II business cycles. There is, however, also evidence that the influence of oil prices on economic performance has diminished (Anderson,1990).

Purpose of the Study

The macroeconomic issue of the causes of business cycle fluctuations has been the subject of considerable debate for some time. The debate has arisen over whether anticipated or unanticipated money, prices, and energy prices affect real variables. By using more correctly specified and estimated models the goal is to shed some light on the issues. Numerous studies have examined the relationships but the results have been conflicting. The purpose is to reassess the roles, and determine if monetary surprises, price surprises, and energy price surprises affect real variables such as output, employment, and unemployment.

The objectives of this research are thus:

1. To reassess the role of price prediction errors and real economic activity;

2. To determine how much of the variation in aggregate real activity is explained by price surprises; that is, how important are the price surprises;

3. To determine how much of each price surprise can be ultimately attributed to fluctuations in money;

4. To examine if money surprises have a separate effect on real economic activity rather than through price surprise channels;

5. To examine the effect of oil price shocks on real economic activity.

Hypotheses

Numerous hypotheses will be tested in this study. Empirical estimation is utilized to test the hypotheses. The predictions that will be tested are provided as follows:

1. Deviations of aggregate real activity from its natural rate are positively related to errors in predicting the price level, using output or employment as the measure of real economic activity.

2. Deviations of aggregate activity from its natural rate are negatively related to errors in predicting the economy wide average of energy prices, using output or employment as the measure of real economic activity.

3. Deviations of aggregate real activity from its natural rate are positively related to unanticipated money growth, using output or employment as the measure of real activity.

4. Unanticipated monetary growth is positively correlated with the price level.

After completing these tests, it will be determined how much of the variation in real activity or the price level is attributed to these variables, and how much remains unexplained.

Outline and Procedures

In Chapter 2, issues and early evidence will be presented. In Chapter 3, a theoretical foundation for the role of price prediction errors, energy price surprises, and money surprises that provide new insights in determining real activity will be developed. Also model formulation will be undertaken. In Chapter 4, estimation of the developed models will be undertaken, and the empirical results will be examined. Chapter 5 will be utilized for summary and conclusions.

CHAPTER 2

ISSUES AND EARLY EVIDENCE

There have been numerous prior studies examining the effects of nominal variables on aggregate real economic activity. This chapter reviews the issues and prior evidence. The chapter is broken into three sections: first, price prediction errors and real economic activity; next, oil and the macroeconomy; and finally, money and real economic activity.

Price Prediction Errors and Real Activity

The most recent literature dealing with price prediction errors and real economic activity is found in the study by Gray and Spencer (1990), which is the starting point of this thesis. They reassess the role of price prediction errors in determining aggregate real activity.

Before Gray and Spencer's study, a small number of studies failed to find evidence of a robust empirical relationship between price level surprises and aggregate real activity. This evidence leads some influential macroeconomists to conclude that the channels through which aggregate demand influences the economy have yet to be identified.

Gray and Spencer provided evidence that the inability of other researchers to verify a positive correlation between demand driven price prediction errors and real activity is due to misspecified models and inappropriate estimation procedures. Their newly specified models will be duplicated in the present study to reassess the role of price prediction errors, and to determine how important the price prediction errors are on aggregate real activity.

It has been shown that in the most prominent natural-rate macro models that price prediction errors play a central role. These macro models can be broken down into two classes: equilibrium models and contracting models. In both models unanticipated movements in the price level are the channel through which aggregate demand disturbances influence the real sector.

In 1973, Lucas developed the equilibrium model. In his equilibrium model, Lucas assumed incomplete information to produce aggregate demand disturbances. The confusion between relative and aggregate price movements causes firms to react to unanticipated price level movements as though they were relative price movements. In this model, people are unable to distinguish between a nominal price change (inflation) and a relative price change. From this it is established that positive price level shocks cause all firms to increase output and generate positive deviations of aggregate output from its natural rate.

Fisher (1977) and Gray (1976) developed the contracting models. These types of models depend on contractually set wages to produce non-neutrality. When there is an unanticipated rise in the price level, then the contractually set wages cause a fall in the real wage of all workers. This results in a rise in aggregate employment and output.

Gray and Spencer test the common implications of the equilibrium and contracting models. Their analysis is distinguished in their treatment of supply-side disturbances and the natural rate of real activity. They find that demand driven price level surprises are positively and significantly correlated with aggregate real economic activity.

Sargent (1976) and Fair (1979) developed the most frequently cited evidence on the effect of price level surprises on real variables. Their empirical work is formulated in terms of the U.S. unemployment rate which is assumed to be negatively related to real activity. Sargent finds a weak negative relationship between price level surprises and deviations of unemployment from its natural rate. Fair, on the other hand, using a sampling period that includes the 1970s finds a very significant positive relationship.

Finally, Mishken (1982) also reports evidence of a positive, though insignificant, correlation between price prediction errors and real activity.

The analysis presented here duplicates Gray and Spencer's (1990) three stage nonlinear least squares empirical estimation, to determine the effect of price level surprises on real economic activity. This study will utilize the more correctly specified and estimated model. The issue of how important the price surprises are will also be addressed.

Oil and the Macroeconomy

It has been argued that oil, or energy price shocks can explain a lot in terms of business cycles. This also has been the subject of debate.

In an economic commentary, Andersen, Bryan, and Pike (1990) established some theory and evidence of oil and the economy. They show that all but one of the last eight recessions were immediately preceded by an oil price shock. This has lead some economists to conclude that oil market disturbances have been a prominent cause of post World War II business cycles.

They provide economic theory to offer insights into the impact of an oil shock on real output and interest rates, labor markets, and the price level. The theory is as follows:

> "At a given level of work effort, output declines because fewer energy resources are flowing into production. The magnitude of the downturn depends on the importance of oil to the production process and the ease with which alternative energy sources can be substituted. The drop in output reduces wealth, and is felt by households as a decline in the value of assets such as equities and real money balances. Now, if consumers believe that the shortage will be short lived, they will hold closely to their current spending level and offset the temporary income loss by borrowing, producing upward pressure on real interest rates. However, if consumers expect a prolonged income and wealth loss, they will reduce their spending to correspond with their diminished budget, leaving borrowing and the real interest rate unaffected."

Hamilton (1983) looked at oil and the macroeconomy since World War II. In his study, Hamilton listed the principal causes of crude oil price increases for the period 1947 to 1981. He determined seven episodes since 1947 that were met with crude oil price increases.These can be shown in Table 1 on the following page:

Table 1

Principal Causes of Crude Oil Price Increases 1947-1981

Episode	Principal Cause
1947-48	Previous investment in production and transportation capacity inadequate to meet post-war needs.
1952-53	Iranian nationalization; strikes by coal and steel workers.
1969	Secular decline in U.S. reserves; strikes by oil workers.
1970	Rupture of trans-Arabian pipeline; Libyan production cutbacks; coal price increases.
1973-74	Stagnating U.S. oil production; OPEC embargo.
1978-79	Iranian revolution.
1980-81	Iran-Iraq war; removal of U.S. price controls.

Source: Hamilton (1983).

Hamilton also illustrates that all but one of the U.S. recessions since World War II have been preceded, typically with a lag of around three-fourths of a year, by a dramatic increase in the price of crude petroleum. Hamilton presents evidence that even over the period 1948-1972 the correlation between oil shocks and aggregate real economic activity is statistically significant and nonspurious. This gives support to the proposition that oil shocks were a contributing factor in at least some of the U.S.

recessions prior to 1972. Evidence is also found that energy price increases may account for much of the post-OPEC macroeconomic performance.

Gray and Spencer (1990) also include energy price surprises among the explanatory variables of the empirical model. Energy price surprises are included in an effort to incorporate at least one important source of real disturbances into their analysis. That is, in their analysis they include a supply shock which had been omitted in most previous studies.

As Andersen, Bryan, and Pike point out, disturbances that impair an economy's ability to produce goods and services are known as supply shocks. Supply shocks include such things as natural disasters, labor disputes, and political upheaval. Since energy is vital to almost all production processes, its scarcity impacts the economy more broadly than supply shocks that are more or less sector specific, such as those caused by droughts or strikes.

In the present study, supply shocks, in the form of oil price shocks will be incorporated. A more correctly specified and estimated model will allow the determination of oil price shocks effect on aggregate real economic activity. As has been shown above, theoretically it certainly appears that oil price shocks have been a prominent cause of post World War II business cycles. This will be tested empirically. As Hamilton points out, oil price increases are neither a necessary nor a sufficient condition for post war recessions. However, the regularity in the timing between oil price increases and the subsequent recessions makes it difficult to attribute their common dependence on some third set of influences endogenous to the macroeconomy.

Money and Real Economic Activity

A hotly debated macroeconomic issue is whether either anticipated or unanticipated monetary policy matters to the business cycle. Three macroeconomic models that evolved from the 1960s through the 1980s provide differing views on the role of money on business cycles. Barro (1989) discusses the evolution of these three models.

In the late 1960s, the Keynesian model was the only macroeconomic model attempting to explain business cycles. According to Keynesians, market failure was due to the mere stickiness of prices or wages, primarily in the downward direction. Keynesian analysis focuses on shocks to aggregate demand, and typically attributes these shocks to government actions or to shifts in private preference that influence consumption or investment demand. The desire to find observable aggregate shocks lead many Keynesians to conclude that monetary disturbances were the source of the business cycles.

The New Classical Approach developed by Lucas in the early 1970s, established the rational expectations assumption, in which people assembled and used information in an efficient manner. The New Classical analysis was aimed at explaining real world business fluctuations. This approach showed that monetary shocks, which affected the general price level in the same direction, could be temporarily mispreceived as shifts in relative prices, which lead to adjustments in the supply of labor and other quantities. Thus, it was claimed that in the short-run monetary shocks affect real variables. These real affects vanished in the long-run, but persisted for awhile because of information lags and the costs of adjusting the quantities of factor inputs. The New Classicals also claimed that the positive relation between monetary shocks and output shows up most clearly with broad monetary aggregates. This relation with narrow aggregates, such as the monetary base, is much weaker.

In the early 1980s, the Real Business Cycle theory was developed. Real Business Cycle models deemphasize monetary causes of the business cycle. These models stress technology shocks or other disturbances to the supply side as central driving forces, but allow an important role for the dynamic elements that influence the ways that shocks propagate. In this real business cycle framework, any positive correlation between output and money reflects the endogenous response of monetary aggregates.

Fackler and Parker (1990) examined the role of anticipated and unanticipated money in the period between the Civil War and the Depression. Their empirical results established the following three points for this time period: first, anticipated M2 and monetary base growth have no effect on output regardless of the output measure used; second, unanticipated M2 and monetary base growth do affect output, regardless of the output measure used; and finally, changes in financial intermediation may be important for the evolution of output over time. Another significant finding is that their Monte Carlo results suggest that endogeneity of the money measure does not affect the F-statistics employed in the hypothesis tests.

Fackler and Parker's results differ from the findings of Mishken (1982). Mishken tests whether anticipated values of aggregate demand variables (rate of nominal GNP growth, inflation rate, or money growth) matter. To estimate, Mishken uses a joint nonlinear procedure, similar to that utilized in this current study. Estimates in Mishken's study find that unanticipated aggregate demand variables lagged as far back as 20 quarters are significantly correlated with output and employment. The empirical evidence does not support the natural rate hypothesis that only unanticipated aggregate demand policy matters. He concludes that anticipated values of aggregate demand variables seem to matter a lot. Anticipated variables were not found to be less important for the post war 1954-1976 data.

Barro (1977) also tested the hypothesis that only unanticipated movements in money affect real economic variables. He determines anticipated money growth to be the amount that could have been predicted based on the historical relation between money growth and a specified set of explanatory variables. Unanticipated money growth was then measured as actual growth less the amount obtained from this predictive relationship. From the empirical evidence, Barro concluded that the current and two annual lags of unanticipated money growth were shown to have considerable explanatory power for unemployment. Anticipated money growth was found to be irrelevant for unemployment, given the values of unanticipated money growth. Thus, Barro's results differ from the latter findings of Mishken.

McCallum (1979) is also a proponent of real business cycle theory. McCallum does not deny that there exists correlations between monetary and real variables, but claims that these reflect responses by the monetary system to fluctuations induced by technology shocks.

There exist other empirical findings for which monetary shocks play no role. These three pertinent studies in chronological order are as follows:

1. Sims (1980, 1982), demonstrated that money

stock innovations have little explanatory power for output fluctuations when a nominal interest rate variable is included in the system. Thus, the conclusion by Sims is that monetary policy is unimportant, or that the effects of money occur via interest rates.

2. Eichenbaum and Singleton (1982) have documented a marked tendency for natural-to-real causality to become insignificant when data series are rendered stationary by means of first differencing.

3. Nelson and Plosser (1982) claimed that monetary impulses can have no effects on the trend components of output or employment, and also found that output fluctuations are dominated by trend, as opposed to cyclical movements.

A final analysis, pertinent to the present study, is presented by Barro (1978). In this, Barro reports empirical results on the relation of money to output (real GNP) and the price level (GNP deflator) for the post World War II period in the U.S.. Barro finds that the hypothesis of a one-to-one contemporaneous link between anticipated money and the price level is supported by the empirical evidence. His findings also indicate a strong expansionary effect of current and lagged values of unanticipated money growth, and that actual money growth is irrelevant for output given the inclusion of unanticipated money growth.

The various empirical conclusions point to the need of a more careful examination of the role of anticipated and unanticipated money, prices, and oil prices in determining real activity in the economy. By correctly formulating and estimating a set of empirical models, in the following chapters, this study will provide new insights into business cycle determinations.

CHAPTER 3

THEORETICAL CONSIDERATIONS AND ECONOMETRIC SPECIFICATION

Introduction

The objective of this chapter is to develop a theoretical foundation and empirical formulation of the models utilized in this study.

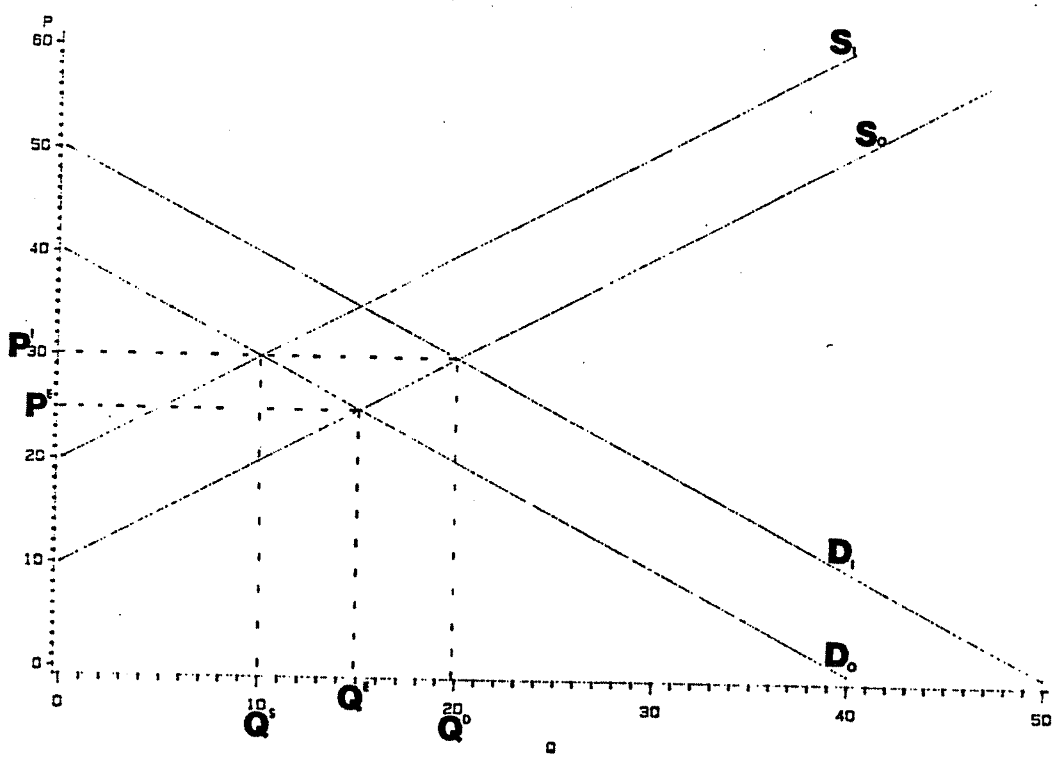
Price prediction errors have played a central role in the most prominent natural-rate macroeconomic models. In these classes of models, unanticipated movements in the price level are the channel through which aggregate demand influences the real sector. As Gray and Spencer (1990) point out, in these kinds of models confusion between relative and aggregate price movements cause firms to react to unanticipated price level movements as though they were, at least in part, relative price movements. Thus, positive price level shocks cause all firms to increase output and generate positive deviations of aggregate output from its natural rate.

Gray and Spencer's 1990 assessment is first duplicated in the present study. Specification of the empirical model includes among explanatory variables a measure of energy price surprises, and a more sophisticated proxy for the natural rate of real activity than was employed in earlier studies. The energy price surprise is included to incorporate at least one important source of real disturbances into the analysis. As in earlier models, it is predicted that deviations of aggregate real activity from its natural rate should be positively related to errors in predicting the price level, and negatively related to errors in predicting the economy-wide average of energy prices, when output and employment are used as the measure of real activity (Mohammadi 1988). When unemployment is used as a measure of real activity, the opposite is expected.

Oil price surprises represent supply-side disturbances, whereas output price surprises represent demand-side disturbances. As Figure 2 on the following page illustrates, a shock to demand causes an increase in the price level, P, and also an increase in real activity as measured by output or employment. A supply shock, that causes the price level to increase by the same amount as the demand shock, leads to a decrease in real activity as measured by output or employment. When unemployment is used as the measure, the opposite is expected.

Thus, in the present study, it is predicted that oil price shocks and output price shocks tend to operate in opposite directions. Energy price surprises should be negatively related to the real activity measures discussed, while output price surprises should be positively related.

Figure 2
Effects of Demand and Supply Shocks on Real Activity



After duplication of Gray and Spencer's assessment this study extends into a new direction. A money surprise, or unanticipated money growth, is incorporated as an explanatory variable. As Barro (1990) points out, there is little evidence that fiscal actions have been major sources of business cycles in U.S. history. Some economists believe that monetary fluctuations - created mainly by governmental actions - have been a principal cause of these cycles.

With the inclusion of unanticipated money as an explanatory variable for real economic activity, it can be determined if money surprises directly affect real activity, and also by what percentage. Many macroeconomic models are often criticized because they do not generate the widely emphasized correlation between the quantity of money and real activity.

In this second model, the study integrates output price surprises, energy price surprises, and money surprises into real business cycle theory. We predict that deviations of real economic activity from its natural rate, as measured by the unemployment rate, should be negatively correlated with unanticipated money growth. When either output or employment are used as the measure of real economic activity, a positively correlated unanticipated money growth is predicted.

In the next section, which is an extension of the second model, the framework is extended to a consideration of the price level, hence the rate of inflation, and unanticipated movements in money. This brings us to Milton Friedman's famous statement, "Inflation is always and everywhere a monetary phenomenon."

Barro (1990) examined U.S. time series data on inflation and monetary growth over 20-year periods from 1860 to 1980. Table 2 reports his results as follows:

Table 2

U.S. Time Series Data on Inflation
and Monetary Growth: Averages for 20-year Periods
(Average growth rates in % per year)

Periods	ΔP	ΔM	ΔM-ΔP	ΔY
1860-1880	1.1	3.4	2.3	4.3
1880-1900	-0.6	3.2	3.8	3.0
1900-1920	4.6	6.5	1.9	2.8
1920-1940	-1.6	2.4	4.0	2.4
1940-1960	4.3	6.8	2.5	3.8
1960-1980	2.1	6.9	2.1	3.5
1860-1980	2.1	4.9	2.8	3.3

(Source: Barro 1990)

Note: ΔP is the growth rate of the GNP deflator. ΔM is the growth rate of currency. ΔY is the growth rate of real GNP.

One theoretical framework that attributes an important role to money is the Quantity Theory of Money (Belongia 1990). The theory is based on the equation of exchange which is typically written as:

$$MV = PT, \tag{1}$$

where M is the quantity of money, V is its velocity of circulation, P is the average price level, and T is the volume of transactions. The quantity theory derived from this equation predicts that the price level varies directly with the quantity of money. In the present study, it is also hypothesized that unanticipated monetary growth is positively correlated with the price level.

Model 1: Gray and Spencer Revisited

As noted earlier, specification of the empirical model includes among the explanatory variables a measure of energy price surprises, output price surprises, and a more sophisticated proxy for the natural rate of real activity. Three different measures of economic performance are utilized; the unemployment rate, the log value of private output, and the log value of private employment.

The first statistical procedure seeks to estimate the effect on unemployment from surprises in output prices PS(t), and energy prices QS(t). Accordingly, PS(t) and

QS(t) are defined throughout the study as follows:

$$PS(t) = P(t) - E_{t-1}P(t) \quad (2)$$

$$QS(t) = Q(t) - E_{t-1}Q(t)$$

where P(t) and Q(t) are the actual logarithms of the price level and the real price of energy at time t. E_{t-1} P(t) is the price that the typical person expected at time t, given all available information at time t-1, and similarly for E_{t-1} Q(t).

After developing the price surprises, the theory suggests a model of the following general form:

$$X(t) = X^*(t) + \alpha PS(t) + \beta QS(t) + e(t), \quad (3)$$

where X(t) and $X^*(t)$ measure actual and natural aggregate real activity at time t respectively. The hypothesis to be tested involves the signs of the coefficients, α and β. With unemployment as the measure of real activity, we expect a negative α and a positive β. For output and employment the opposite is expected.

Nonstatioarity

Stationarity is an important concept in time series modeling. A process is weakly, or covariance, stationary if it satisfies the following criteria: (i) the mean is independent of t; (ii) the variance is independent of t; and (iii) each autocovariance $E(e_t\ e_s)$, depends only on the difference between t and s (Harvey, 1981).

It can be argued that when the unemployment rate is utilized, a stationary series is rendered. However, it is clear that the levels of output and employment are nonstationary. Nevertheless, the theory surrounding stationary time series can be applied to the nonstationary series by the simple expedient of taking the first differences. Thus, when output and employment are incorporated as the measures of aggregate real activity, the empirical models are estimated in the first difference form. This follows from tests by Gray and Spencer.

Figures 3,4, and 5 show the relationships between unemployment, output, employment, and time, respectively. As the figures illustrate, employment and output are nonstationary series. This is due to the fact that the means of both measures of real activity are on a rise. Unemployment is a stationary series due to the fact that it exhibits mean reverting behavior.

Figure 3
Unemployment Rate 1948-1988

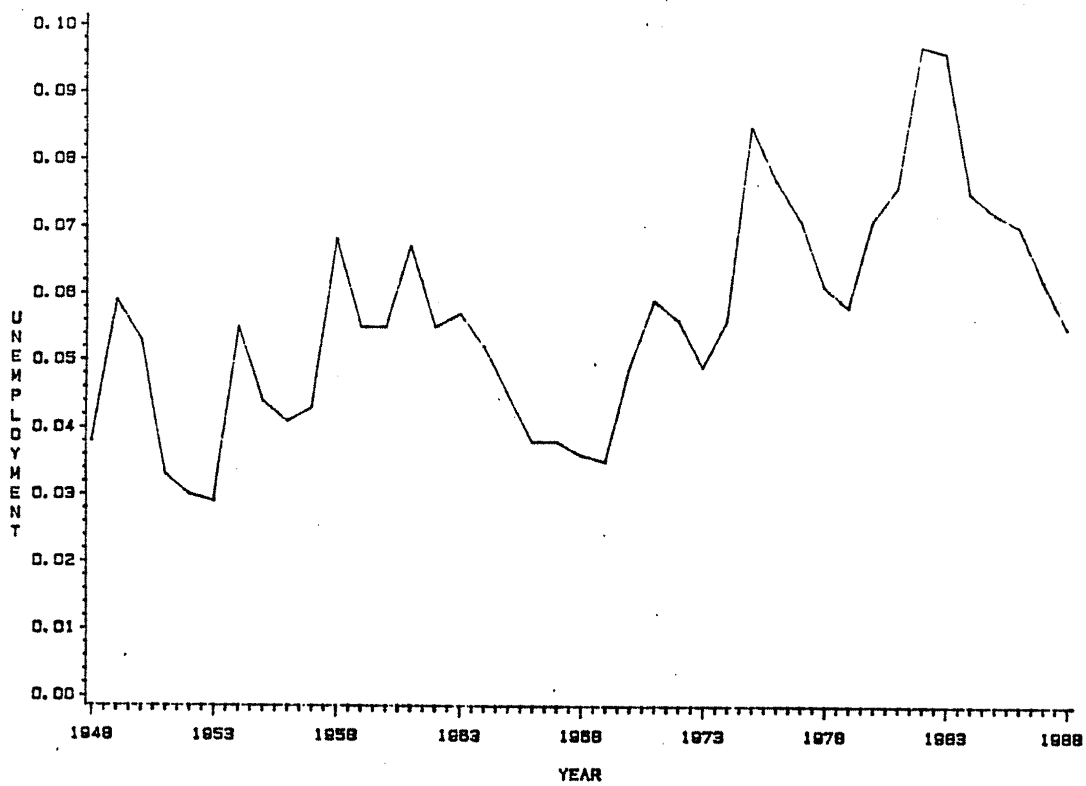


Figure 4
Real GNP 1948-1988

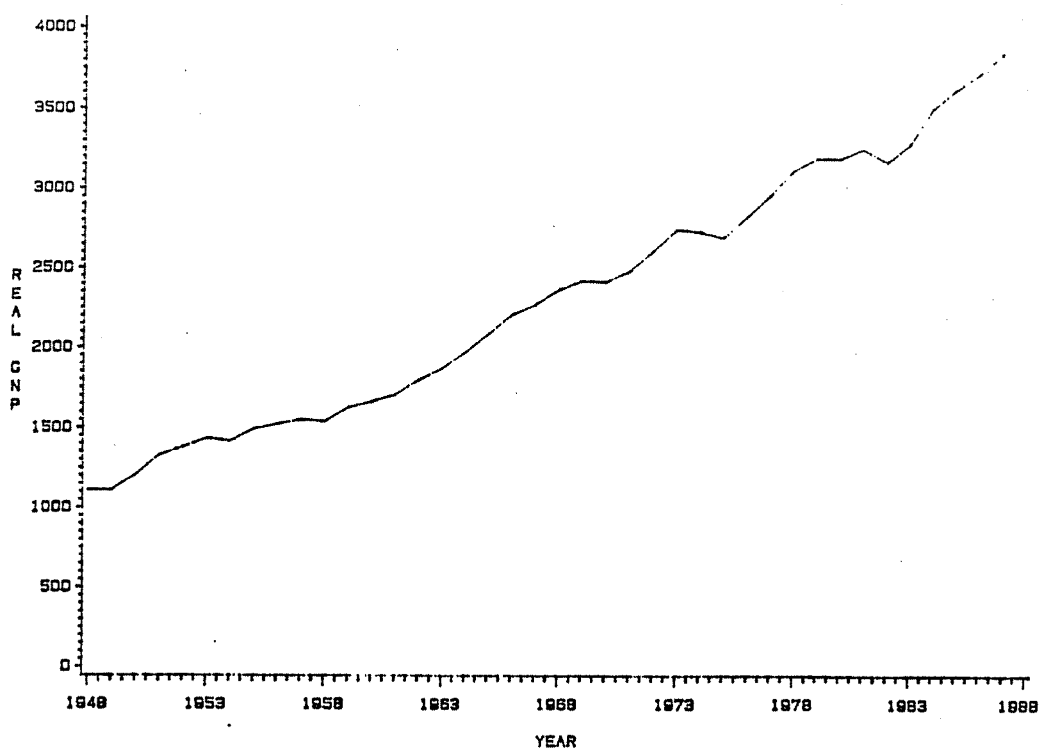
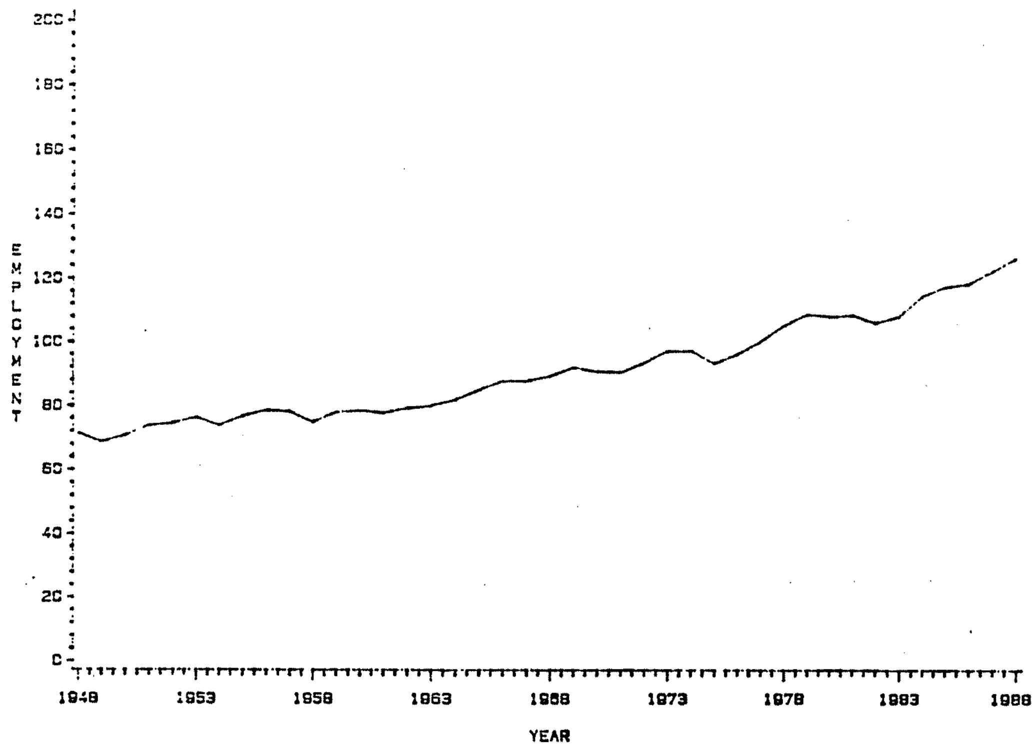


Figure 5
Employment 1948-1988



Unobservable Variables

The explanatory variables, PS(t) and QS(t), are unobservable. Thus, it is necessary to obtain proxies for each, and to obtain efficient estimates, the equations generating the proxies are estimated jointly with equation (3). Another unobservable parameter is the natural rate, $X^*(t)$. A suitable proxy is developed for the natural rate, and this is also estimated jointly.

Natural Rate Measure

As developed by Gray and Spencer, following Lilien (1982), this paper employs a more sophisticated measure of the natural rate than utilized in prior studies. This study employs the more sophisticated measure of the natural rate which takes explicit account of the role of sector specific shocks in determininig the level of aggregate real activity. The proxy is constructed in a two stage process. The first stage obtains a measure denoted SIGMAE, which is an index of dispersion of employment changes across industries at a point in time. Equation (4) illustrates the calculation of the measure as follows:

$$\text{SIGMAE}(t) = \left(\sum_{i=1}^{29} \psi_i(t)\,[\xi_i(t)]^2\right)^{\frac{1}{2}}, \qquad (3)$$

where ξ_i = [$emp_i(t)-emp_i(t-1)$] - [$EMP(t)-EMP(t-1)$] and $\psi_i(t)$ = the ratio of employment in industry i at time t to total employment in the twenty-nine industry classification at time t. Here, emp_i denotes the log value of the level of employment in industry i and EMP denotes the log value of aggregate employment. Thus, SIGMAE measures the standard deviation of percentage changes in employment across industries. A larger value of SIGMA indicates a greater degree of dispersion across industries in changes in the level of employment. With some industries increasing employment while others are reducing, more frictional and structural is expected to occur. Thus, the natural rate is an increasing function of SIGMAE.

The second stage in constructing the natural rate proxy is developed because SIGMAE has been criticized on the grounds that you would expect aggregate disturbances to affect industries differently. So, SIGMAE may also reflect the influence of some aggregate disturbances. This gives the possibility that SIGMAE may be confounded with the effects of the price surprise terms. Thus, SIGMAE is purged on the effects of these terms as in equation (4) and the residual, SIG, is the proxy for the size of industry specific disturbances of the natural rate.

Output and Energy Price Proxies

It is assumed in this analysis that the price level is endogenous. As equation (5) illustrates, price level forecasts are generated by taking the fitted value of a reduced form equation for the GNP deflator. Specifically, the logarithm of the GNP deflator is regressed on a constant, the lagged values of SIGMAE and X, and two lagged values each of the logarithms of the money stock (M), the real price of energy, and the GNP deflator itself.

$$P(t) = a_0 + a_1X(t-1) + a_2SIGMA(t-1) + a_3M(t-1) + a_4M(t-2) + a_5Q(t-1) + a_6Q(t-2) + a_7P(t-1) + a_8P(t-2) + \eta(t). \quad \textbf{(5)}$$

Thus, $P(t) = E_{t-1}P(t) + \eta(t)$. The fitted values from this equation are subtracted from the actual value of the logarithm of the GNP deflator to obtain the proxy for the output price surprise, $PS(t) = \eta(t)$.

In obtaining a proxy for the energy price surprise, real energy price forecasts are generated by taking the fitted value of a reduced form equation for the real price of energy. Specifically, the real price of energy is regressed on a constant, two lagged values of the real price of energy, a dummy variable, and the dummy variable multiplied by the lagged values of the real price of energy. The generating process experienced a structural change between 1973 and 1974. For both the period 1948-1973 and 1974-1986 it is assumed that the generating process is known to be second-order autoregressive, thus the above dummy specification. This is illustrated in equation (6) as follows:

$$Q(t) = b_0 + b_1Q(t-1) + b_2Q(t-2) + b_3DUM(t) + b_4DUM(t)Q(t-1) + b_5DUM(t)Q(t-2) + \epsilon(t). \quad (6)$$

Thus, $Q(t) = E_{(t-1)}Q(t) + \epsilon(t)$. The fitted values from this equation are subtracted from the actual value of the real price of energy to obtain the proxy for the energy price surprise, $QS(t) = \epsilon(t)$.

Estimation of Model 1

Due to the joint dependency and cross-correlation between the errors, the following system is estimated using nonlinear three stage least squares. This gives more efficient estimators than estimating the equations separately. Each measure of real economic activity is estimated jointly with the equations that determine the proxy variables as follows:

$$X(t) = \mu + \delta SIG(t) + \lambda X(t-1) + \alpha[P(t)-E_{t-1}P(t)] + \beta[Q(t)-E_{t-1}Q(t)] + \upsilon(t) \quad (7)$$

$$P(t) = a_0 + a_1X(t-1) + a_2SIGMA(t-1) + a_3M(t-1) + a_4M(t-2) + a_5Q(t-1) + a_6Q(t-2) + a_7P(t-1) + a_8P(t-2) + \eta(t) = E_{t-1}P(t) + \eta(t) \quad (8)$$

$$Q(t) = b_0 + b_1Q(t-1) + b_2Q(t-2) + b_3DUM(t) + b_4DUM(t)Q(t-1) + b_5DUM(t)Q(t-2) + \epsilon(t) = E_{t-1}Q(t) + \epsilon(t) \quad (9)$$

$$Sigma(t) = c_0 + c_1[P(t)-E_{t-1}P(t)] + c_2[Q(t)-E_{t-1}Q(t)] + \omega(t) \quad (10)$$

where $\omega(t) = SIG(t)$.

In this case, the system is estimated for the model of unemployment. Exactly the same system is estimated for output and employment except that equation (7) takes the first difference form due to the nonstationarity discussed earlier. Also, as noted, it is assumed that the price level is the only endogenous variable appearing on the right-hand-side of equation (7). It is also assumed that in the unemployment model the error term follows an AR(1) process. Gray and Spencer tested for serial correlation and found that when unemployment is used as the measure of real activity the error is AR(1). Thus, when unemployment is estimated, RHO is utilized to handle the correlation. Using output or employment no serial correlation was present. Finally, a lagged value of the measure of aggregate real activity also appears on the right-hand-side of equation (7) to handle the effect of adjustment costs.

Model 2: Inclusion of Money

Model 1 is now adjusted to include unanticipated monetary growth. Previous evidence has been inconclusive regarding the role in which money surprises affect prices, and in the role in which money surprises directly affect real activity. It is hypothesized that the unanticipated components of movements in money affect real economic variables like the unemployment rate, employment, or the level of output.

Specification of this empirical model includes among the explanatory variables a measure of output price surprises, energy price surprises, money surprises, and the natural rate proxy as noted earlier. Again, three different measures of economic performance are utilized; the unemployment rate, the log value of private output, and the log value of private employment.

The first statistical procedure attempts to estimate the effect on unemployment from surprises in money, MS(t), along with surprises in output price, PS(t), and energy price, QS(t), as described earlier. The measure of unanticipated money growth, which is actual growth less the anticipated portion, is obtained as follows:

$$MS(t) = M(t) - E_{t-1}M(t), \qquad (11)$$

where M(t) is the actual logarithm of the money supply at time t. $E_{t-1}M(t)$ is the money supply that the typical person expected at time t, given all available information at time t-1.

Utilizing the price surprises developed earlier, and after developing the unanticipated money growth estimate, Model 2 takes the following general form:

$$X(t) = \lambda X(t-1) + \delta SIG(t) + \alpha PS(t) + \beta QS(t) + \gamma MS(t) + e(t), \qquad (12)$$

where, X(t) measures aggregate real activity at time t. The hypothesis to be tested involves the signs of the coefficients. When unemployment is used as the measure of real economic activity we expect a negative α, a positive β and a negative γ. With output and employment utilized as the measure of real activity, we expect the opposite signs.

Employing the proxies for output price, energy price, and the natural rate as developed earlier, it becomes necessary to develop a proxy for the money surprise. This is due to the fact that the explanatory variable MS(t) is also unobservable.

Money Surprise Proxy

The money supply level forecasts are generated by taking the fitted value of a reduced form equation for the money stock. Independent variables include the lagged unemployment rate, two lagged values of the money stock, the inflation rate and the real interest rate. The inflation rate is obtained by taking the log value of the real price of output in period t-1, and subtracting the log value of the real price of output in period t-2. The real interest rate is obtained by taking the lagged values of the three month Treasury bill rate, and subtracting the inflation rate as calculated above. Equation (13) illustrates the money growth rate equation as follows:

$$M(t) = d_0 + d_1M(t-1) + d_2M(t-2) + d_3X(t-1) + d_4PI(t-1) + d_5RI(t-1) + \nu(t), \quad \textbf{(13)}$$

where M(t) is the money stock at time t, M(t-1) and M(t-2) are lagged values of the money stock, X(t-1) is the lagged value of the unemployment rate, PI(t-1) is the inflation rate at time t-1, and RI(t-1) is the real interest rate at time t-1.

In the specification of equation (13), M(t) also equals $E_{t-1}M(t) + \nu(t)$. The fitted values from this equation are thus subtracted from the actual value of the money growth rate to obtain the proxy for the money surprise, MS(t)=.

Estimation of Model 2

In order to estimate Model 2, nonlinear three stage least squares procedure is again employed . The nonlinear estimate gives consistent and asymptotically efficient estimates. The joint dependency and cross correlation between the errors calls for this type of estimation technique. Each measure of real activity is estimated jointly with the equations that determine the proxy variables as follows:

$$X(t) = \mu + \delta SIG(t) + \lambda X(t-1) + \alpha[P(t) - E_{t-1}P(t)] \quad \textbf{(14)}$$
$$+ \beta[Q(t) - E_{t-1}Q(t)] + \gamma[M(t) - E_{t-1}M(t)] + \rho(t)$$

$$P(t) = a_0 + a_1X(t-1) + a_2SIGMA(t-1) + a_3M(t-1) \quad \textbf{(15)}$$
$$+ a_4M(t-2) + a_5Q(t-1) + a_6Q(t-2) + a_7P(t-1)$$
$$+ a_8P(t-2) + +a_9[M(t)-E_{t-1}M(t)] + \eta(t)$$

$$Q(t) = b_o + b_1Q(t-1) + b_2Q(t-2) + b_3DUM(t) \quad \textbf{(16)}$$
$$+ b_4DUM(t)Q(t-1) + b_5DUM(t)Q(t-2) + \epsilon(t)$$
$$= E_{t-1}Q(t) + \epsilon(t)$$

$$SIGMA(t) = c_0 + c_1[P(t)-E_{t-1}P(t)] \quad \textbf{(17)}$$
$$+ c_2[Q(t)-E_{t-1}Q(t)] + c3[M(t)-E_{t-1}M(t)] + \omega(t)$$

$$M(t) = d_0 + d_1M(t-1) + d_2M(t-2) + d_3X(t-1) \quad \textbf{(18)}$$
$$+ d_4PI(t-1) + d_5RI(t-1) + \nu(t)$$
$$= E_{t-1}M(t) + \nu(t).$$

Since it is anticipated that money surprises affect the price of output, this is thus included as shown in equation (15). Also note that since the money surprise is unobservable at the time of the price surprise, $P(t) - E_{t-1}P(t)$ in equation (14) does not include the money surprise component. That is, $P(t) - E_{t-1}P(t) = a_9[M(t)-E_{t-1}M(t)] + \eta(t)$.

The natural rate measure, SIGMA, shows the index of the dispersion of employment changes across industries at a point in time. It is anticipated that money surprises will affect industries differently, that is, industries respond differently to money surprises. Hence, the money surprise is also included in the SIGMA equation. SIG is the proxy for the size of industry specific disturbances, and is equal to the residual of the SIGMA regression less the money surprise due to this being unobservable.

The system given by equations (14) through (18) is estimated for the model of unemployment. Due to the nonstationarity of the other real activity measures, output and employment, the same system is estimated for these measures except the first difference is employed.

Decomposition of Variance

Following the estimation of the models developed, it will be determined how much of the variation in the dependent variables is explained by the independent variables. This will be established for model 1 using unemployment as the measure of real economic activity, and also for model two using unemployment as the dependent variable.

To determine the amount of variation explained, the variation in unemployment can be resolved by the following equations.

Model 1: Variation of Unemployment

$$\begin{aligned} Var(X_t) = {} & \lambda^2 Var(X_{t-1}) + \delta^2 Var(SIG_t) + \alpha^2 Var(PS_t) \\ & + \beta^2 Var(QS_t) + Var(\nu_t) \\ & + 2[\lambda\delta Cov(X_{t-1},SIG_t) + \lambda\alpha\ Cov(X_{t-1},PS_t) \\ & + \lambda\beta\ Cov(X_{t-1},QS_t)] + 2[\delta\alpha\ Cov(SIG_t,PS_t) \\ & + \delta\beta\ Cov(SIG_t,QS_t)] + 2[\alpha\beta\ Cov(PS_t,QS_t)] \end{aligned} \tag{19}$$

By entering the computed values into equation (19), we can determine the variance of unemployment. With the variance of unemployment calculated, we can subtract the variance of the independent variables to determine how much of the variation in unemployment is determined by the independent variables. It should also be noted that lagged unemployment is included in the equations determining SIGMAE and Q. This is done so that the covariances of (X_{t-1},SIG_t) should be zero. That is, since lagged unemployment is included in determining SIGMAE and Q, there should be zero correlation between the errors from these equations and lagged unemployment. Note also that $Cov(SIG_t,PS_t) = Cov(SIG_t,QS_t) = 0$, since PS_t and QS_t are right hand side variables in (17). Thus, equation 19 reduces to:

$$\mathrm{Var}(X_t) = \lambda^2\mathrm{Var}(X_{t-1}) + \delta^2\mathrm{Var}(SIG_t) + \alpha^2\mathrm{Var}(PS_t) + \beta^2\mathrm{Var}(QS_t) + \mathrm{Var}(\nu_t) + 2[\alpha\beta\ \mathrm{Cov}(PS_t,QS_t)]. \qquad (20)$$

Model 2: Variation of Unemployment

$$\mathrm{Var}(X_t) = \lambda^2\mathrm{Var}(X_{t-1}) + \delta^2\mathrm{Var}(SIG_t) + \alpha^2\mathrm{Var}(PS_t) + \beta^2\mathrm{Var}(QS_t) + \gamma^2\mathrm{Var}(MS_t) + \mathrm{Var}(\rho_t) + 2[\lambda\delta\ \mathrm{Cov}(X_{t-1},SIG_t) + \lambda\alpha\ \mathrm{Cov}(X_{t-1},PS_t) + \lambda\beta\ \mathrm{Cov}(X_{t-1},QS_t)] + \lambda\delta\ \mathrm{Cov}(X_{t-1},MS_t)] + 2[\delta\alpha\ \mathrm{Cov}(SIG_t,PS_t) + \delta\beta\ \mathrm{Cov}(SIG_t,QS_t) + \delta\gamma\ \mathrm{Cov}(SIG_t,MS_t)] + 2[\alpha\beta\ \mathrm{Cov}(PS_t,QS_t) + \alpha\delta\ \mathrm{Cov}(PS_t,MS_t)] + 2[\beta\delta\ \mathrm{Cov}(QS_t,MS_t)] \qquad (21)$$

The amount of variation in unemployment explained by the independent variables can again be determined as explained in Model 1. All covariances should equal zero, as explained above, except for $\mathrm{Cov}(PS_t,QS_t)$, $\mathrm{Cov}(PS_t,MS_t)$, and $\mathrm{Cov}(QS_t,MS_t)$.

Data

All models developed are based upon annual time-series units of observation. The study incorporates the data for the years 1948-1988. The data set utilized in the empirical analysis was collected from various sources as follows:

-unemployment is the civilian unemployment rate, collected from the Economic Report of the President (Feb. 1990),

-output is Gross National Product, in 1982 dollars, collected from the Economic Report of the President (Feb. 1990),

-employment is full time equivalent employment in all private domestic industries, non-farm business sector, 1977=100, collected from the Economic Report of the President (Feb. 1990),

-money supply is new M1, collected from Gordon (1990), and the monetary base, collected from the Federal Reserve Bulletin,

-treasury bill rate is the three-month Treasury bill rate, collected from the Economic Report of The President (Feb. 1990),

-price of output is the GNP deflator, 1982=100, collected from Gordon (1990),

-price of energy is the producer price index for fuels and other related products and power, collected from the Economic Report of the President (Feb. 1990),

-surplus, used as an instrument variable, is the real natural employment surplus, collected from Gordon (1990) multiplied by the GNP deflator,

-SIGMA is the proxy for variation in sectoral employment, collected from Gray and Spencer (1990), for the years 1948-1986, and calculated for the years 1987-1988 as described in equation (4) with data collected from the Monthly Labor Review.

The definition of money is important in the empirical estimation. In October 1982, the Federal Open Market Committee (FOMC) officially de-emphasized M1 as an intermediate target variable in conducting monetary policy (Belongia 1990). Many people disagree about the appropriate definition of money to test its implications. In this study, the money supply is represented by M1 and M2. M1 is the most popular definition of money, which is the sum of currency held by the public and checkable deposits. Money supply is also represented by M2, or less liquid money. To examine the implications of different definitions of money, the M2 definition of money is employed along with M1.

CHAPTER 4

EMPIRICAL RESULTS

Introduction

The objective of this chapter is to provide empirical estimates of the models developed in the prior chapter. The first section examines Model 1, utilizing the various measures of aggregate economic activity as discussed. The next section examines the empirical estimation of Model 2, in which the money surprise is included as an explanatory variable. Next, the hypothesis concerning the indirect effect of money surprises on real activity is examined, and the results of the other hypotheses are illustrated. The final section examines the decomposition of variance. In each section the signs of the coefficients and their significance are determined, and the prior stated hypotheses are tested.

Model 1: Empirical Estimation

Model 1 was estimated utilizing the civilian unemployment rate, the log value of output, and the log value of employment as the measures of real aggregate economic activity. The explanatory variables utilized include a constant, μ, the proxy for the natural rate of real activity, SIG, a lagged value of the measure of real activity, X, the output price surprise, PS, and the energy price surprise, QS.

Model 1 was first estimated using unemployment as the dependent variable. Both M1 and M2 were utilized as definitions of the money supply. RHO was employed to correct for the auto-regressive error as explained in the prior chapter. Equation (22) examines the formulation of Model 1 utilizing the unemployment rate as the measure of real activity as follows:

$$X(t) = \mu + \gamma SIG(t) + \lambda X(t-1) + \alpha PS(t) + \beta QS(t) + \nu(t). \quad (22)$$

Model 1 was also estimated utilizing output, real GNP, and employment as the dependent variables. Exactly the same system is estimated as with unemployment as the dependent variable, except the first difference form is utilized due to the nonstationary series of output and employment as discussed earlier. Therefore, Model 1, utilizing either output or the unemployment rate as the measure of real activity can be specified in equation 23 as follows:

$$DY(t) = \mu + \delta DSIG(t) + \lambda DY(t-1) + \alpha DPS(t) + \beta DQS(t) + \nu(t). \quad \textbf{(23)}$$

This equation, whether it be for output or unemployment, is again estimated with the equations that determine the proxy variables, using nonlinear three stage least squares.

Table 3 reports the results of Model 1 using unemployment, output, and employment as the dependent variables for the period 1948-1988 as is illustrated on the following page.

Table 3

Model 1: 1948-1988

Panel A: M1 definition of Money

Depen. Var.	Cons.	SIG	X(t-1)	PS(t)	QS(t)	RHO
Unemployment	.0251	.3398	.5499	-.3484	.0003	.576
T-ratio	1.04	2.02	1.27	1.94	.01	1.31
					R^2 = .7285	
Output	.0314	-.5780	.3539	.6493	-.0350	N/A
T-ratio	3.46	2.69	2.12	2.34	.93	N/A
					R^2 = .5825	
Employment	.0150	-.5110	.3273	.4966	.0242	N/A
T-ratio	2.54	2.06	1.77	1.87	.79	N/A
					R^2 = .5380	

Panel B: M2 Definition of Money

Depen. Var.	Cons.	SIG	X(t-1)	PS(t)	QS(t)	RHO
Unemployment	.0331	.2894	.4141	-.4929	.0019	.719
T-ratio	1.78	1.94	1.32	2.56	.09	3.00
					R^2 = .7380	
Output	.0314	-.2502	.2905	1.118	-.0502	N/A
T-ratio	3.61	1.67	1.99	4.19	1.50	N/A
					R^2 = .4408	
Employment	.0141	-.4270	.2984	.7399	.0019	N/A
T-ratio	2.49	1.65	1.63	2.49	.32	N/A
					R^2 = .3810	

As noted, the equations that determine the proxy variables are estimated jointly with the equations that determine the level of real activity. Table 4 reports the results of the estimates from the other equations, or the equations that determine the proxy variables, for the three definitions of real activity and utilizing the M1 definition of money.

Table 4

Model 1: Estimates of Other Equations
Panel A: Unemployment

MODELS	Unemployment	Output	Employment
VARS.			
X(t-1)	.1010	.0519	.1069
	(.47)	(1.17)	(1.04)
SIGMA(t-1)	-.2547	-.1966	-.1019
	(1.39)	(1.12)	(.50)
M1(t-1)	.0799	.0916	-.0248
	(.59)	(.72)	(.18)
M1(t-2)	-.0179	.0177	.0697
	(.12)	(.12)	(.44)
Q(t-1)	.0754	.0955	.0696
	(2.61)	(3.01)	(2.19)
Q(t-2)	-.0842	-.0718	-.0722
	(2.80)	(2.16)	(2.13)
P(t-1)	1.580	1.451	1.527
	(12.7)	(9.18)	(10.1)
P(t-2)	-.6422	-.6053	-.5933
	(4.20)	(3.93)	(3.49)
R^2	.9995	.9995	.9994
Q(t-1)	1.321	1.051	1.088
	(1.57)	(1.10)	(1.24)
Q(t-2)	-.3467	-.1049	-.1348
	(.41)	(.11)	(.15)
DUM(t)	-.0571	-.0247	-.0263
	(.52)	(.22)	(.24)
DUM(t)Q(t-1)	-.1578	.1375	.0701
	(.18)	(.08)	(.08)
DUM(t)Q(t-2)	-.0764	-.3305	-.2738
	(.09)	(.30)	(.30)
R^2	.9401	.9386	.9386
PST	-.1334	-.4348	-.1834
	(.60)	(.98)	(.98)
QST	-.0151	.0074	-.0094
	(.53)	(.34)	(.34)
R^2	.0474	.1520	.1520

Examining the results from Model 1 using unemployment, the estimates are of the predicted, or hypothesized signs: a negative α, a positive β, and a positive δ were obtained. This supported the hypotheses that unemployment should be negatively related to errors in predicting the price level and positively related to errors in predicting the economy wide average of energy prices.

Using a five percent level of significance it is found that the estimates of SIG(t), X(t-1), and PS(t), are all significant when either M1 or M2 are employed as the measure of the money supply. RHO is significant with the M2 definition of money. A surprising result is in the estimate of the energy surprise, QS(t). The t-ratios of .01 and .09, using M1 and M2 respectively, establish insignificance of the energy price surprise. This result differs from Gray and Spencer's analysis, in which the energy price surprise was found to be significant, although they note that energy price surprises are occasionally insignificant in some of their formulations. This result also tends to refute the claim that oil market disturbances have been a prominent cause of post-World War II business cycles.

Examining the significant estimates utilizing unemployment as the measure of activity, indicates that a one percent increase in SIG(t) causes a .29 to .34 percentage point increase in the unemployment rate. A one percent increase in lagged unemployment causes a .41 to .55 percentage point increase in the unemployment rate. Finally, a one percent increase in PS(t) leads to a .34 to .49 percentage point decrease in the unemployment rate.

It should be noted that in estimation of this model, there seems to be a problem with robustness. The model was run using unemployment in percent terms, such as 3.8 for 1948, and also using unemployment as the percent divided by 100, such as .038 for 1948. The simple change in the scale of the dependent variable, caused a large degree of variation in the results. This leads to the conclusion that it is not a very robust model.

Model 1 was next estimated using the log value of output, real GNP, as the dependent variable. Again, the parameter estimates have the predicted signs. Using output as the dependent variable, a positive α, a negative β, and a negative δ were obtained. This supports the prediction that deviations of output should be negatively related to energy price surprises. Also, the estimate on SIG is of the predicted sign. Deviations of output should be negatively related to interindustry changes in employment, and thus the results verify this.

The estimated coefficients on the variables DSIG(t), DY(t-1), and DPS(t) are all significant at the .05 level when either M1 or M2 is employed. Using output as the measure of real activity, it is found that the estimate of the energy price surprise is not significant. This reaffirms the result as when unemployment was utilized as the measure of real activity.

Examining the significant estimates, a one percent increase in DSIG(t) leads to a .25 to .58 percentage point decrease in output. A one percent increase in lagged output causes a .29 to .35 percentage point increase in output, while a one percent output price surprise causes a .6493 percentage point increase in output. As noted, the estimate on the energy price surprise was found to be insignificant.

Finally, examining the results of Model 1 using employment, the sign of the estimate concerning the energy price surprise does not support the hypothesis. It was predicted, as in the case of output, that deviations from employment should be negatively related to energy price surprises. The estimate gives a positive coefficient on the energy price surprise. However, the estimate is not statistically significant.

The estimates on the variables DSIG(t), DX(t-1), and DPS(t) are all significant at the .1 level when either M1 or M2 are employed. Examining these significant estimates, indicates that a one percent increase in DSIG(t) leads to a .43 to.51 percentage point increase in employment. A one percent increase in lagged employment causes a .30 to .33 percentage point increase in employment, while a one percent output price surprise causes a .50 to .74 percentage point increase in employment.

As was noted earlier, the estimators seem to be sensitive to outliers. An estimator is said to be robust if its desirable properties are not sensitive to violations of the condition under which it is optimal (Kennedy, 1989). The estimators from Model 1 seem to be nonrobust.

Model 2: Empirical Estimation

Model 2 includes a measure of unanticipated money supply in addition to the explanatory variables in Model 1. As with Model 1, three different measures of real activity were utilized; the unemployment rate, the log value of private output, and the log value of private employment. Two definitions of the money supply, M1 and M2, are again employed in the analysis.

Model 2 was first estimated utilizing the civilian unemployment rate. The model was estimated using annual data for the years 1948-1988. The error term in the unemployment model is assumed to follow an Ar(1) process. Thus, in the case of unemployment, RHO is utilized to correct for the serial correlation. Equation (24) examines the formulation of Model 2, using unemployment as the dependent variable as follows:

$$X(t) = \mu + \delta SIG(t) + \kappa X(t-1) + \alpha PS(t) + \beta QS(t) + c MS(t) + e(t). \quad (24)$$

This equation is estimated jointly with the equations that determine the proxy variables. Model 2 differs from Model 1 in that a proxy variable was developed to determine the money surprise variable. Nonlinear three stage least squares was again employed as the estimation technique. In the case of output or employment, again the same system is estimated but in first difference form due to the nonstationarity of the series. Table 5 reports the results of Model 2 as follows:

Table 5

Model 2: 1948-1988

Panel A: M1 definition of Money

Depen. Var.	Cons.	SIG	X(t-1)	PS(t)	QS(t)	MS(t)
Unemployment	.0188	.4866	.6675	-.6497	.0297	.210
T-ratio	1.02	1.24	2.09	2.18	.86	1.10
				R^2 = .7172		
Output	.0268	-.4738	.4440	.9160	-.0579	-.106
T-ratio	2.84	1.95	2.49	2.67	1.27	.46
				R^2 = .4408		
Employment	.0145	-.5351	.3149	.7344	-.0061	-.275
T-ratio	2.21	1.91	1.58	2.19	.13	1.18
				R^2 = .3810		

Table 5 (cont.)

Panel B: M2 Definition of Money

Depen. Var.	Cons.	SIG	X(t-1)	PS(t)	QS(t)	MS(t)
Unemployment	.0251	.3397	.5499	-.4484	.0028	.2129
T-ratio	1.04	1.64	2.01	1.99	.01	1.25
					R^2 = .7072	
Output	.0297	-.2504	.2986	1.051	-.0503	-.106
T-ratio	3.36	1.45	1.82	2.68	1.38	.65
					R^2 = .4308	
Employment	.0161	-.4018	.2401	.7696	.0005	-.116
T-ratio	2.61	1.47	1.27	2.44	.01	.67
					R^2 = .4148	

The equations that determine the proxy variables were again estimated jointly with the equations that determine the level of real activity. Table 6, on the following page, illustrates the estimates of these other equations, using unemployment as the measure of real activity and M1 as the definition of money.

Table 6

Model 2: Estimates of Other Equations

MODELS Vars.	Unemployment	Output	Employment
X(t-1)	.4568	.0086	-.0062
	(1.99)	(.20)	(.06)
SIGMA(t-1)	-.6189	-.4475	-.3913
	(3.90)	(2.67)	(2.01)
M1(t-1)	.1777	.0584	.0552
	(1.20)	(.43)	(.37)
M1(t-2)	.0367	.0985	.0975
	(.23)	(.64)	(.58)
Q(t-1)	.1144	.1026	.0948
	(4.47)	(3.59)	(3.21)
Q(t-2)	-.0975	-.0928	-.0896
	(3.77)	(3.11)	(2.93)
P(t-1)	1.557	1.519	1.556
	(12.9)	(9.97)	(10.7)
P(t-2)	-.8022	-.6903	-.7142
	(5.33)	(4.58)	(4.21)
MST	.4733	.4470	.4077
	(4.65)	(3.89)	(3.26)
R^2	.9997	.9996	.9996
Q(t-1)	1.550	1.419	1.363
	(2.06)	(1.70)	(1.78)
Q(t-2)	-.6068	-.4839	-.4219
	(.80)	(.58)	(.55)
DUM(t)	-.0348	-.0211	-.0193
	(.32)	(.19)	(.18)
DUM(t)Q(t-1)	-.3648	-.2193	-.1881
	(.47)	(.26)	(.24)
DUM(t)Q(t-2)	.1814	.0493	.0117
	(.23)	(.06)	(.01)
R^2	.9387	.9391	.9396
PST	-.1729	-.4338	-.1560
	(.53)	(1.78)	(.75)
QST	-.0150	-.0056	-.0142
	(.41)	(.18)	(.47)
MST	-.0950	.0437	-.1245
	(.48)	(.25)	(.80)
R^2	.1153	.0945	.1250
M1(t-1)	1.264	1.129	1.182
	(6.07)	(5.97)	(5.88)
M1(t-2)	.2310	-.1072	-.1675
	(1.05)	(.55)	(.83)
X(t-1)	.1542	.0391	.0893
	(.60)	(1.21)	(.71)

Table 6 (cont.)

PI(t-1)	.2118	.1067	.1443
	(1.32)	(.63)	(.86)
RI(t-1)	-.0026	-.0021	-.0025
	(1.69)	(1.49)	(1.35)
R^2	.9990	.9991	.9990

Examining the results of Model 2, using unemployment, a negative α, a positive δ, and a positive β were obtained. This supports the predictions that deviations of unemployment should be negatively related to errors in predicting the price level, and positively related to errors in predicting the economy wide average of energy prices and the size of the industry specific disturbances. Examining the sign of the coefficient on the money surprise, γ, a positive relationship is obtained. This is contrary to the prediction that deviations of unemployment should be negatively related to errors in predicting the money stock. Theoretically speaking, a surprise increase in the money stock should lead to a reduction in interest rates, which causes an increase in investment, and thus an increase in output and employment. Therefore, a decrease in unemployment is expected. There is also a real balance effect or the Pigou effect which is the direct stimulus to aggregate demand caused by an increase in the real money supply and does not require a decline in the interest rate. It is the direct stimulus to consumption spending that occurs when a price deflation causes an increase in the real money supply (Gordon 1990).

Next, the significant estimates were examined. The estimates on the variables of lagged unemployment and the output price surprise were found to be significant. The rest of the variables were found to be insignificant. Once again, as in Model 1, the energy price surprise was found not to have an effect on unemployment. Thus, deviations of unemployment seem to be unaffected by the supply side disturbances, while demand driven disturbances were significant.

In testing the direct effect of the money surprise on unemployment, this estimate was found to be insignificant. Thus, a surprise in the money stock is shown to have no direct effect on unemployment. However, the money surprise was utilized in the output price equation, which develops the proxy for the output price surprise. This is reillustrated in equation (25) as follows:

$$P(t) = a_0 + a_1X(t-1) + a_2SIGMA(t-1) + a_3M(t-1) + a_4M(t-2) + a_5Q(t-1) + a_6Q(t-2) + a_7P(t-1) + a_8P(t-2) + +a_9MS(t) + \eta(t) \qquad (25)$$

Examining the estimate on the coefficient of the money surprise, using M1, a_9 = .4733 with a t-ratio of 4.65. The money surprise is found to have a significant effect on prices, and thus, it is found to indirectly effect unemployment via the price surprise, but has no direct effect on unemployment.

Next, examining the results of Model 2 utilizing output as the dependent variable all estimated coefficients exhibit the predicted signs except for the estimates of the money surprise. The hypotheses are supported that output should be positively related to errors in predicting the price level, and negatively related to errors in predicting the economy wide average of energy prices. The hypothesis is rejected concerning the sign of the money surprise. It was predicted that surprise increases in the money stock should lead to an increase in output. The evidence is contrary to this hypothesis.

Next, examining the significant estimators, it was found that DSIG(t) is significant at the .1 level when M1 is utilized, and insignificant when M2 is used. Lagged output and the price surprise are also found to be significant in explaining output, with the price surprise being strongly significant when M2 is employed. The energy price surprise and the money surprise were again found to be insignificant when either M1 or M2 were employed. These results support the results obtained when unemployment was used as the dependent variable.

Finally, the separate effect of the money surprise on prices was examined to determine if the money surprise has an indirect effect on output. Examining the estimate on the money surprise utilized in the price equation, as equation (25) pointed out, $a_9 = .4470$ with a t-ratio of 3.89. Thus, the money surprise is strongly significant in determining prices and therefore affects output indirectly via the price surprise.

Finally, Model 2 was examined using the log value of private employment as the measure of real activity. Examining the signs of the estimates, all estimators exhibit the predicted signs except, once again, the estimate of the money surprise.

Next, examining the significance of the estimates, it is found that the output price surprise is the only significant variable when either M1 or M2 are employed. Lagged employment, the energy price surprise, the money surprise, and the proxy for industry specific disturbances are all found to be insignificant. The output price surprise appears to be the only variable that explains anything about employment in Model 2. As with the other measures of real activity, the energy price surprise and the money surprise are insignificant.

In determining the indirect effect of the money surprise, as illustrated in equation (23), $a_9 = .4077$ with a t-ratio of 3.26. Thus, once again the money surprise has no direct effect on the measure of real activity, but operates indirectly through the price surprise.

Examination of the Hypotheses

It was determined that the money surprise has no direct effect on the measures of real activity. However, it may have an indirect effect via the price surprise. To examine the null hypothesis that includes both the direct and indirect effects, the null hypothesis can be determined by equation (26) as follows:

$$dX/dMS = \partial X/\partial MS + \partial X/\partial PS * \partial PS/\partial MS \qquad (26)$$

Solving this equation the result = $\gamma + \alpha a_9$. Thus the null hypothesis is Ho: $\gamma + \alpha a_9 = 0$. Examining the indirect effect, the null hypothesis becomes Ho: $\alpha a_9 = 0$, and after solving for the assymptotic t-statistic we get $\alpha a_9/\sigma \sim t$ with degrees of freedom for k equal to $(k_\alpha + k_{a9})/2$. The estimated value of σ is given by equation (27) as follows:

$$\sigma = a_9^2 \, v(\alpha) + \alpha^2 \, V(a_9) + 2 \, \alpha a_9 \, Cov(\alpha, a_9). \qquad (27)$$

Computing these numbers, a t-value of 1.90 is obtained, which is significant at the 5 percent level. Also, $\hat{\alpha}a_9$ = -.308, so a one percent increase in the money supply causes a decline in the unemployment rate of approximately .3 percentage points.

Tables 7 and 8 summarize the hypotheses for Model 1 and Model 2 respectively. The first column indicates whether the sign of the estimated coefficient is consistent with theoretical prediction. The second column indicates whether the null hypothesis of a zero coefficient would be rejected at the 5 percent level, 10 percent level, or would not be rejected at either of these in a one tailed test. All results are for the M1 definition of money.

Table 7

Model 1: Hypotheses

REAL ACTIVITY/ Ind. Variable	HYPOTHESIS SIGN	SIGNIFICANCE
UNEMPLOYMENT		
SIG(t)	Consistent	0.1
PS(t)	Consistent	0.1
QS(t)	Consistent	Fail to Reject
OUTPUT		
SIG(t)	Consistent	0.1
PS(t)	Consistent	0.1
QS(t)	Consistent	Fail to Reject
EMPLOYMENT		
SIG(t)	Consistent	0.1
PS(t)	Consistent	0.1
QS(t)	Inconsistent	Fail to Reject

Table 8

Model 2: Hypotheses

REAL ACTIVITY/ Ind. Variable	Hypothesis: SIGN	Hypothesis: SIGNIFICANCE
UNEMPLOYMENT		
SIG(t)	Consistent	Fail to Reject
PS(t)	Consistent	0.1
QS(t)	Consistent	Fail to Reject
MS(t)	Inconsistent	Fail to Reject
OUTPUT		
SIG(t)	Consistent	0.1
PS(t)	Consistent	0.1
QS(t)	Consistent	Fail to Reject
MS(t)	Inconsistent	Fail to Reject
EMPLOYMENT		
SIG(t)	Consistent	Fail to Reject
PS(t)	Consistent	0.1
QS(t)	Consistent	0.1
MS(t)	Inconsistent	Fail to Reject

Variance Estimation

The amount of variation in unemployment that can be attributed to the independent variables for both Model 1 and Model 2 is next established. As was explained in the prior chapter, this allows for the determination of how much of the variation in unemployment is explained by the various independent variables.

Entering the computed values for the parameter estimates, the variances, and the covariances allows for the determination of the variance of unemployment. Dividing each right-hand-side estimate by the variation in unemployment establishes the proportion of the variation in unemployment explained by the independent variables. Table 9 examines the results of the percent variation in unemployment for both Models 1 and 2.

Table 9

Percentage of Variation in Unemployment (X) Explained by the Independent Variables

VARIABLES	Model 1	Model 2
$k^2V(X_{t-1})$	39.5%	51.0%
$\delta^2V(SIG)$	9.5%	10.0%
$\alpha^2V(PS)$	7.9%	11.1%
$\beta^2V(QS)$	0.0%	1.3%
$c^2V(MS)$	N/A	3.5%
Residual	52.3%	32.5%
$2\delta\alpha C(SIG,PS)$	-0.2%	0.0%
$2\delta\beta C(SIG,QS)$	0.0%	0.0%
$2\delta c C(SIG,MS)$	N/A	0.0%
$2k\delta C(X_{t-1},SIG)$	-4.3%	-3.8%
$2k\alpha C(X_{t-1},PS)$	-0.3%	0.0%
$2k\beta C(X_{t-1},QS)$	0.0%	0.0%
$2kc C(X_{t-1},MS)$	N/A	0.6%
$2\alpha\beta C(PS,QS)$	-4.2%	-2.4%
$2\alpha c C(PS,MS)$	N/A	0.0%
$2\beta c C(QS,MS)$	N/A	-3.0%

Examining the results from Table 9, in Model 1 the residual term accounts for the greatest amount of variation in unemployment. Lagged unemployment explains over 39 percent of the variation in unemployment, which is the next highest amount of variation explained. The significant variables corresponding to the price surprise and the proxy of industry specific disturbances together explain more than 17 percent of the variation in unemployment. Whereas, the energy price surprise explains practically nothing in terms of the variation in unemployment.

Next, examining Model 2 which incorporates the money surprise, the variation in unemployment is explained the most by lagged unemployment, which accounts for over 50 percent of the variation. The residual term accounts for the next meaningful portion of the variation. The other significant estimate in Model 2, besides lagged unemployment, is the price surprise. This estimate explains 11 percent of the variation in unemployment. The proxy for industry specific disturbances explains 11 percent of the variation. This result is curious since this variable was found to be insignificant in Model 2.

The results confirm the assumption that the covariances approach zero, and thus explain an insignificant amount of the variation in unemployment.

CHAPTER 5

SUMMARY AND CONCLUSIONS

The objectives of this study were fourfold. First, a previous study was replicated with an extension of two years of data. From this a determination of the effects of price surprises, energy price surprises, and the natural rate of real activity was established. Secondly, money surprises were incorporated into the model to determine the effects of price surprises, energy price surprises, money surprises, and the natural rate of real activity on real economic activity. Next, money surprises were examined to determine if money had an indirect effect on real activity through prices. Finally, for both models developed, the amount of variation in unemployment explained by the various independent variables was calculated.

Most economists, and prior studies, acknowledge the primary relationship between changes in the nominal quantity of money and changes in the aggregate price level. Establishing a link between nominal money and the business cycle has long been debated by macroeconomists. The U.S.

economy has also experienced several energy crises over the past 45 years. It has been noted that all but one of the last eight recessions were immediately preceded by an oil price shock, leading some economists to conclude that oil market disturbances have been a prominent cause of post World War II business cycles.

Some influential macroeconomists have concluded that the channels through which aggregate demand influences the economy have yet to be identified. These earlier studies found a minor role of the effect of price surprises on real economic activity. Gray and Spencer's 1990 study did identify an important channel, namely price surprises, through which aggregate demand influences the real sector.

In this study, we first reexamine the role of price prediction errors and energy price surprises in determining the level of real aggregate activity. A proxy for the variance of industry-specific disturbances is included as an explanatory variable in the models. This allows a measure of the natural rate of aggregate real activity. These models were estimated using U.S. annual data over the period 1948-1988. Unemployment, output, and employment were all used as measures of real activity. The following conclusions are drawn from Model 1:

1. The data are consistent with the prediction that demand driven price level surprises are positively and significantly correlated with aggregate real

economic activity. This confirms the results obtained by Gray and Spencer.

2. The data fail to support the hypothesis that energy price surprises are negatively and significantly correlated with aggregate real economic activity. The energy price surprises were found to be insignificant using any of the measures of real activity. The signs corresponding to the energy price surprise almost always exhibited the predicted values.
3. The natural rate measure is supported by the data. The hypothesized signs and significance are supported utilizing all measures of real activity.

Next, money surprises were incorporated into the model. The output price surprises, energy price surprises, money surprises, and the natural rate were employed together to determine the effects on real economic activity. Again, the model was estimated using U.S. annual data over the period 1948-1988. The following conclusions are drawn from Model 2:

1. The data are again consistent with the hypothesis that demand driven price level surprises are positively and significantly correlated with aggregate real economic activity.
2. The data fail to support the hypothesis that

energy price surprises are significantly correlated with aggregate real activity. Energy price surprises were found to be insignificant, although exhibiting the hypothesized signs.

3. The estimate of the natural rate measure is found to be insignificant, although weak significance is found in some of the formulations. The data support the predicted signs.
4. The data fail to support the hypothesis that money surprises are significantly correlated with real activity. The signs on the money surprise estimates also fail to support the predictions.
5. Finally, it was found that money surprises do have an indirect effect on real activity. The data support the hypothesis that money surprises are strongly and significantly correlated with prices, and thus have an indirect effect on real activity.

Next, the amount of variation in unemployment explained by the various independent variables for both models was examined. In Model 1, lagged unemployment explained over 39 percent of the variation. The estimates of the price surprise and the natural rate together explained over 17 percent of the variation in unemployment. In Model 2, lagged unemployment explained over 50 percent of the variation in unemployment. The estimate of the industry specific disturbance and the price surprise together explained 21 percent of the variation.

In summary, it is interesting that when money surprises are included along with price surprises the money surprises explain nothing. The demand driven price surprises were found to explain a lot in terms of business cycles. Also, when energy price surprises, or supply side disturbances, are included with the other variables they are found to be insignificant. This result implies that oil market disturbances have not been a prominent cause of post WWII business cycles. Another interesting result is that the variables of interest explain very little in terms of the variation in unemployment.

Further research could be ensued by estimating the models with exclusion of various explanatory variables. Estimating Model 2 with the exclusion of the output price surprise could establish a more direct test of the money surprise on real economic activity. This is left for future research.

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