

1996

Comparison of explanatory power and forecasting performance for inflation-rate models

Pi-Liang Sung
Iowa State University

Follow this and additional works at: <https://lib.dr.iastate.edu/rtd>

 Part of the [Economics Commons](#)

Recommended Citation

Sung, Pi-Liang, "Comparison of explanatory power and forecasting performance for inflation-rate models" (1996). *Retrospective Theses and Dissertations*. 17172.
<https://lib.dr.iastate.edu/rtd/17172>

This Thesis is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.

Comparison of explanatory power and forecasting performance for
inflation-rate models

by

Pi-Liang Sung

ISU
1996
5862
c. 3

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE

Department: Economics

Major: Economics

Major Professor: Dennis R. Starleaf

Iowa State University

Ames, Iowa

1996

Copyright © Pi-Liang Sung, 1996. All rights reserved.

Graduate College
Iowa State University

This is to certify that the Master's thesis of
Pi-Liang Sung
has met the thesis requirements of Iowa State University

Signatures have been redacted for privacy

TABLE OF CONTENTS

ACKNOWLEDGMENTS	vii
CHAPTER 1 INTRODUCTION	1
Review of Inflation in U.S.	1
Statement of the Problem	4
Objective	5
Organization	5
CHAPTER 2 LITERATURE REVIEW	6
CHAPTER 3 THEORETICAL AND EMPIRICAL MODELS	15
Theoretical Models	15
Empirical Specification	20
Empirical Models	21
The general model	22
The monetarist model	23
The expectations-augmented Phillips-curve model	23
CHAPTER 4 EMPIRICAL ANALYSIS	25
Data Description	25
Selection of the Appropriate Lag Lengths of Variables	26
Model specification	29
Regression Analysis	35
Correlation coefficients	35

Parameter estimates for three models	36
Out-of-Sample Forecasting Tests	37
Discussion	42
CHAPTER 5 SUMMARY AND CONCLUSIONS	49
Summary	49
Conclusions	51
APPENDIX COMPUTER PROGRAMS	53
REFERENCES	70

LIST OF TABLES

Table 1.1	The average annual rates of inflation over some important periods	2
Table 4.1	The SBC of each variable	28
Table 4.2	Correlation coefficients between the inflation rate and variables .	36
Table 4.3	The parameter estimates for the general model, Q1/1957 - Q1/1994	38
Table 4.4	The parameter estimates for the monetarist model, Q1/1957 - Q1/1994	39
Table 4.5	The parameter estimates for the expectations-augmented Phillips- curve model, Q1/1957 - Q1/1994	40
Table 4.6	Values of one-step-ahead forecasts, Q1/1990 - Q1/1994	43
Table 4.7	MSE for three models	48

LIST OF FIGURES

Figure 1.1	The U.S. quarterly rates of inflation, Q1/1957 - Q1/1994	3
Figure 4.1	SBC of π	30
Figure 4.2	SBC of \hat{M} and \hat{G}	31
Figure 4.3	SBC of \hat{w} and LBF	32
Figure 4.4	SBC of $\hat{P}G$ and RPE	33
Figure 4.5	SBC of RPF and gap	34
Figure 4.6	Observed values v.s. predicted values (general model)	44
Figure 4.7	Observed values v.s. predicted values (monetarist model)	45
Figure 4.8	Observed values v.s. predicted values (expectations-augmented Phillips-curve model)	46

ACKNOWLEDGMENTS

For the completion of this thesis, I would like to thank my major professor, Dr. Dennis R. Starleaf, for his encouragement, guidance, and patience. I appreciate his time on reading an earlier draft of this thesis and correcting my English. This study could not be finished without his help.

I would also like to thank the other members of my committee, Dr. Helen H. Jensen and Dr. Mark Kaiser, for their suggestions and comments on my research.

Additionally, I am very grateful to my parents and sisters for their understanding and financial support.

Finally, I would like to give many thanks to Yang, Li for his help with my statistical analysis and computer skills during this process. Without his helpful guidance, I can not finish this research on time.

CHAPTER 1 INTRODUCTION

Inflation is an important concern for most people and it is also a serious macroeconomic problem confronting policymakers. What is inflation? By definition, inflation is a “persistent” upward movement in “the general price level of goods and services”. Notice that it concerns the general level of prices, not just one or two individual prices, and it is a continuing phenomenon, not just a single increase in the price level. The measurement of observed rates of inflation is the rate of change of an index of prices such as the Implicit Price Deflator for Gross National Product (IPDGNP) or the Consumer Price Index (CPI).

Review of Inflation in U.S.

Here, we will review the U.S. time series data on inflation measured by fixed-weight GNP price deflator. Figure 1.1 plots quarterly rates of inflation from Q1/1957 to Q1/1994, and Table 1.1 reports average annual rates of inflation over some important periods. Over the past almost forty years, the average annual rate of inflation was 4.416 percent, shown in the first row of Table 1.1. Before Q3/1967 the average rate of inflation was 2.116 percent per year; this was a period of low and steady inflation. This was followed by a slow climb in inflation from Q3/1967 to Q2/1970, the rate of inflation averaged about 5.123 percent. However, dramatic changes in inflation occurred in Q3/1970, Q4/1970 and Q1/1971. After that, the rate rose slowly again. The average rate of inflation was about 5.719 percent per year from Q2/1971 to Q4/1973. In the pe-

riods Q1/1974 - Q4/1975 and Q1/1980 - Q4/1981, there were two inflationary bursts as the inflation rate rose to 5.8 percent and above. The rate of inflation went down sharply from a peak of nearly 11.12 percent in Q1/1980 - Q4/1981 to value below 5.84 percent for Q1/1982 - Q4/1985. During Q1/1986 - Q4/1989, the rate of inflation averaged about 3.528 percent per year. After 1990 the inflation rate continuously fell to about 1.36 percent in Q3/1992, Q3/1993 and Q4/1993. For Q1/1990 - Q1/1994, the average rate of inflation was low at about 2.968 percent per year.

Table 1.1 The average annual rates of inflation over some important periods

Period	Average Rates of Inflation
Q1/1957 - Q1/1994	4.416
Before Q3/1967	2.116
Q3/1967 - Q2/1970	5.123
Q2/1971 - Q4/1973	5.719
Q1/1974 - Q4/1975	8.864
Q1/1980 - Q4/1981	9.288
Q1/1982 - Q4/1985	4.020
Q1/1986 - Q4/1989	3.528
After Q1/1990	2.968

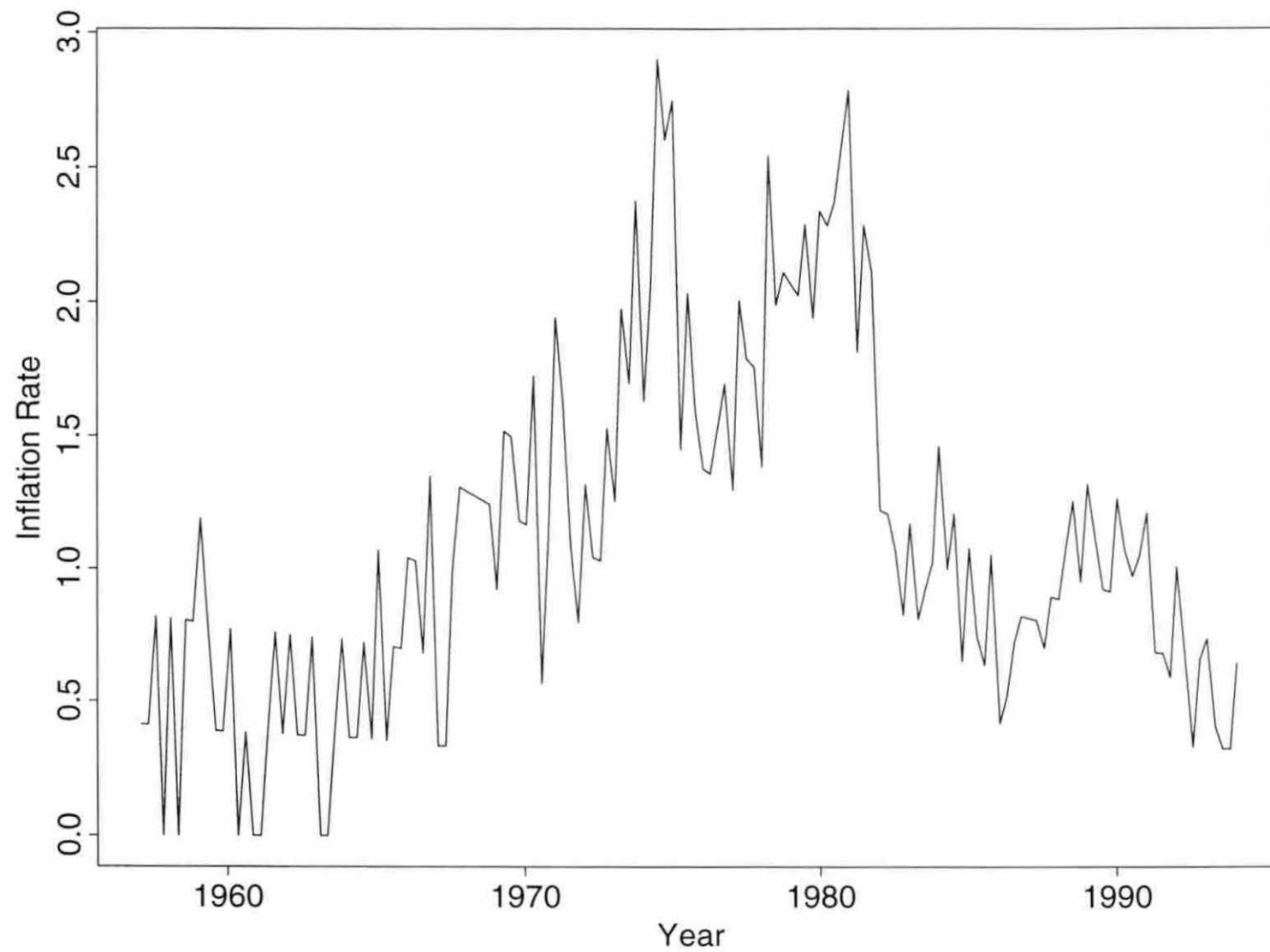


Figure 1.1 The U.S. quarterly rates of inflation, Q1/1957 - Q1/1994

Statement of the Problem

During several decades, many macroeconomists have presented a variety of theories and built different models to explain inflation. Forecasters and inflation analysts have tried to predict and understand the variables which affect inflation. There are several schools of macroeconomic thought such as monetarism, Keynesian, New Classical Economics and expectations-augmented Phillips curve. In the monetarism view, which is similar to modern versions of the quantity theory of money, inflation is primarily a monetary phenomenon. Changes in the money supply have primary effect on the price level, especially over the long run. The evidence shows that money growth and inflation are not related closely in the short period, and monetarists generally believe that monetary policy has powerful short-term effects on the real economic activity. In the Keynesian view, economic slack as measured by the unemployment rate is important in explaining the rate of inflation. Inflation reacts positively to excess demand for goods and services, and negatively to excess supply. Changes in the rate of inflation are determined by the gap between potential output and actual output, and also by exogenous forces. The New Classical Economics (rational expectations macroeconomics) assumes continuous market clearing and rational behavior, but introduces incomplete information about prices. The rational expectations model with instantaneous market clearing claims that inflation adjusts immediately and fully to changes in anticipated monetary policy. The propositions of expectations-augmented Phillips curve are that inflation adjusts gradually in response to changes in economic slack due to adaptive expectations and nominal wage and price rigidities. Beyond these basic concepts, there are many branches having controversial propositions and varieties of models. Which theory can explain the most? Which model can predict well? Whom should we believe? Haslag and Ozment (1991) have suggested that a general model combining the monetarist and expectations-augmented Phillips-curve models is a good approach with strong explanatory power on inflation. They

argue that the monetarist models ignore the nonmonetary effects and the expectations-augmented Phillips-curve models ignore the monetary effects, so that these two models by themselves do not explain inflation sufficiently and successfully. However, the general model encompasses the monetarist and expectations-augmented Phillips-curve models and yields better predictions of the rate of inflation than either of the two individual models. They retained all variables of these two models. But does the general model really explain the rate of inflation adequately if we extend the sample periods?

Objective

The objective of this study is to test whether the general model is superior to either the monetarist or expectations-augmented Phillips-curve models by using the U.S. quarterly data from Q1/1957 to Q1/1994. This study basically uses the models suggested by Haslag and Ozment. The sample period is extend from 1959-1988 to 1957-1994. However, the data collected are a little different and the method of selecting the appropriate lag lengths is also different. We believe that the results of this study provide better explanatory power on the rate of inflation from 1957 to 1994.

Organization

This study is organized as follows. Chapter 2 contains a comprehensive review of various studies of inflation. Chapter 3 identifies theoretical models and empirical models: the monetarist model, the expectations-augmented Phillips-curve model and the general model. Chapter 4 contains data description and methodology, selection of the appropriate lagged values of dependent and independent variables, regression results and forecast performance, and compares the different results. Chapter 5 provides a summary of the results and conclusions of this study.

CHAPTER 2 LITERATURE REVIEW

Much literature has been published on the topic of inflation. Macroeconomic analysts have explored the causes of inflation. Money growth has been considered the main causal factor for inflation, especially in the long term. However, many nonmonetary factors such as relative price of energy, relative price of food, government expenditures, actual output, potential output, capacity utilization, the unemployment rate, the natural rate of unemployment, the foreign exchange value of the dollar, growth in private and public debt and interest rates are thought to influence the inflation rate.

Barth and Bennett (1975) empirically tested the causal relationships among four economic variables in the post-World War II period. These variables are the wholesale price index, the consumer price index, the money supply, and the hourly wages of production workers. There are two basic schools of thought on inflation: cost-push and demand-pull. The cost-push advocates have insisted that the source of rising prices is market power rather than excess demand. Wages are raised by strong labor unions, and prices increase as wage costs are passed on to consumers. Besides this, there is another kind of market power. Prices are increased directly by oligopolistic firms. This view implies that when the monetary authority validates inflation to eliminate unemployment, the money supply is increased in response to the rise in the price level. In the view of demand-pull adherents or the monetarists, inflation occurs because of excessive money growth or too much money chasing too few goods. This view implies that the monetary authority causes inflation by permitting an excessive rate of increase in the nominal stock of money. If the inflation is primary demand-pull it means that there is a unidi-

rectional causal chain from the stock of money to prices. Conversely, if the cost-push theory is correct, the unidirectional causal chain is from prices to money. Furthermore, a unidirectional causal chain from wages to prices should be observed if labor union activity has caused the cost-push phenomenon. Barth and Bennett concluded there is a unidirectional causal link running from money to wholesale and consumer prices. They also found unidirectional causality running from consumer prices to wages. Their findings indicate the rate of inflation over the post-World War II period resulted from increases in the money supply. It is a demand-pull phenomenon, *i.e.*, the results support the monetarist view. These results are consistent with Milton Friedman's argument that "long-period changes in the quantity of money relative to output determine the secular behavior of prices. Substantial expansions in the quantity of money over short periods have been a major proximate source for the accompanying inflation in prices" [p.277]. Finally, they suggested that monetary policy is the appropriate weapon in the fight against inflation.

Andersen and Karnosky (1977) investigated the role of the growth rate of money as a factor leading to inflation. They used the modified St.Louis Federal Reserve Bank model. In the original model, the influence of monetary policy actions was measured by changes in the money stock and fiscal policy actions were measured by high-employment government expenditures. The model incorporated a recursive macroeconomic process. The recursive process was that one block decided changes in nominal GNP, and a second block decided the division of a given change in nominal GNP into changes in output and changes in the price level. In the modified St.Louis model the structural equations of each block are specified and these parameters are estimated by the direct estimation of reduced form equations. All equations are specified as log-linear in the variables. In addition, the modified model adds some exogenous variables. Andersen and Karnosky found that money growth was the basic source of inflation. When money growth increases aggregate nominal spending increases and market behavior of firms and suppliers of labor

services then leads to a faster rate of price increase. They also found that the faster growth of aggregate spending yields changes in the price level, unit labor costs, wage payments, and output per labor-hour.

Tatom (1981) tested a reduced-form model for nominal GNP, the price level and the unemployment rate to explain and assess the magnitude of energy price effects. His hypothesis was that an increase in the price of energy resources relative to the price of business output results in lower potential output, productivity and the optimal capital intensity of production. In addition, when energy prices rise, the rate of inflation moves in the same direction. Besides, there are temporary effects on total spending and employment. He found that during the periods of 1974-1975 and 1979-1980 when energy prices increased, potential output and productivity decreased, and the rate of inflation increased. Furthermore, total spending, actual output and the unemployment rate were affected temporarily by the rise in energy prices because of imperfect price flexibility. He concluded that changes in the energy prices affect the rate of inflation.

Fama (1982) used money-demand theory and a rational-expectations version of the quantity theory of money to analyze inflation. He ascertained that monthly, quarterly and annual data consistently indicate that rates of inflation have a positive relationship with the growth rate of money and a negative relationship with the growth rate of real activity. He also found that the monetary base (currency and bank reserves held against deposits) is the relevant monetary factor in the inflation process and that demand deposits (the major component of M1) are irrelevant. In addition, interest rates contain the best possible forecasts of inflation in efficient markets.

Hafer (1983) provided some evidence about the monetary and nonmonetary factors in explaining the rate of inflation. He reported that the average rate of money growth and the relative price of energy are correlated with inflation, and that the response of inflation to these variables is different in the long run from the short run. During the long run, there is a one-to-one correspondence between money growth and inflation. On the other

hand, nonmonetary factors have an important bearing on the inflation rate in the shorter term. He also presented a model showing that money growth and relative energy price effects are useful in forecasting short-term movements in inflation. The forecast results showed that the relative energy price influenced significantly the trend of inflation, and the relative energy price explains the difference between the actual rate of inflation and the rate determined by money growth alone. In 1984, Hafer published another paper on inflation. In this paper he again emphasized that inflation corresponds to the trend of money growth over the long run and that relative energy price affects short-run inflation. However, he also added the relative food price as an important determinant of short-run inflation. In other words, these two components, relative energy price and relative food price, temporally are significant factors influencing the rate of inflation.

King and Plosser (1984) provided a theoretical model which included two productive sectors with one intermediate and one final good. The model indicates that the variations in external money, real activity, the nominal interest rate, and a measure of the cost of banking services are important in explaining the movements in the price level.

Hill and Robinson (1989) indicated that nonmonetary factors such as the gap between actual output and potential output, changes in commodity prices, movements in the foreign exchange value of the dollar, and growth in private and public debt can be useful to predict inflation. Although money growth is the source of inflation, it does not mean the past changes in the money supply can forecast the rate of inflation well. Inflation ultimately occurs when the money supply exceeds money demand, and excess money growth produces an aggregate excess in the demand for goods and services. There are direct and indirect effects on product prices. The indirect effect is through the factor markets and the costs of production. In order to satisfy the demand for products, firms hire more labor and buy more raw factors of production. This high demand for the labor and factors leads to shortages, and wages and the factor prices rise. The rise in the factor prices is passed through to product prices. This analysis implies that information on

factor scarcity and factor prices should be useful in predicting inflation. They tested whether the wage growth and measures of factor scarcity are good predictors on inflation. The wage growth is measured as the growth in the total compensation of nonfarm employees. The factor scarcity is measured as the labor scarcity which is the difference between the unemployment rate and an estimate of the natural rate of unemployment and as capital scarcity which is the capacity utilization rate. They predicted inflation in the 1980s with a forecasting model which is derived from an analysis of inflation in U. S. consumer price from 1960 to 1980. They concluded that during the 1980s, wage growth and factor scarcity have proven more accurate as predictors of inflation than have M1 growth and M2 growth.

Ball (1993) ascertained that inflation occurs when the growth rate of money supply continuously exceeds the growth rate of output. Beyond that, the average rate of inflation is decided by the difference between the average rate of money growth and the average growth rate of output. In practice, money growth is the most essential factor and variation in output growth is the second one. However, various demand shocks such as government spending and price shocks such as food and energy prices should be responsible for the fluctuation of inflation over shorter periods. He thought that after 1950 the year-to-year fluctuations in U. S. inflation are mostly explained by the demand and price shocks. He also indicated that short-term changes in inflation affect the trend of long-term inflation because of inflationary expectations.

Weiner (1994) pointed out the relationship between the natural rate of unemployment and inflationary pressures. The natural rate of unemployment, the lowest possible unemployment rate that is consistent with stable inflation, is not observable but can be estimated. He presented estimates of the natural rate and the actual values of the unemployment rate from 1961 to 1994. He found that the actual unemployment rate has seldom equaled the natural unemployment rate. The relatively high level of the natural rate stems from an imperfect labor market. Individuals are unemployed at the natural

rate because they may have the wrong skills, have less motivation to accept jobs, live in the wrong place or their reservation wages are too high to be hired by employers. In the 1970s the natural rate of unemployment was high because the share of women and youths in the labor force was growing, and the two oil shocks and productivity decline enhanced the cost of labor. In the 1980s and 1990s, the natural rate of unemployment fell somewhat due to demographic trends such as the rapid decrease in the share of youths in the labor force. Forces tending to keep the natural rate high include the decline in manufacturing jobs relative to service jobs, the gap between high-technology job requirements and low-technology labor skills, and the downsizing and restructuring of firms. The unemployment gap between the actual unemployment rate and the natural unemployment rate is an indicator of inflationary forces. The unemployment gap equals the actual unemployment rate minus the natural unemployment rate. When the gap is negative, the actual unemployment rate is below the natural unemployment rate. Conversely, when the gap is positive, the actual unemployment rate is above the natural unemployment rate. A negative gap is associated with rising inflation in historical experience.

Garner (1994) argued that capacity utilization is still a reliable indicator of inflationary pressures. When real output grows sharply, competition for scarce productive resources puts direct pressure on wages and other production costs and then consumer price inflation increases. Some economists have claimed that the relationship between the capacity utilization rate (which measures the percent of the nation's industrial capacity currently in use) and the inflation rate is no longer valid because of the greater openness of the economy. Shortages of domestic goods can be offset with the imported goods. Moreover, capacity is not a constraint on economic growth because of the corporate reengineering, adoption of new computer and telecommunication technologies, and high levels of business equipment investment. However, Garner provided evidence to the effect that capacity utilization rate is related to the rate of inflation regardless

of international trade, rapid technological improvement or business investment. Most domestic goods and services are not traded internationally so that much of national output is effectively insulated from foreign markets. Furthermore, foreign products are not usually perfect substitutes for domestic residents.

Modigliani and Papademos (1975) observed that money growth presents very little significance to explain the rate of inflation, when the level of unemployment and many other nonmonetary variables are present in the model.

Davidson (1982) emphasized that it is not necessary and is counterproductive to concentrate on short-run price movements. The policymakers should focus on the appropriate long-run monetary goal and ignore short-run measurements of inflation because the monetary policies to fight short-run changes in the rate of inflation increase the risk of higher underlying or long-run trend of inflation. The short-run tight money following short-run inflation helps to generate recessionary conditions, resulting in longer periods of expansionary monetary policy and an increase in the trend growth rate of the money supply.

Stein (1982) provided evidence to the effect that the level of unemployment does not affect inflation when lagged money growth is taken into account. He insisted that "rapid money growth is inflationary at all levels of unemployment" [p.143].

Benderly and Zwick (1984) concluded that unemployment and lagged money growth affect the rate of inflation and relative energy price also strongly affects inflation. In contrast to the findings of both Modigliani-Papademos and Stein, they emphasized that both the level of unemployment and lagged money growth affect inflation when using a preferred measure of unemployment and assuming the effect of energy prices.

Mehra (1991) noted the causality between the inflation and wage growth. He found that there is a relationship between the long-term movements in the rate of growth in prices and labor costs. However, the rate of inflation causes wage growth and wage growth does not cause inflation. Basically, his report does not support the assumption of

the price-markup of the inflation process in the expectations-augmented Phillips-curve model. Conversely, it supports the original wage-type Phillips-curve model that past inflation and the past output gap can forecast future wage growth well.

Some studies have compared and tested the explanatory power and forecast performance of the inflation-rate models. These studies are as follows:

Rea (1983) compared the explanatory power of three models of inflation and unemployment over the 1895-1979 period. These three models are Keynesian model with a negatively sloped Phillips curve, Stein's (1978) monetarist model without a Phillips curve relation, and the natural rate model with a vertical Phillips curve. He found that no model can explain inflation and unemployment well over the entire time span since 1895. During the 1895-1956 period Keynesian model with a negatively sloped Phillips curve described inflation and unemployment better than other two models. During the 1957-1979 period Stein's monetarist model was superior to other two models. He inferred that there are at least two obstacles so that it is difficult to find a general theory of inflation and unemployment. The first obstacle is the changes in inflationary expectations. Not only the effects of changes in the monetary standard and policy rules should be known through allowance but also the time at which people realize the implication of these changes have to be taken into account. The second obstacle is that it is difficult to find stable functional relationships because the gradual changes in labor contracts and the economic environment. He suggested an appropriate method should be found to permit these developments to be incorporated into models when they happened rather than refer them as special effects.

Stockton and Glassman (1987) tested the inflation forecasting performance of several models. They estimated a kind of the equations of aggregate price over a general period and then made comparisons to dynamic simulations beyond the period of estimation. Moreover, they explained "the sensitivity of the forecast performance of each model to the choice of its specification" [p.108]. Finally, they found Phillips curve performs

better in the period of 1981-1984, but it does not fit the model well before 1981. The equations of the monetarist model predict as well as in the earlier periods and better than the expectations-augmented Phillips curve in some cases. However, in the final three forecasting periods, the predict performance of these equations was much worse.

Rangazas and Abdullah (1988) described a general empirical model which is both a good approximation to the actual process generating the data and which combines the models used in past studies. They thought that a good model should include all variables which are important theoretically and empirically. They replaced annual data with quarterly data. They found that government purchases, unemployment and relative price of energy are not significant factors explaining inflation after one year. Their study implies the effects of government purchases, unemployment and relative price of energy should be considered in a short-run model.

CHAPTER 3 THEORETICAL AND EMPIRICAL MODELS

Theoretical Models

Haslag and Ozment (1991) presented the general inflation-rate model which combines the monetarist model and the expectations-augmented Phillips-curve model. They derived the general model by using a theoretical framework of aggregate demand and aggregate supply. The slope of aggregate supply curve of the monetarist model is vertical due to the assumption that the labor market always clears at its full-employment level. The slope of aggregate supply curve of the expectations-augmented Phillips-curve model is horizontal due to the assumption that prices are a marked-up over wages. The general model with the positive slope of aggregate supply curve can be reduced to the monetarist model or the expectations-augmented Phillips-curve model by setting particular coefficients to be zero. The rate of inflation increases in order to depress demand growth or stimulate supply growth when the demand growth exceeds the supply growth. Conversely, the rate of inflation decreases in order to induce more demand growth or less supply growth when the supply growth exceeds the demand growth. In short, the rate of inflation increases or decreases in order to maintain the commodities market equilibrium. The simple equations of aggregate demand and aggregate supply that include the factors that affect demand growth and supply growth are as follows:

$$y_t^d = a_1 (M_t - P_t) + a_2 G_t \quad (3.1)$$

$$y_t^s = y_t^p - \phi_1 (w_t - P_t - w_t^*) \quad (3.2)$$

where all variables are measured as natural logarithms and

y = output

d denotes demand

s denotes supply

t denotes the current time period

M = the money supply

P = the price level

G = government expenditures

y^p = the potential level of output

w = the nominal wage rate

w^* = the full-employment real wage rate

a_1 , a_2 , and $\phi_1 > 0$

In equation (3.1), aggregate output demand responds positively to government expenditures and the level of real money balances (the gap between the log of the money supply and the log of the price level). Aggregate supply equation (3.2) is positively related to the potential level of output, and negatively related to the difference between the real wage rate and its full-employment level.

It is assumed that wages are contracted before all the shocks are realized. Essentially, laborers try to obtain a real wage using expected inflation and the demand pressures observed last period. The expression of wage growth is the following:

$$\hat{w}_t = \lambda \hat{w}_{t-1} + (1 - \lambda) [\pi_t^e + \hat{w}^{*e}] + \delta (\bar{U}_{t-1} - U_{t-1}) \quad (3.3)$$

where

\hat{w} = the rate increase in the nominal wage

π^e = the expected inflation rate

\hat{w}^{*e} = the expected growth rate in the market-clearing real wage rate

U = the unemployment rate

\bar{U} = the natural rate of unemployment

$1 > \lambda > 0, \delta > 0$

Equation (3.3) indicates that nominal wage growth is positively related to the lagged value of nominal wage growth, the expected rate of inflation, the expected growth rate of the market-clearing real wage rate, and the difference between the actual and natural unemployment rates. These three equations (3.1, 3.2 and 3.3) constitute the behavioral equations of the theoretical general inflation-rate model. A reduced form in π_t can be derived as follows: Assume that output demand is equal to output supply (equation 3.4). Substitute (3.1) and (3.2) into (3.4) to obtain equation (3.5). The lag value of equation (3.5) is equation (3.6). Subtracting the equation (3.6) from the equation (3.5), to obtain equation (3.7). Substitute for $M_t - M_{t-1}$, $P_t - P_{t-1}$, $G_t - G_{t-1}$, $y_t^p - y_{t-1}^p$, $w_t - w_{t-1}$, $w_t^* - w_{t-1}^*$ with \hat{M}_t , π_t , \hat{G}_t , \hat{y}_t^p , \hat{w}_t , \hat{w}_t^* to get equation (3.8). Substitute for nominal wage growth with equation (3.3) to obtain equation (3.9). Solve (3.9) for π_t to obtain the reduced form, equation (3.11).

$$y_t^d = a_1 (M_t - p_t) + a_2 G_t \quad (3.1)$$

$$y_t^s = y_t^p - \phi_1 (w_t - p_t - w_t^*) \quad (3.2)$$

$$\hat{w}_t = \lambda \hat{w}_{t-1} + (1 - \lambda) [\pi_t^e + \hat{w}^{*e}] + \delta (\bar{U}_{t-1} - U_{t-1}) \quad (3.3)$$

$$y_t^d = y_t^s \quad (3.4)$$

$$a_1 (M_t - P_t) + a_2 G_t - y_t^p + \phi_1 (w_t - P_t - w_t^*) = 0 \quad (3.5)$$

$$a_1 (M_{t-1} - P_{t-1}) + a_2 G_{t-1} - y_{t-1}^p + \phi_1 (w_{t-1} - P_{t-1} - w_{t-1}^*) = 0 \quad (3.6)$$

$$a_1 (M_t - M_{t-1}) - a_1 (P_t - P_{t-1}) + a_2 (G_t - G_{t-1}) - (y_t^p - y_{t-1}^p) + \phi_1 [(w_t - w_{t-1}) - (P_t - P_{t-1}) - (w_t^* - w_{t-1}^*)] = 0 \quad (3.7)$$

$$a_1 \hat{M}_t - a_1 \pi_t + a_2 \hat{G}_t - \hat{y}_t^p + \phi_1 [\hat{w}_t - \pi_t - \hat{w}_t^*] = 0 \quad (3.8)$$

$$a_1 \hat{M}_t - a_1 \pi_t + a_2 \hat{G}_t - \hat{y}_t^p + \phi_1 \{ [\lambda \hat{w}_{t-1} + (1 - \lambda)(\pi_t^\epsilon + \hat{w}^{*\epsilon}) + \delta(\bar{U}_{t-1} - U_{t-1})] - \pi_t - \hat{w}_t^* \} = 0 \quad (3.9)$$

$$(a_1 + \phi_1) \pi_t = a_1 \hat{M}_t + a_2 \hat{G}_t - \hat{y}_t^p + \phi_1 \{ [\lambda \hat{w}_{t-1} + (1 - \lambda) \pi_t^\epsilon + (1 - \lambda) \hat{w}^{*\epsilon} - \hat{w}_t^*] + \delta(\bar{U}_{t-1} - U_{t-1}) \} \quad (3.10)$$

$$\pi_t = \frac{1}{a_1 + \phi_1} \{ a_1 \hat{M}_t + a_2 \hat{G}_t - \hat{y}_t^p + \phi_1 [\lambda \hat{w}_{t-1} + (1 - \lambda) \pi_t^\epsilon - \phi_1 [\lambda \hat{w}^{*\epsilon} + (\hat{w}^* - \hat{w}^{*\epsilon})] + \phi_1 \delta(\bar{U}_{t-1} - U_{t-1}) \} \quad (3.11)$$

The equation (3.11) is the theoretical general inflation-rate model. According to this equation, inflation is positively related to changes in money growth, government-spending growth, changes in last period's wage growth and the gap between the actual and natural unemployment rates. It is also negatively related to potential output growth and the growth in the market-clearing real wage rate.

The general model is reduced to the monetarist model by assuming the wages are so flexible that the labor market always clears at its full-employment level. It means the real wage is always equal to its market-clearing level ($w_t - P_t = w_t^*$) and ϕ_1 is equal to zero. With ϕ_1 equal to zero, the model reduces to:

$$\pi_t = \frac{1}{a_1} [a_1 \hat{M}_t + a_2 \hat{G}_t - \hat{y}_t^p] \quad (3.12)$$

Equation (3.12) indicates that inflation is related only to money growth, government-spending growth and potential output growth.

The general model is reduced to the expectations-augmented Phillips-curve model by assuming that there is some degree of wage stickiness that permits underemployment and overemployment (*i.e.*, employment can be above or below full employment). Under the original assumption of price-markup in the expectations-augmented Phillips-curve model, the aggregate supply curve is horizontal at a price level which is equal to the wage rate plus a reservation-markup. In this model w^* is regarded as a target real wage rate, rather than the market clearing real wage, reflecting the desired markup of price above unit-labor costs. In order to affect the assumption that firms follow the markup scheme, ϕ_1 is assumed to be infinity. The resulting equation is as follows:

$$\pi_t = [\lambda \hat{w}_{t-1} + (1 - \lambda) \pi_t^e] - [\lambda \hat{w}^{*e} + (\hat{w}^* - \hat{w}^{*e})] + \delta (\bar{U}_{t-1} - U_{t-1}) \quad (3.13)$$

Equation (3.13) shows the rate of inflation is influenced by the factors which move the aggregate supply curve, but is not directly affected by shifts in the aggregate demand curve. Money growth affects the inflation via the unemployment-rate gap term.

The monetarist model that only prices are influenced by shifts in aggregate demand and the expectations-augmented Phillips-curve model that only output is influenced by shifts in aggregate demand are the special cases of the general model. The general model with the positive aggregate supply curve considers both. In terms of equation (3.11), the monetarist version drops the terms of lagged values of wage growth and the unemployment-rate gap. The expectations-augmented Phillips-curve version drops the terms of money growth and government-expenditures growth.

Empirical Specification

Some of variables shown in the equation (3.11) are very difficult to translate directly into observable data. Moreover, there are some important factors that should be considered in the formulation of the empirical model. Commonly, the growth rate of the market-clearing real wage rate is affected by factors involving the production function and labor demand and also by labor supply factors. Furthermore, these factors will affect inflation by their impact on potential output. Productivity growth and the growth rate of raw materials influence labor demand, and labor force growth influences labor supply. For example, if productivity growth increases, labor demand will increase and then the growth rate of market-clearing real wages will increase in order to eliminate disequilibrium in the labor market. If the supply of raw materials increases, the demand for labor will move in the same direction and then the growth rate of market-clearing real wages also will rise. As the growth rate of market-clearing real wages rises, the rate of inflation falls as equation (3.11) indicates. The increases in the productivity growth and the growth rate of raw materials induce greater growth rate of potential output in the commodities market and this leads to lower inflation. Regarding labor supply, when labor force growth rises the growth rate of the market-clearing real wage rate decreases in order to maintain the equilibrium in the labor market. When the growth rate of the market-clearing real wage rate decreases, the rate of inflation increases. On the other hand, a greater growth rate of the labor force results in the higher growth rate of potential output and then the rate of inflation must decrease in order to maintain the equilibrium of the commodities market. Potential output growth has the greater effect on the rate of inflation, so inflation is inversely related to labor force growth.

In this study, we use output per hour of all persons in the nonfarm business sector as the measure of productivity, the percentage change in the labor force participation rate as labor force growth and the changes of the price of food relative to the general price level

and the changes of the price of energy relative to the general price level as the growth rate of raw materials. All of these variables are suggested by Tatom (1981), Hafer (1983), Gordon (1985), Stockton and Struckmeyer (1989), and Mehra (1990). There is the expected value of the growth rate of the market-clearing real wage rate in the equation (3.11). The sample means of the growth rates of productivity, the labor force, and the raw materials are regarded as the expected values of these variables. The expected inflation rate is not directly observable, hence, one of the alternative ways is that using these factors in the equation (3.11) to forecast inflation. Assuming that expected inflation is conditioned on information available at previous period, the expected inflation rate relies on the lagged values of the factors in equation (3.11).

Empirical Models

Empirically, the models are constituted by the observable data which stand for the effects of changes of the growth rate of the market-clearing real wage rate and the expected inflation rate conditioned on information available at the previous period. Inflation in the empirical general model is a function of the growth rate of the adjusted monetary base, the growth rate of government expenditures, the growth rate of the average hourly compensation of all employees in the nonfarm business sector, the labor participation rate, the growth rate of the mean-adjusted output per hour of all persons in the nonfarm business sector, the seasonally adjusted consumer price index for energy relative to the seasonally adjusted consumer price index less food and energy, the seasonally adjusted consumer price index for food relative to the seasonally adjusted consumer price index less food and energy, the gap between the civilian and natural unemployment rate, and a dummy variable for the time period in which price controls were in effect. The empirical general model is represented as the following expression:

The general model

$$\begin{aligned}
\pi_t = & C_0 + \sum_{i=0}^{m_1} \beta_t \hat{M}_{t-i} + \sum_{i=0}^{m_2} \delta_t \hat{G}_{t-i} + \sum_{i=1}^{m_3} \tau_t \pi_{t-i} + \sum_{i=1}^{m_4} \lambda_t \hat{w}_{t-i} + \sum_{i=1}^{m_5} \zeta_t LBF_{t-i} \\
& + \sum_{i=1}^{m_6} \mu_t \hat{P}G_{t-i} + \sum_{i=1}^{m_7} \nu_t RPE_{t-i} + \sum_{i=1}^{m_8} \xi_t RPF_{t-i} + \sum_{i=1}^{m_9} \theta_t gap_{t-i} \\
& + \gamma D_t
\end{aligned} \tag{3.14}$$

where

π = rate of increase in the GNP deflator

\hat{M} = the growth rate of the St. Louis Federal Reserve Bank's adjusted monetary base

\hat{G} = the growth rate of government expenditures

\hat{w} = the growth rate of the average hourly compensation of all employees in the nonfarm business sector

LBF = labor force participation rate

$\hat{P}G$ = the growth rate of the mean-adjusted output per hour of all persons in the nonfarm business sector

RPE = the seasonally adjusted consumer price index for energy relative to the seasonally adjusted consumer price index less food and energy

RPF = the seasonally adjusted consumer price index for food relative to the seasonally adjusted consumer price index less food and energy

U = the civilian unemployment rate

\bar{U} = the natural unemployment rate

$gap = U - \bar{U}$ = the difference between U and \bar{U}

D = the dummy variable that has the value 1 from Q1/1971 to Q4/1972 and 0 otherwise.

$C, \beta, \delta, \tau, \lambda, \zeta, \mu, \nu, \xi, \theta, \gamma$ are parameter estimates

$m_i, i = 1, 2, 3, 4, \dots, 9$ stand for the lag lengths of the variables

The monetarist model

The empirical monetarist model is derived from the empirical general model. The variables of the unemployment-rate gap and lagged values of wage growth are not included in the monetarist model. Although, the equation (3.12) does not include the expected inflation rate, it is fairly common to keep the terms of the lagged values of the inflation rate and money growth in the equation to account for dynamics. Beyond that, the variables of supply shock such as the relative price of energy should also be included in the monetarist model, since supply shocks affect potential output. In conclusion, the growth rate of the average hourly compensation of all employees in the nonfarm business sector and the gap between the civilian and natural unemployment rates are dropped from the general model to yield the monetarist model. The monetarist model can be expressed as follows:

$$\begin{aligned} \pi_t = & C_0 + \sum_{i=0}^{m_1} \beta_t \hat{M}_{t-i} + \sum_{i=0}^{m_2} \delta_t \hat{G}_{t-i} + \sum_{i=1}^{m_3} \tau_t \pi_{t-i} + \sum_{i=1}^{m_5} \zeta_t LBF_{t-i} \\ & + \sum_{i=1}^{m_6} \mu_t \hat{P}G_{t-i} + \sum_{i=1}^{m_7} \nu_t RPE_{t-i} + \sum_{i=1}^{m_8} \xi_t RPF_{t-i} + \gamma D_t \end{aligned} \quad (3.15)$$

The expectations-augmented Phillips-curve model

The empirical expectations-augmented Phillips-curve model is derived from the empirical general model. Money growth and government-spending growth are not included in the expectations-augmented Phillips curve model. In this model, the aggregate supply curve is horizontal so that the shifts in the aggregate demand curve do not affect the price level. This means that shifts in the aggregate demand curve do not directly affect the rate of inflation. Statistically, the sum of coefficients of contemporaneous and lagged values of money growth and the contemporaneous value of government-spending growth

are equal to zero. Hence, the variables of the growth rate of the adjusted monetary base and the growth rate of the average hourly compensation of all employees in the nonfarm business sector are dropped from the general model to yield the expectations-augmented Phillips-curve model. The expectations-augmented Phillips-curve can be expressed as follows:

$$\begin{aligned} \pi_t = & C_0 + \sum_{i=1}^{m_3} \tau_t \pi_{t-i} + \sum_{i=1}^{m_4} \lambda_t \hat{w}_{t-i} + \sum_{i=1}^{m_5} \zeta_t LBF_{t-i} + \sum_{i=1}^{m_6} \mu_t \hat{P}G_{t-i} \\ & + \sum_{i=1}^{m_7} \nu_t RPE_{t-i} + \sum_{i=1}^{m_8} \xi_t RPF_{t-i} + \sum_{i=1}^{m_9} \theta_t gap_{t-i} + \gamma D_t \end{aligned} \quad (3.16)$$

CHAPTER 4 EMPIRICAL ANALYSIS

Data Description

In this study, the time-series data that were collected and used are a little different with the data reportedly used by Haslag and Ozment in their original paper. In the term of the growth rate of the St.Louis Federal Reserve Bank's adjusted monetary base, we will convert the monthly adjusted monetary base series to quarterly data and then calculate the growth rate. At first, we will calculate the sum of every three values and then divide the value by three to get the quarterly data. For example, we will add the values of January, February and March and then divide the sum-value by three. We will regard the value as a quarter datum. Then we will recalculate the sum of values of April, May and June, and then divide the value by three. We will get next quarter datum. All monthly data will be converted to quarterly data by the same process. After getting the quarterly adjusted monetary base series, we will calculate the growth rate by using first differences of the logarithms. In the terms of the growth rate of government expenditures, the growth rate of the average hourly compensation of all employees in the nonfarm business sector and the rate of increase in the GNP deflator, we will directly get the quarterly series data. We just need to calculate the growth rate by using first differences of the logarithms. In the term of the growth rate of the mean-adjusted output per hour of all persons in the nonfarm business sector, we will calculate the growth rate of the quarterly data by using first difference of the logarithms, and then adjust the mean by subtracting the sample mean from the quarterly growth rate. In the term of the labor

force participation rate, we will divide the civilian labor force (16 years and over) by the civilian non-institutional population and multiply by 100 to have the labor force participation rate, expressed as a percentage. Then, we will convert the resulting data series to a quarterly data series. The seasonally adjusted consumer price index for energy relative to the seasonally adjusted consumer price index less food and energy is obtained by dividing the seasonally adjusted consumer price index for energy by the seasonally adjusted consumer price index less food and energy. The seasonally adjusted consumer price index for food relative to the seasonally adjusted consumer price index less food and energy is computed similarly. We will get the monthly series data (RPE and RPF). Due to the lack of series data of the seasonally adjusted consumer price index for energy from 1957 to 1965 we will substitute the missing values with the nonseasonally adjusted consumer price index for energy at the same periods. Of course, we have to convert these series to the quarterly series. In the term of the gap between the civilian and natural unemployment rate, we will convert the series of the civilian unemployment to a quarterly series, and we will regard the nonaccelerating inflation rate of unemployment as the natural unemployment rate. We will use the annual figure for all four quarters of each year. Finally, we will have the gap by subtracting the natural unemployment rate from the civilian unemployment rate. In the term of the dummy variable, we will set its value at one from Q1/1971 to Q4/1972, when wage and price controls were in effect, and zero otherwise.

Selection of the Appropriate Lag Lengths of Variables

The Schwartz Bayesian Criteria (SBC) method was employed to determine the appropriate lag length for the lagged dependent variable, and then it was employed to determine the appropriate lag length for the independent variables. The SBC method involves minimizing the residual sum of squares of a regression subject to a penalty for

the loss of degrees of freedom. Adding another lagged variable to a regression decreases the residual sum of squares and thus tends to decrease SBC, but it also tends to increase SBC through the penalty term for loss of degrees of freedom. The appropriate lag length is determined by the smallest SBC. For example, the appropriate lag length for the inflation rate (the lagged dependent variable) is determined by the smallest value of SBC which is manipulated by using the SBC equation. The appropriate number of lagged values of the money growth is determined by using the same procedure assuming the lag length for inflation is known. Repeat the same steps for the independent variables, treating the inflation rate as the manipulated variable. Schwartz Bayesian Criteria (SBC) is represented by the following expression:

$$SBC = [T \ln(\text{residual sum of squares})] + [n \ln(T)] \quad (4.1)$$

where

T = number of usable observations

n = number of parameters estimated

In this study, we consider 149 observations and ten lagged values. Table 4.1 presents SBC for the lagged dependent variable and each independent variable. The table shows the SBC of the inflation rate is the smallest at lag length three (432.7630), so we will select three as the number lagged values of inflation rate in the equation. With the three lagged values of the growth rate of inflation known, Table 4.1 shows the smallest SBC (431.8577) for the growth rate of the adjusted monetary base is for a lagged value of zero, the smallest SBC (431.8106) for the growth rate of the government-spending is for the lagged value of zero, the smallest SBC (431.7455) for the growth rate of the nominal wage is at the lag length of one, the smallest SBC (437.5110) for the labor force participation growth rate is for the lag length of one, the smallest SBC (437.6317) for the growth rate of productivity is for the lag length of one, the smallest SBC (436.7777)

Table 4.1 The SBC of each variable

Variable	The Order of Lags					
	0	1	2	3	4	5
π	—	454.9476	432.7941	432.7630*	433.1568	436.6090
\hat{M}	431.8577*	434.2601	438.9915	446.4937	448.8592	469.9267
\hat{G}	431.8106*	437.4116	442.6085	445.5930	446.6082	467.8734
\dot{w}	—	431.7455*	438.4278	443.9822	440.8993	469.7220
LBF	—	437.5110*	442.3934	447.2022	446.1030	464.6964
$\hat{P}G$	—	437.6317*	442.2970	446.5925	448.6788	470.2727
RPE	—	436.7777*	441.6731	445.7239	445.9520	465.8736
RPF	—	435.2697*	440.0704	445.5693	447.1003	469.5962
gap	—	434.3070*	441.0555	446.0961	447.2565	467.4395

* indicates the smallest value of SBC

for the growth rate of the relative price of energy is for the lag length of one, the smallest SBC (435.2697) for the growth rate of the relative price of food is for the lag length of one, and the smallest SBC (434.3070) for the unemployment-rate gap is for the lag length of one. Figures 4.1, 4.2, 4.3, 4.4 and 4.5 show the SBCs graphically. In conclusion from the test of SBC, we set $m_1 = 0$, $m_2 = 0$, $m_3 = 3$, $m_4 = 1$, $m_5 = 1$, $m_6 = 1$, $m_7 = 1$, $m_8 = 1$ and $m_9 = 1$. The Schwartz Bayesian criteria (SBC) indicates that the equation should include the contemporaneous value of the growth rate of the adjusted monetary base, the contemporaneous value of the growth rate of government expenditures, three lagged values of inflation, one lagged value of the growth rate of the nominal wage, one lagged value of the labor force participation rate growth, one lagged value of the productivity growth, one lagged value of the growth rate of the relative price of energy, one lagged value of the growth rate of the relative price of food, and one lagged value of the unemployment-rate gap. We will use these lag structures in the general, monetarist, and expectations-augmented Phillips-curve models.

Model specification

The general model is described by the following expression:

$$\begin{aligned} \pi_t = & C_0 + \beta_t \hat{M}_t + \delta_t \hat{G}_t + \sum_{i=1}^3 \tau_i \pi_{t-i} + \lambda_t \hat{w}_{t-1} + \zeta_t LBF_{t-1} \\ & + \mu_t \hat{P}G_{t-1} + \nu_t RPE_{t-1} + \xi_t RPF_{t-1} + \theta_t gap_{t-1} + \gamma D_t \end{aligned} \quad (4.2)$$

The monetarist model is described by the following expression:

$$\begin{aligned} \pi_t = & C_0 + \beta_t \hat{M}_t + \delta_t \hat{G}_t + \sum_{i=1}^3 \tau_i \pi_{t-i} + \zeta_t LBF_{t-1} \\ & + \mu_t \hat{P}G_{t-1} + \nu_t RPE_{t-1} + \xi_t RPF_{t-1} + \gamma D_t \end{aligned} \quad (4.3)$$

SBC of PI

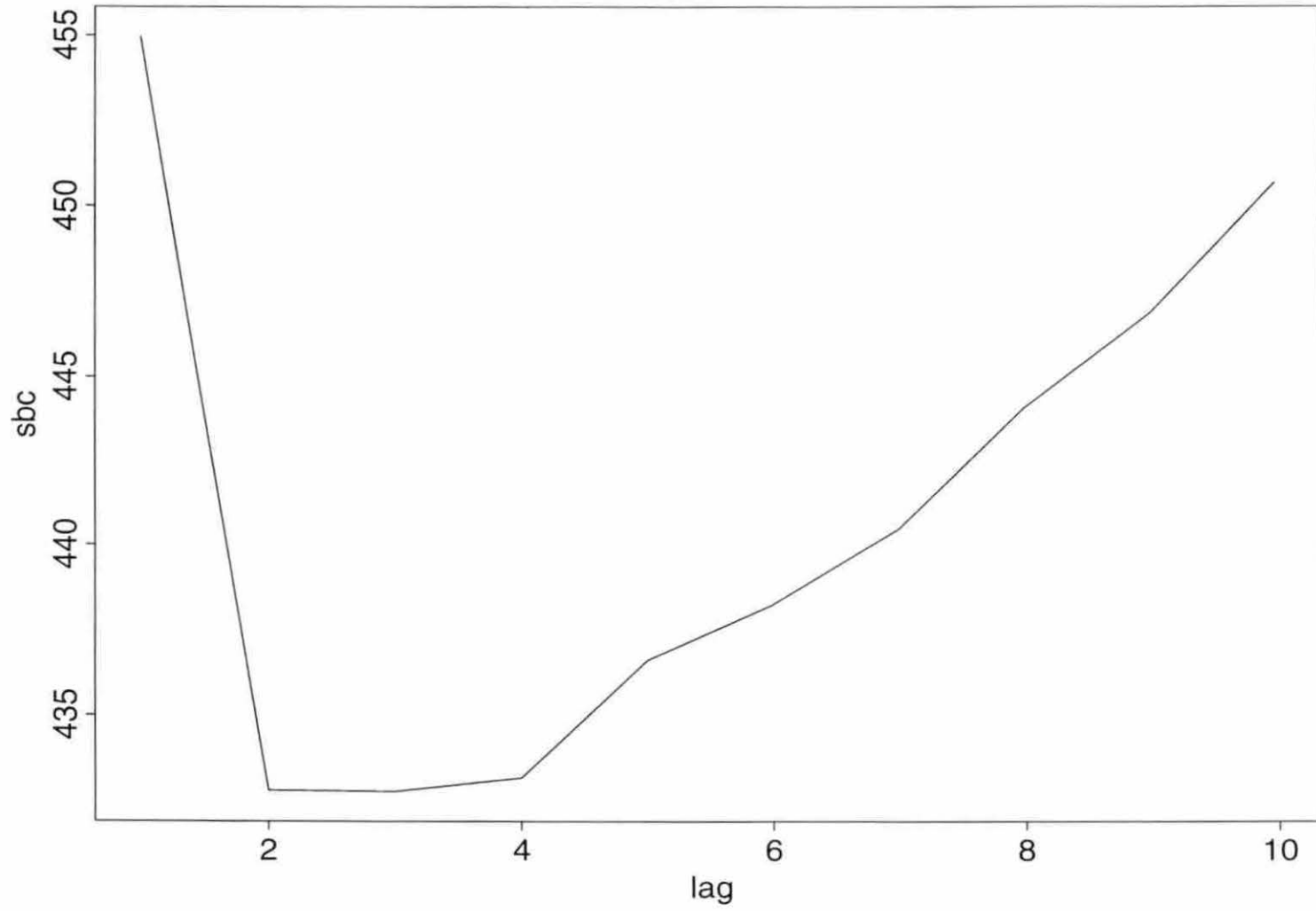


Figure 4.1 SBC of π

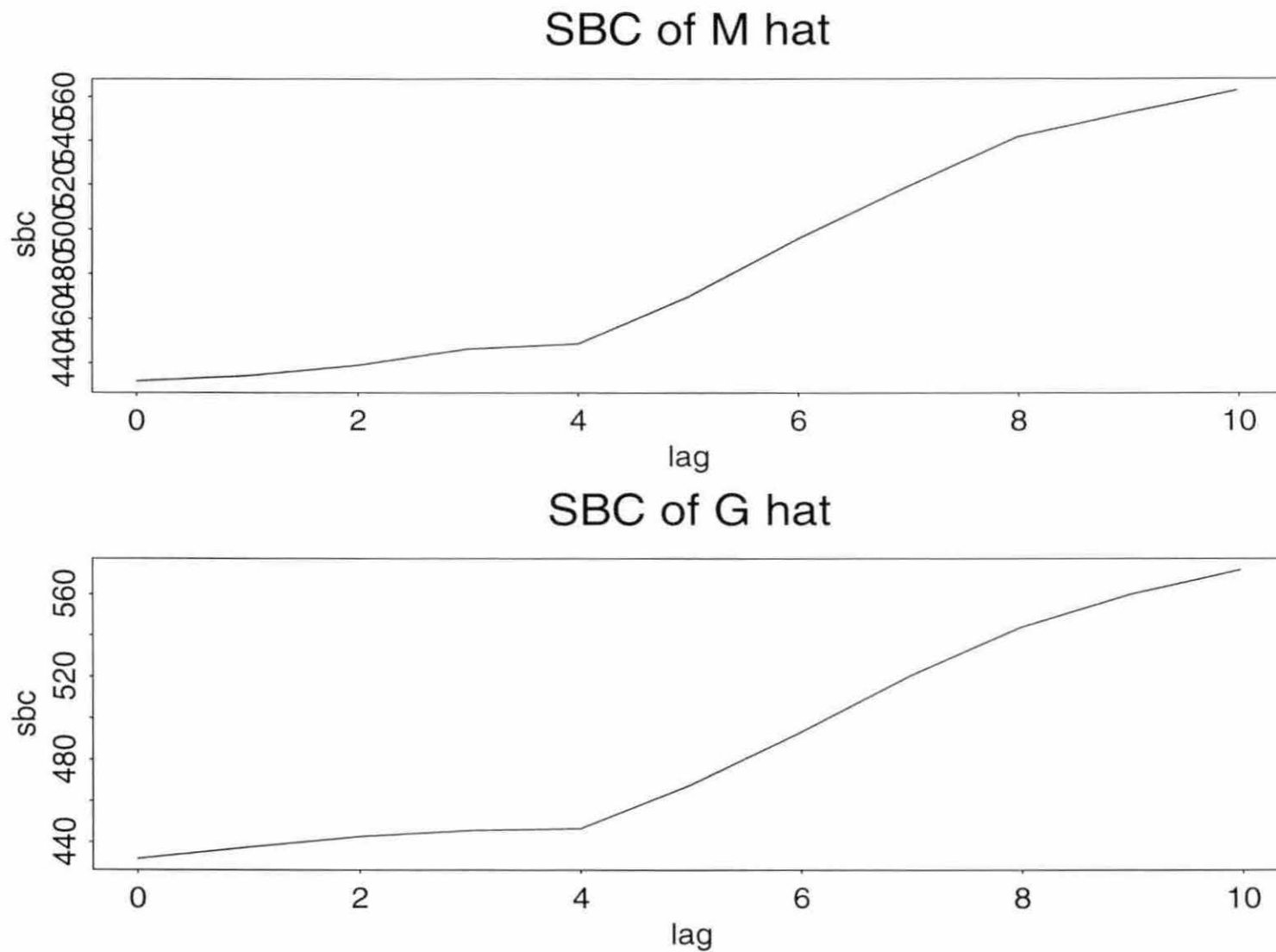


Figure 4.2 SBC of \hat{M} and \hat{G}

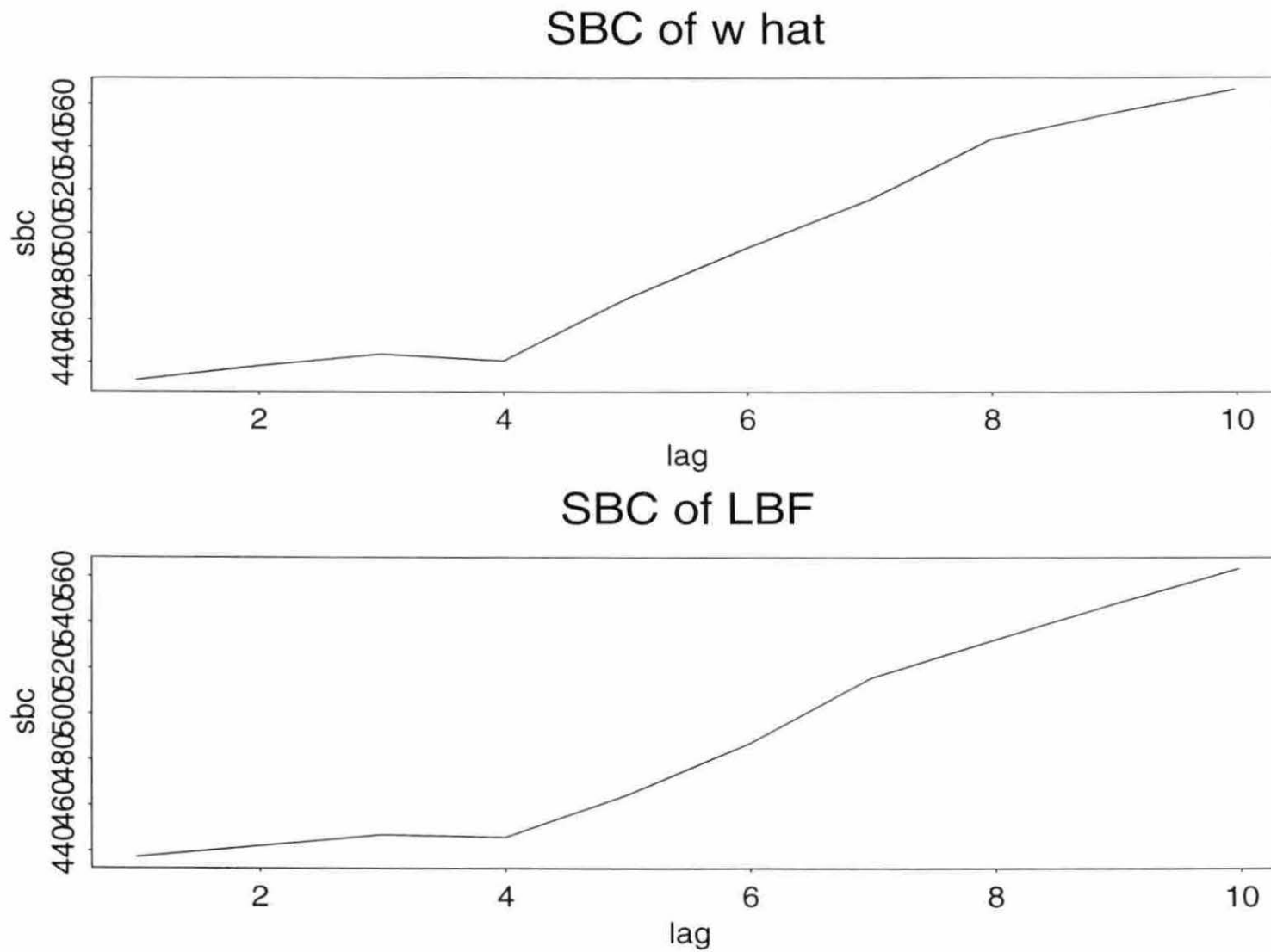


Figure 4.3 SBC of \hat{w} and LBF

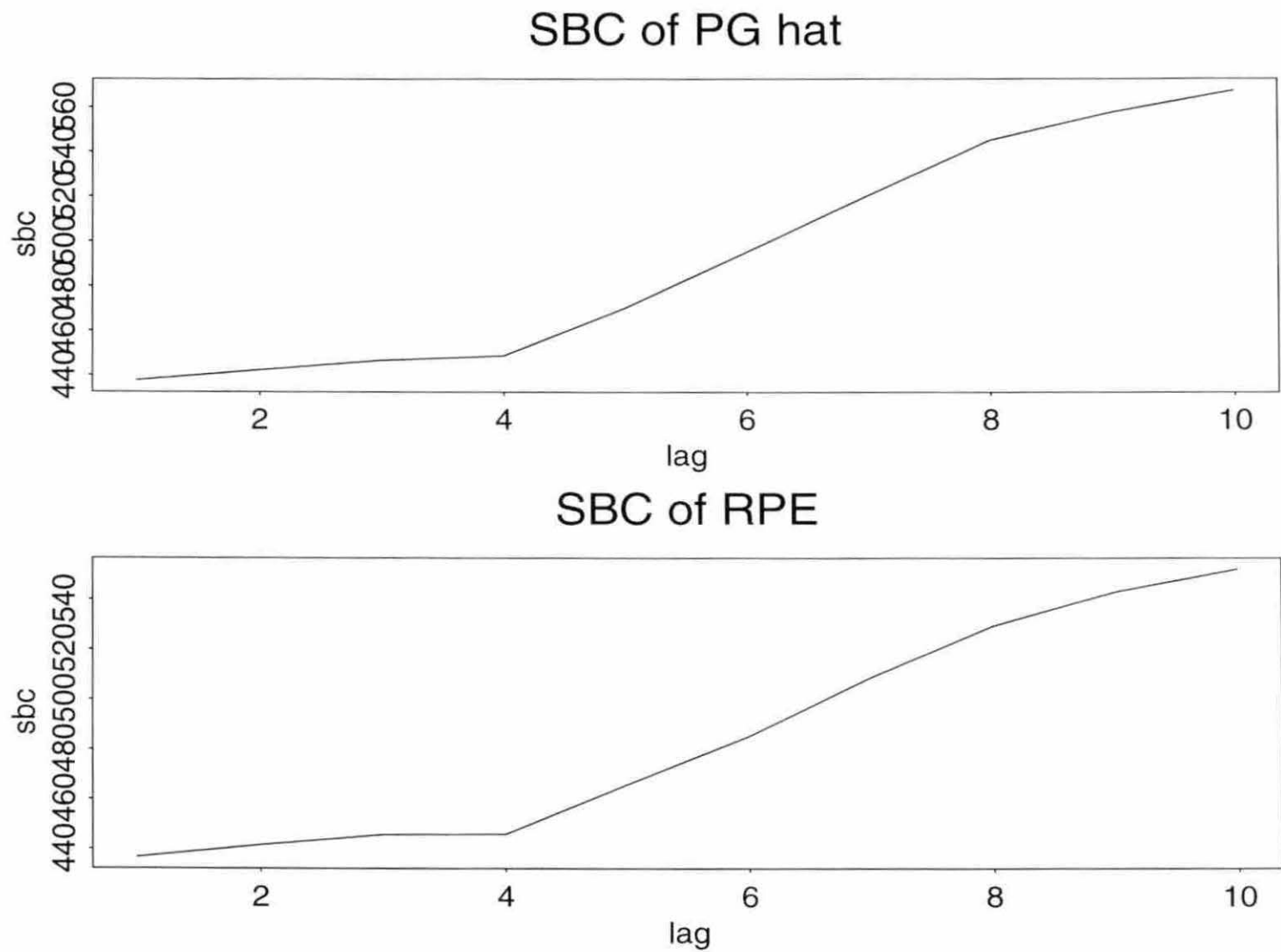


Figure 4.4 SBC of $\hat{P}G$ and RPE

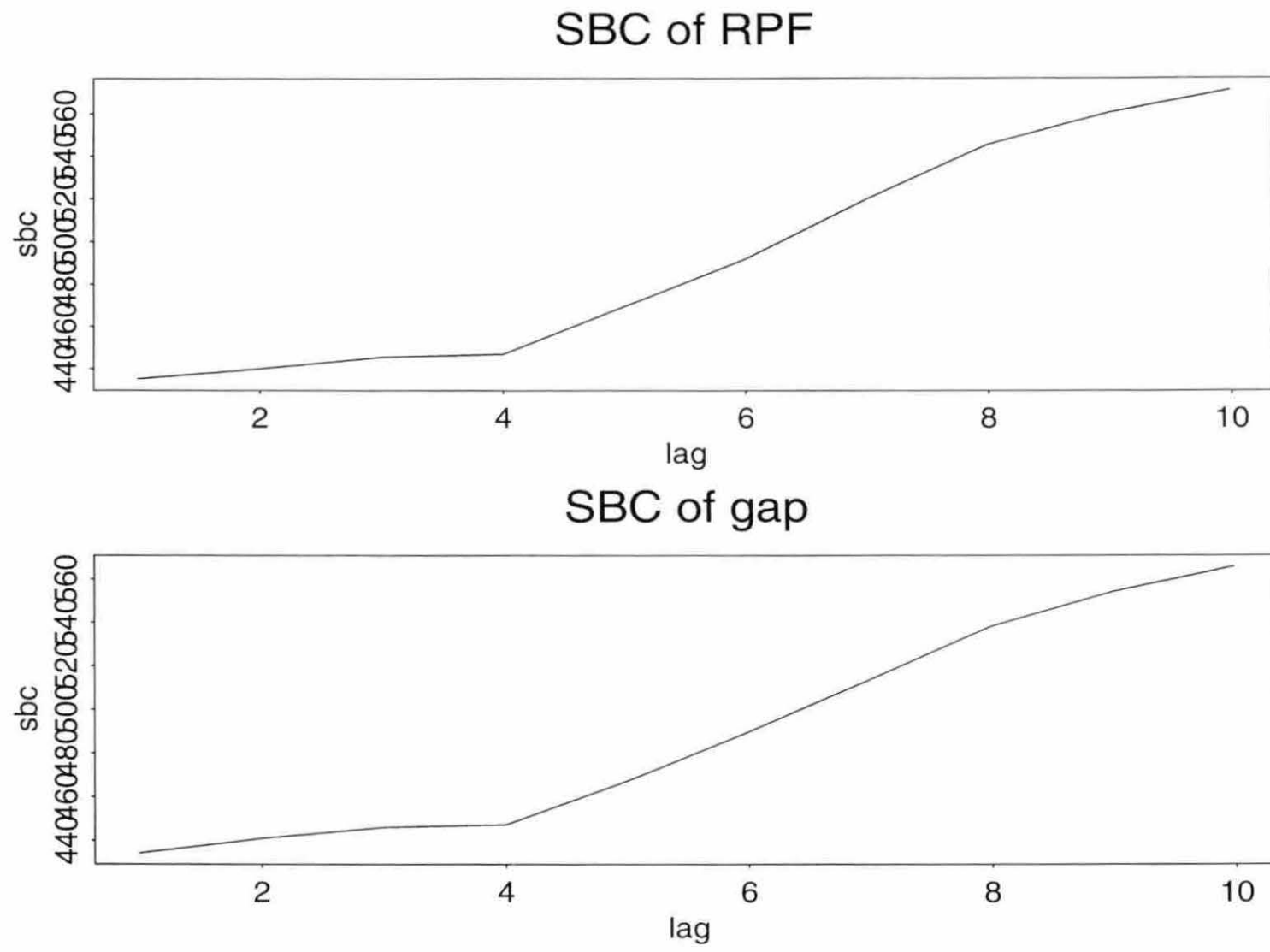


Figure 4.5 SBC of RPF and gap

The expectations-augmented Phillips curve is described by the following expression:

$$\begin{aligned} \pi_t = & C_0 + \sum_{i=1}^3 \tau_i \pi_{t-i} + \lambda_t \hat{w}_{t-1} + \zeta_t LBF_{t-1} + \mu_t \hat{P}\hat{G}_{t-1} \\ & + \nu_t RPE_{t-1} + \xi_t RPF_{t-1} + \theta_t gap_{t-1} + \gamma D_t \end{aligned} \quad (4.4)$$

Regression Analysis

Correlation coefficients

The least squares procedure was employed to estimate these models. The rate of inflation is the dependent variable, the other terms are independent variables, and the error term should be added in these equations (4.2, 4.3 and 4.4). C_0 is the constant term or intercept of this equation. $\beta, \delta, \tau, \lambda, \zeta, \mu, \nu, \xi, \theta, \gamma$ are parameters. We will estimate these parameters by using least squares method which means minimizing the error sum of squares. Table 4.2 presents the correlation coefficients between the inflation rate (dependent variable) and other potential explanatory variables. The correlation coefficients of the contemporaneous value of the growth rate of the adjusted monetary base (\hat{M}_t), the contemporaneous value of the growth rate of government expenditures (\hat{G}_t), the lagged one value of the growth rate of wages (\hat{w}_{t-1}), the lagged one value of the growth rate of productivity ($\hat{P}\hat{G}_{t-1}$), the lagged one value of the growth rate of the relative price of energy (RPE_{t-1}) and the growth rate of the relative price of food (RPF_{t-1}) are all significantly different from zero at the 5-percent level. These results indicate that these potential explanatory variables are significantly correlated with the rate of

inflation. However, the correlation coefficients of the lagged one value of the labor force participation rate (LBF_{t-1}) and the lagged one value of the unemployment-rate gap (gap_{t-1}) are not significantly different from zero at the 5-percent level, which means these two variables have low explanatory power to the rate of inflation.

Table 4.2 Correlation coefficients between the inflation rate and variables

Variable	Correlation Coefficients	P-value
\hat{M}_t	0.2997**	0.0002
\hat{G}_t	0.2946**	0.0003
\hat{w}_{t-1}	0.6895**	0.0001
$\hat{P}G_{t-1}$	-0.2294**	0.0050
RPE_{t-1}	0.3591**	0.0001
RPF_{t-1}	0.6227**	0.0001
LBF_{t-1}	0.1580	0.0552
gap_{t-1}	0.0075	0.9283

** indicates that the correlation coefficient is significantly different from zero at the 5-percent level.

Parameter estimates for three models

The regression results are presented in Table 4.3, 4.4 and 4.5, one table for each model. Table 4.3 contains the results from the estimating the equation of the general model. All of the significant coefficients have the hypothesized sign. The coefficients on the one and two lagged values of the growth rate of inflation, the lagged one value of the growth rate of wages, the lagged one value of the growth rate of the relative price of

food, and the lagged one value of the unemployment-rate gap are statistically significant at the 5-percent level. These coefficients suggest that increases in the wage growth, the growth rate of the relative price of food, and the unemployment-rate gap result in higher inflation. The adjusted R-square, a proportion of the variation in the inflation rate which is explained by the multiple regression equation, is 0.7074.

Table 4.4 reports the regression results of the estimating equation of the monetarist model. All of the significant coefficients have the hypothesized sign. The coefficients on the one and two lagged values of the inflation rate are statistically significant at the 5-percent level. In addition, there are statistically significant coefficients at the 10-percent level for the three lagged values of the inflation rate and the relative price of food. The adjusted R-square is 0.6807.

Table 4.5 contains the regression results from estimating the equation of the expectations-augmented Phillips-curve model. All the significant coefficients except that for the labor force participation rate have the hypothesized sign. In addition, it also reports that there are statistically significant coefficients at the 5-percent level on the one and two lagged values of the growth rate of inflation, the one lagged value of the growth rate of the wage, the one lagged value of the relative price of food, and the one lagged value of the unemployment-rate gap. There are statistically significant coefficients on the one lagged value of the growth rate of the labor force participation rate and the dummy variable at the 10-percent level. The report shows that increases in the wage growth, the relative price of food and the unemployment-rate gap result in higher inflation. The adjusted R-square is 0.7067.

Out-of-Sample Forecasting Tests

In this section, we will discuss the forecasting tests and compare the goodness of the forecasts of the three models. We use the one-step-ahead forecasts which means that

Table 4.3 The parameter estimates for the general model,
Q1/1957-Q1/1994

Variable	Coefficient Estimate	Standard Error	T for H0: Parameter=0	Pro > T
Intercept	-3.0555	1.4139	-2.161**	0.0325
\hat{M}_t	0.0702	0.0530	1.325	0.1876
\hat{G}_t	0.0122	0.0167	0.732	0.4652
π_{t-1}	0.2105	0.0897	2.347**	0.0204
π_{t-2}	0.2367	0.0876	2.702**	0.0078
π_{t-3}	0.1371	0.0856	1.603	0.1114
\hat{w}_{t-1}	0.1508	0.0750	2.012**	0.0463
LBF_{t-1}	0.0160	0.0159	1.011	0.3137
$\hat{P}G_{t-1}$	0.0141	0.0447	0.316	0.7528
RPE_{t-1}	0.0047	0.0038	1.246	0.2150
RPF_{t-1}	0.0180	0.0082	2.219**	0.0282
gap_{t-1}	-0.0913	0.0307	-2.979**	0.0034
D	0.2410	0.1544	1.561	0.1209

** indicates significance at the 5-percent level.

Table 4.4 The parameter estimates for the monetarist model,
Q1/1957 - Q1/1994

Variable	Coefficient Estimate	Standard Error	T for H0: Parameter=0	Prob > T
Intercept	-1.1981	1.3790	-0.869	0.3865
\hat{M}_t	0.0570	0.0544	1.047	0.2971
\hat{G}_t	0.0150	0.0174	0.861	0.3909
π_{t-1}	0.3250	0.0871	3.730**	0.0003
π_{t-2}	0.3180	0.0874	3.637**	0.0004
π_{t-3}	0.1480	0.0881	1.681*	0.0950
LBF_{t-1}	0.0003	0.0160	0.016	0.9873
$\hat{P}G_{t-1}$	0.0024	0.0440	0.055	0.9564
RPE_{t-1}	-0.0029	0.0032	-0.913	0.3627
RPF_{t-1}	0.0151	0.0084	1.802*	0.0738
D	0.1036	0.1567	0.661	0.5098

** indicates significance at the 5-percent level.

* indicates significance at the 10-percent level.

Table 4.5 The parameter estimates for the expectations-augmented Phillips-curve model, Q1/1957 - Q1/1994

Variable	Coefficient Estimate	Standard Error	T for H0: Parameter=0	Prob > T
Intercept	-3.5495	1.3656	-2.599**	0.0104
π_{t-1}	0.2310	0.0888	2.604**	0.0103
π_{t-2}	0.2298	0.0876	2.624**	0.0097
π_{t-3}	0.1401	0.0852	1.645	0.1023
\hat{w}_{t-1}	0.1631	0.0746	2.188**	0.0304
LBF_{t-1}	0.0250	0.0140	1.775*	0.0781
$\hat{P}G_{t-1}$	0.0150	0.0448	0.336	0.7371
RPE_{t-1}	0.0040	0.0038	1.080	0.2820
RPF_{t-1}	0.0190	0.0081	2.330**	0.0213
gap_{t-1}	-0.0857	0.0303	-2.829**	0.0054
D	0.2820	0.1522	1.852*	0.0662

** indicates significance at the 5-percent level.

* indicates significance at the 10-percent level.

forecasts of the inflation rate in time period t use all the information available at that time. In other words, we are assumed to know the lagged values of each of the variables, and then use the parameter estimates which are updated each period as new information becomes available to forecast the next period's inflation rate. For example, we fit the general model, the monetarist model and the expectations-augmented Phillips-curve model using the time series data for Q1/1957 - Q4/1989 to get the parameter estimates for each regression equation. Then we use these parameter estimates to forecast inflation with each of the three models for Q1/1990. We will refit the three models using the series data for Q1/1957 - Q1/1990 and forecast the inflation for Q2/1990 using the updated parameter estimates. We keep refitting the models using successively more observations and forecasting one-step-ahead until we run out of data. Table 4.6 indicates that the forecasting results from Q1/1990 to Q1/1994. Figures 4.6, 4.7 and 4.8 show the observed values and the predicted values for these three models. In general, the three models capture the trend of disinflation during the forecast period. However, all three forecast series display considerable less short-run volatility than does the actual inflation series. The forecasting accuracy of these three models was compared with the computation of the mean square error (MSE) for each of the models. The formula of mean square error is as follows:

$$MSE = \frac{\sum_{t=1}^m (X_{n+t} - \hat{X}_{n+t})^2}{m} \quad (4.5)$$

where

X = observed value

\hat{X} = predicted value

n = the size of sample used to find estimator

m = the size of post-sample

Table 4.7 indicates that the expectations-augmented Phillips-curve model has the smallest MSE, which means the predictions of the expectations-augmented Phillips-curve model of the inflation rate from Q1/1990 to Q1/1994 are in general more accurate than either the general or the monetarist models.

Discussion

The results of this study are different from those of the original paper. The manipulated values of variables in the original paper are not known. But, the sources of some variables are not the same. For example, for the original paper, the series of the natural rate of unemployment were calculated by using the methodology developed by Peter Clark (1982). However, in this study we used the nonaccelerating inflation rate of unemployment which is from the Congressional Budget Office as the natural rate of unemployment.

Haslag and Ozment provided evidence that the general model is a better predictor than either the monetarist or expectations-augmented Phillips-curve models. Both monetary and nonmonetary factors are important to explain the rate of inflation. This means that the general model which encompasses the monetarist model and the expectations-augmented Phillips-curve model has the most explanatory power. In regard to the determination of the appropriate lag lengths, they identified equation (3.14), the general model, by using the Schwartz criterion method. The Schwartz criterion indicates that the contemporaneous value and one lagged value of the growth rate of the adjusted monetary base, and the contemporaneous value of government expenditures growth are included in the equation. Furthermore, the Schwartz criterion indicates that two lagged values of the growth rate of inflation, the unemployment-rate gap, the growth rate of wage, and the growth rate of the relative price of energy are included in the equation. The one lagged value of the growth rate of productivity, the labor force participation

Table 4.6 Values of one-step-ahead forecasts, Q1/1990 - Q1/1994

Period	General	Monetarist	Phillips-curve	Actual Values
Q1/1990	1.1638	1.1147	1.1613	1.2636
Q2/1990	1.3070	1.1931	1.3023	1.0705
Q3/1990	1.3860	1.2539	1.3743	0.9713
Q4/1990	1.2699	1.2150	1.2266	1.0490
Q1/1991	1.1774	1.0867	1.1500	1.2100
Q2/1991	1.1396	1.2098	1.1362	0.6849
Q3/1991	1.0529	1.0870	1.0755	0.6803
Q4/1991	0.9202	0.9566	0.8956	0.5915
Q1/1992	0.8685	0.8771	0.8238	1.0059
Q2/1992	0.9309	0.9605	0.9052	0.6650
Q3/1992	0.9009	0.9585	0.8780	0.3309
Q4/1992	0.8937	0.8725	0.7910	0.6584
Q1/1993	0.6961	0.7109	0.6897	0.7356
Q2/1993	0.6645	0.7989	0.6190	0.4063
Q3/1993	0.6883	0.7826	0.6342	0.3239
Q4/1993	0.6648	0.6973	0.6006	0.3228
Q1/1994	0.5563	0.5682	0.5382	0.6426

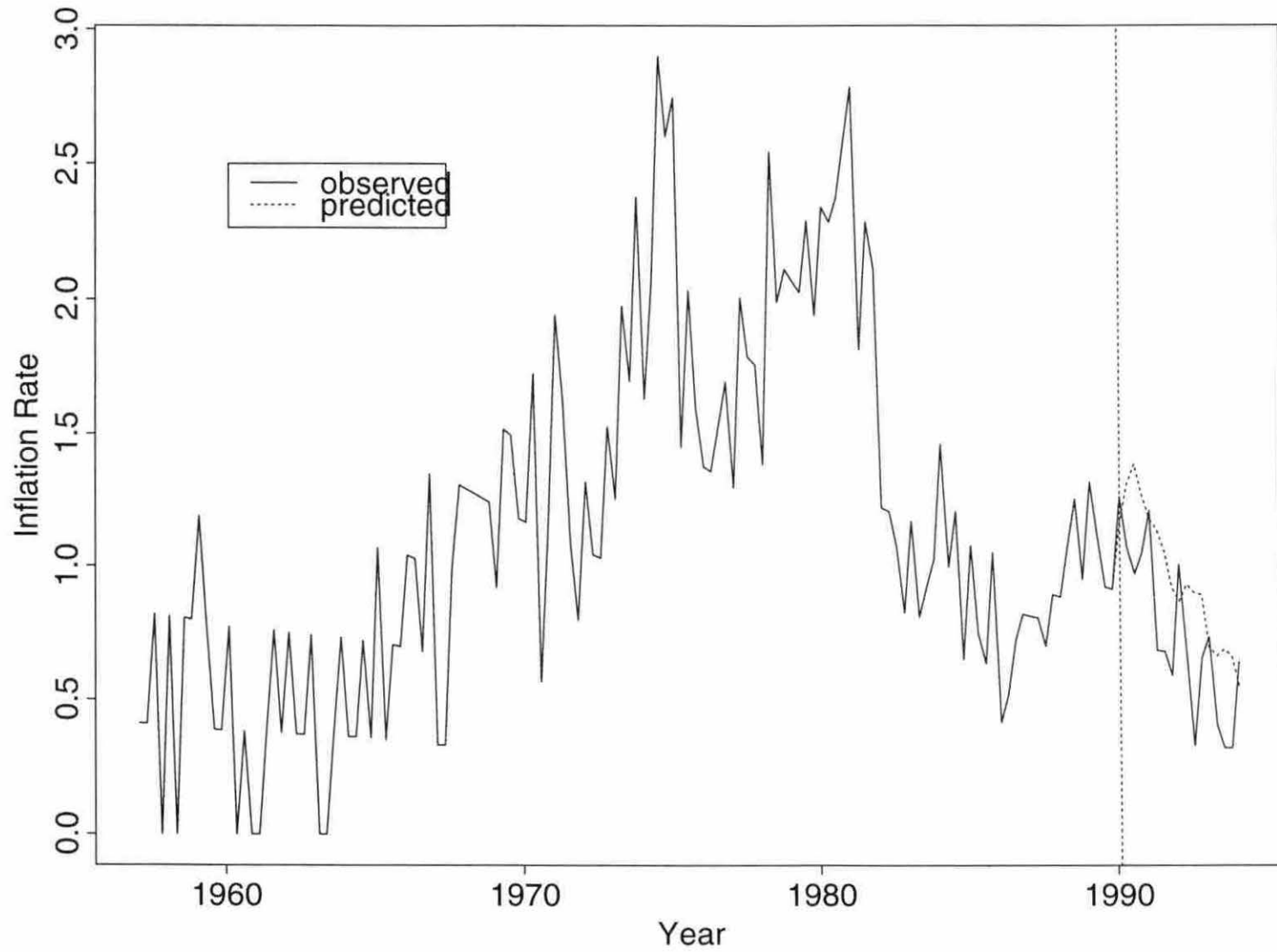


Figure 4.6 Observed values v.s. predicted values (general model)

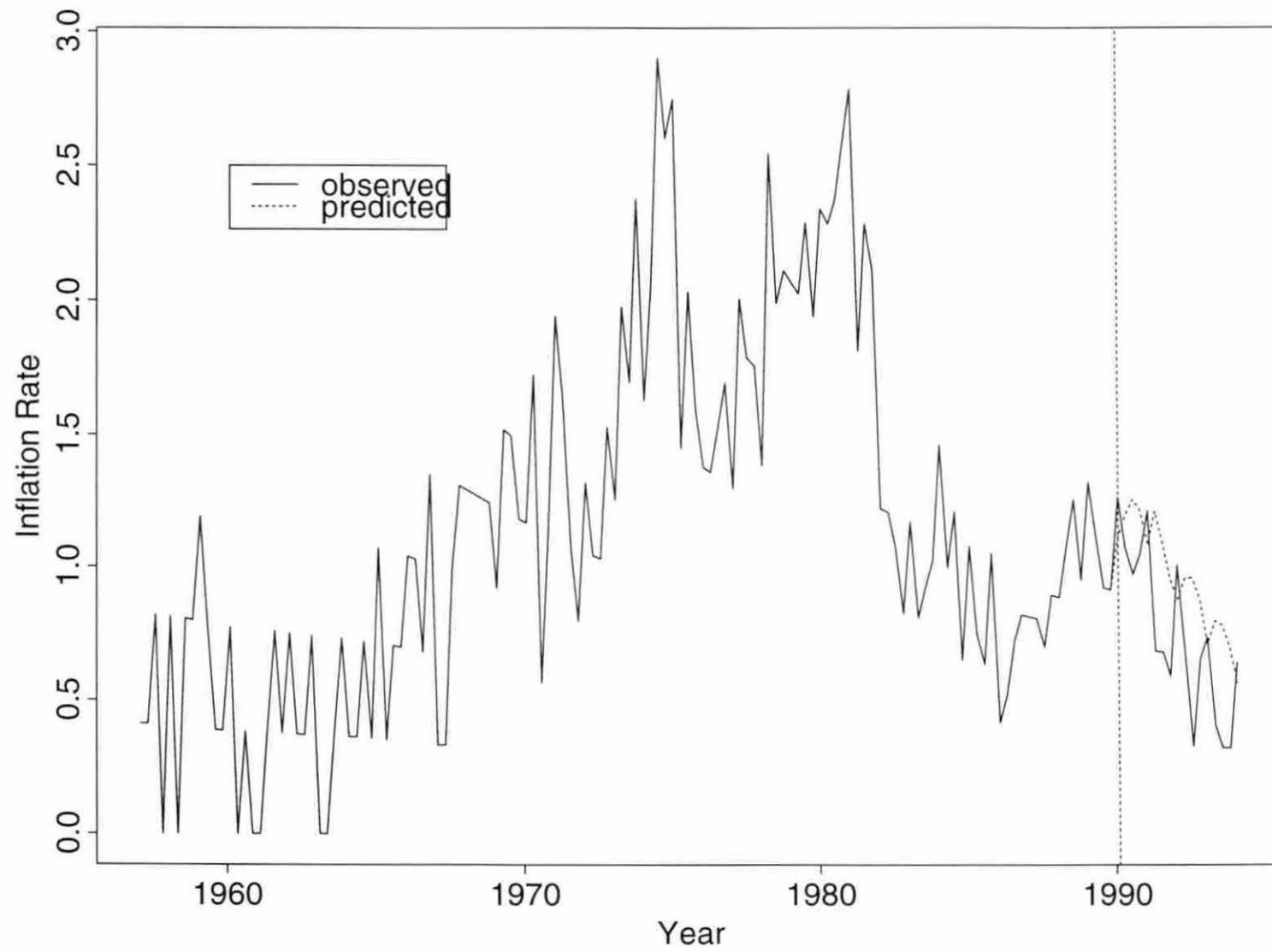


Figure 4.7 Observed values v.s. predicted values (monetarist model)

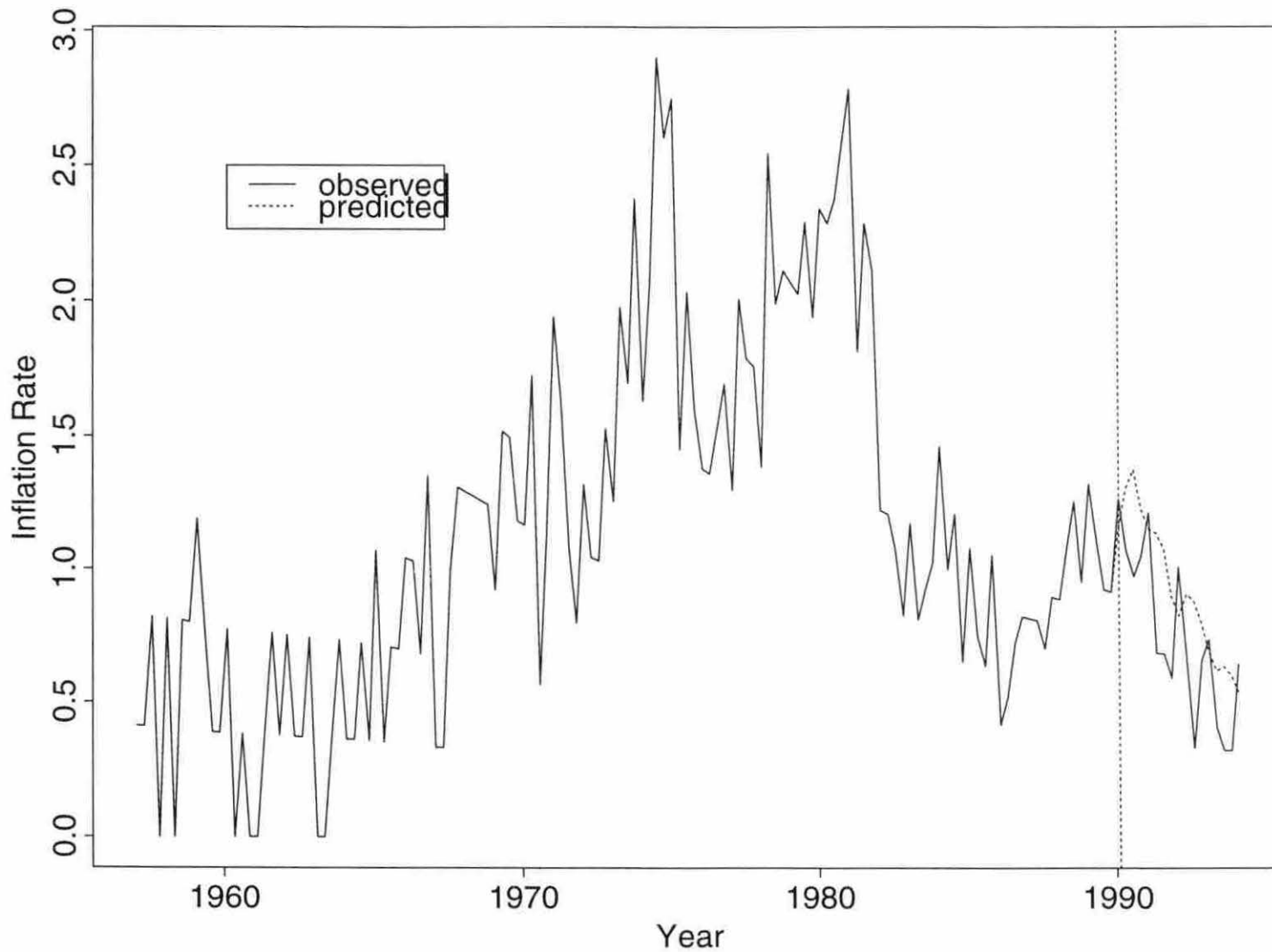


Figure 4.8 Observed values v.s. predicted values (expectations-augmented Phillips-curve model)

growth rate, and the growth rate of the relative price of food are included in the equation. In short, the Schwartz criterion identifies that the appropriate lag lengths are $m_1 = 1, m_2 = 0, m_3 = 2, m_4 = 2, m_5 = 1, m_6 = 1, m_7 = 2, m_8 = 1, m_9 = 2$. However, this study indicates that the equation includes the contemporaneous terms of the growth rate of the adjusted monetary base and the government expenditures growth, the one lagged value of the wage growth, the labor force participation growth rate, the growth rate of productivity, the growth rate of the relative price of energy, the growth rate of the relative price of food and the unemployment-rate gap ($m_1 = 0, m_2 = 0, m_3 = 3, m_4 = 1, m_5 = 1, m_6 = 1, m_7 = 1, m_8 = 1, m_9 = 1$). In the result of the coefficient estimates for the general inflation-rate equation, they found that the coefficients on the one lagged value of inflation rate and the growth rate of the adjusted monetary base, and the two lagged value of the growth rate of the relative price of energy and the growth wage were statistically significant at the 5-percent level. This indicates that there is at least one statistically significant coefficient at the 5-percent level on lagged values of the growth rate of the monetary base, inflation rate, the growth rate of the relative price of energy, and wage growth. In other words, increases in the growth rate of the adjusted monetary base, wage growth, and the growth rate of the relative price of energy result in higher inflation rate. There is statistically significant coefficient at the 10-percent level on the lagged value of the growth rate of productivity. Moreover, the coefficients on the one and two lagged values of the unemployment-rate gap were statistically significant individually at the 6-percent and 8-percent level. However, this present study indicates that the coefficients on the two lagged value of the inflation rate, and the one lagged value of the growth rate of wages, the growth rate of the relative price of food and the unemployment-rate gap are statistically significant at the 5-percent level. In the result of the one-step-ahead forecasts, they presented that the prediction of the inflation during the 1980s of the general model is more accurate than either the monetarist or expectations-augmented Phillips-curve models. The mean

errors of these three models were not significantly different from zero, which means that forecasts of each of these three models are unbiased. They calculated the root mean square error (RMSE). The RMSE of the general model is the lowest, *i.e.*, the general model has strong explanatory power on the rate of inflation. However, this present study indicates that the expectations-augmented Phillips-curve model is more accurate than other two models, *i.e.*, it has the stronger explanatory power for the rate of inflation.

Table 4.7 MSE for three models

Model	MSE
General	0.0904
Monetarist	0.1052
Expectations-Augmented Phillips-Curve	0.0796

CHAPTER 5 SUMMARY AND CONCLUSIONS

Summary

Many macroeconomists have discussed the causes of inflation. Many analysts and forecasters have tried to present good theories and build appropriate models to explain and forecast the rate of inflation. During the last several decades the U.S. inflation rates have fluctuated dramatically. Before Q3/1967 the average annual rate of inflation was 2.116 percent. In the periods Q1/1974-Q4/1975 and Q1/1980-Q4/1981, the average annual rates of inflation were 8.864 percent and 9.288 percent. After that, the inflation rate gradually decreased to average about 3 or 4 percents. In this study we compare and discuss the general, monetarist, and expectation-augmented Phillips-curve models suggested by Haslag and Ozment. The general model combining the monetarist model and the expectations-augmented Phillips-curve model is a good approach with strong explanatory power. The monetarist model and the expectations-augmented Phillips-curve model are the special cases of the general model. The general model can be reduced to the individual models by setting particular constrains. These models are derived from a theoretical framework of aggregate demand and aggregate supply. The empirical specification includes observable variables and some important factors. The empirical general model consists of the variables of the growth rate of the St.Louis Federal Reserve Bank's adjusted monetary base (\hat{M}), the growth rate of government expenditures (\hat{G}), the growth rate of the average hourly compensation of all employees in the nonfarm business sector (\hat{w}), the labor force participation rate (LBF), the growth rate of the

mean-adjusted output per hour of all persons in the nonfarm business sector ($\hat{P}\hat{G}$), the seasonally adjusted consumer price index for energy relative to the seasonally adjusted consumer price index less food and energy (RPE), the seasonally adjusted consumer price index for food relative to the seasonally adjusted consumer price index less food and energy (RPF), the unemployment-rate gap (gap), and a dummy variable (D) for a brief time period in which government wage and price controls were in effect. The empirical monetarist model which assumes wages are so flexible that the labor market always clears at its full-employment level drops the terms of the growth rate of the average hourly compensation of all employees in the nonfarm business sector (\hat{w}) and the unemployment-rate gap (gap) from the general model. The expectations-augmented Phillips-curve model which assumes there is some degree of wages stickiness that permits underemployment and overemployment drops the terms of the growth rate of the St.Louis Federal Reserve Bank's adjusted monetary base (\hat{M}) and the growth rate of government expenditures (\hat{G}) from the general model. This study is to test whether the general model is superior to either the monetarist or expectations-augmented Phillips-curve models by using the U.S. quarterly data. Sample period used in this paper is longer than that used by Haslag and Ozment (1957-94 rather than 1959-88) and the data employed are a little different.

At first, we determine the appropriate lag lengths for the lagged dependent and independent variables by using the Schwartz Bayesian Criteria (SBC) method. The appropriate lag length of the inflation rate is three, the appropriate lag length of the growth rate of the St.Louis Federal Reserve Bank's adjusted monetary base and the growth rate of government expenditures is zero. This means that there are only contemporaneous effects on these two variables. The appropriate lag length of other variables is one. We then analyzed correlation coefficients and parameter estimates for these three models. These variables except the lagged one value of labor force participation rate and unemployment-rate gap are significantly correlated with the rate of inflation. The result

of parameter estimates for the general model indicates that increases in the wage growth, the growth rate of the relative price of food, and the unemployment-rate gap result in a higher inflation rate. The result of parameter estimates for the monetarist model indicates that the three lagged values of the growth rate of inflation and one lagged value of the growth rate of the relative price of food are statistically significant at 5-percent or 10-percent levels. The result of parameter estimates for the expectations-augmented Phillips-curve model indicates that the two lagged values of the growth rate of inflation, the one lagged value of the growth rate of the wage, the one lagged value of the growth rate of the relative price of food, the one lagged value of the unemployment-rate gap, the one lagged value of the labor force participation rate and the dummy variable are statistically significant at 5-percent or 10-percent levels. In short, increases in the wage growth, the growth rate of the relative price of food, the labor force participation rate, and the unemployment-rate gap result in higher inflation rate. The adjusted R-square of these three models are 0.7074, 0.6807, and 0.7067. Finally, we test the out-of-sample forecast performance. Forecasting the rate of inflation from Q1/1990 to Q1/1994 by using the method of one-step-ahead forecasts and comparing the forecasting accuracy of these three models by calculating mean square error (MSE). We conclude that the expectations-augmented Phillips-curve model has the smallest MSE value, *i.e.*, the model has better prediction performance than either the general or monetarist models.

Conclusions

The results of this study indicate that expectations-augmented Phillips-curve model provides powerful explanation on the rate of inflation. We compare these three models in an one-step-ahead forecasting test. The expectations-augmented Phillips-curve model presents better forecasting performance over the period of 1957-1994. This analysis does not support the results which are presented by Haslag and Ozment. They have

ascertained that the general model which combines features of two different theories is useful in explaining the rate of inflation. Moreover, they tested the general model has better forecasting accuracy. In this study we extend the sample periods and analyze these variables using the appropriate statistic methods. The test does not show the general model is superior to the monetarist or expectations-augmented Phillips-curve models. However, the results represent that the expectations-augmented Phillips-curve model is better than the monetarist model and the general model in explaining and forecasting the rate of inflation.

APPENDIX COMPUTER PROGRAMS

The splus program of SBC for π

```
"sbcpi.prg"<-
function()
{
pi <- scan("pi.out")
n3 <- length(pi)
xpi <- matrix(0, 148, 10)
SBC.pi <- c(rep(0, 10))
TT <- n3 - 10
m3 <- 0
repeat {
  m3 <- m3 + 1
  xpi[m3:148, m3] <- pi[1:(149 - m3)]
  ypi <- pi[(m3 + 1):149]
  ls.pi <- lsfit(xpi[m3:148, 1:m3], ypi)$residuals
  pisum.res <- t(ls.pi) %*% ls.pi
  SBC.pi[m3] <- (TT * log(pisum.res)) +
                (m3 + 1) * log(TT)
  if(m3 == 10)
    break
}
return(SBC.pi)
}
```

The splus program of SBC for \hat{M}

```

"sbcm.prg"<-
function()
{
pi <- scan("pi.out")
mhat <- scan("ambsl.out")
n3 <- length(pi)
SBC.m <- c(rep(0, 11))
x.pi <- cbind(pi[3:148], pi[2:147], pi[1:146])
y.pi <- pi[4:149]
TT <- n3 - 10
m11 <- -1
m12 <- 0
repeat {
  m11 <- m11 + 1
  xm.pi <- cbind(x.pi, mhat[(3 + 1 - m11):(149 - m11)])
  ls.m11 <- lsfit(xm.pi, y.pi)$residuals
  m11sum.res <- t(ls.m11) %*% ls.m11
  SBC.m[m11 + 1] <- (TT * log(m11sum.res)) +
                    ((m11 + 3 + 1) * log(TT))
  if(m11 == 3)
    break
}
repeat {
  m12 <- m12 + 1
  y.m12 <- pi[(m12 + 3 + 1):149]
  x.m12 <- cbind(xm.pi[2:(146 - m12 + 1)],
                 mhat[1:(146 - m12)])
  ls.m12 <- lsfit(x.m12, y.m12)$residuals
  m12sum.res <- t(ls.m12) %*% ls.m12
  SBC.m[m12 + 4] <- (TT * log(m12sum.res)) +
                    ((m12 + 3 + 3 + 1) * log(TT))
  if(m12 == 7)
    break
}
return(SBC.m)
}

```

The splus program of SBC for \hat{G}

```

"sbcxp.prg"<-
function()
{
pi <- scan("pi.out")
xphat <- scan("xp.out")
n3 <- length(pi)
SBC.xp <- c(rep(0, 11))
x.pi <- cbind(pi[3:148], pi[2:147], pi[1:146])
y.pi <- pi[4:149]
TT <- n3 - 10
xp11 <- -1
xp12 <- 0
repeat {
  xp11 <- xp11 + 1
  xxp.pi <- cbind(x.pi, xphat[(3 + 1 - xp11):(149 - xp11)])
  ls.xp11 <- lsfit(xxp.pi, y.pi)$residuals
  xp11sum.res <- t(ls.xp11) %*% ls.xp11
  SBC.xp[xp11 + 1] <- (TT * log(xp11sum.res)) +
    ((xp11 + 3 + 1) * log(TT))
  if(xp11 == 3)
    break
}
repeat {
  xp12 <- xp12 + 1
  y.xp12 <- pi[(xp12 + 3 + 1):149]
  x.xp12 <- cbind(xxp.pi[2:(146 - xp12 + 1)],
    xphat[1:(146 - xp12)])
  ls.xp12 <- lsfit(x.xp12, y.xp12)$residuals
  xp12sum.res <- t(ls.xp12) %*% ls.xp12
  SBC.xp[xp12 + 4] <- (TT * log(xp12sum.res)) +
    ((xp12 + 3 + 3 + 1) * log(TT))
  if(xp12 == 7)
    break
}
return(SBC.xp)
}

```

The splus program of SBC for \hat{w}

```

"sbcw.prg"<-
function()
{
pi <- scan("pi.out")
wagehat <- scan("wage.out")
n3 <- length(pi)
SBC.w <- c(rep(0, 10))
x.pi <- cbind(pi[3:148], pi[2:147], pi[1:146])
y.pi <- pi[4:149]
TT <- n3 - 10
w11 <- 0
w12 <- 0
repeat {
  w11 <- w11 + 1
  xw.pi <- cbind(x.pi, wagehat[(3 + 1 - w11):(149 - w11)])
  ls.w11 <- lsfit(xw.pi, y.pi)$residuals
  w11sum.res <- t(ls.w11) %*% ls.w11
  SBC.w[w11] <- (TT * log(w11sum.res)) + ((w11 + 3 + 1)
    * log(TT))
  if(w11 == 3)
    break
}
repeat {
  w12 <- w12 + 1
  y.w12 <- pi[(w12 + 3 + 1):149]
  x.w12 <- cbind(xw.pi[2:(146 - w12 + 1), ],
    wagehat[1:(146 - w12)])
  ls.w12 <- lsfit(x.w12, y.w12)$residuals
  w12sum.res <- t(ls.w12) %*% ls.w12
  SBC.w[w12 + 3] <- (TT * log(w12sum.res)) +
    ((w12 + 3 + 3 + 1) * log(TT))
  if(w12 == 7)
    break
}
return(SBC.w)
}

```

The splus program of SBC for *LBF*

```
"sbclbf.prg"<-
function()
{
pi <- scan("pi.out")
lbf <- scan("lbf.out")
n3 <- length(pi)
SBC.lbf <- c(rep(0, 10))
x.pi <- cbind(pi[3:148], pi[2:147], pi[1:146])
y.pi <- pi[4:149]
TT <- n3 - 10
lbf1 <- 0
lbf2 <- 0
repeat {
  lbf1 <- lbf1 + 1
  xlbfi.pi <- cbind(x.pi, lbf[(3 + 1 - lbf1):(149 - lbf1)])
  ls.lbf1 <- lsfit(xlbfi.pi, y.pi)$residuals
  lbf1sum.res <- t(ls.lbf1) %*% ls.lbf1
  SBC.lbf[lbf1] <- (TT * log(lbf1sum.res)) +
    ((lbf1 + 3 + 1) * log(TT))
  if(lbf1 == 3)
    break
}
repeat {
  lbf2 <- lbf2 + 1
  y.lbf2 <- pi[(lbf2 + 3 + 1):149]
  x.lbf2 <- cbind(xlbfi.pi[2:(146 - lbf2 + 1)],
    lbf[1:(146 - lbf2)])
  ls.lbf2 <- lsfit(x.lbf2, y.lbf2)$residuals
  lbf2sum.res <- t(ls.lbf2) %*% ls.lbf2
  SBC.lbf[lbf2 + 3] <- (TT * log(lbf2sum.res)) +
    ((lbf2 + 3 + 3 + 1) * log(TT))
  if(lbf2 == 7)
    break
}
return(SBC.lbf)
}
```

The splus program of SBC for $\hat{P}G$

```
"sbcpg.prg"<-
function()
{
pi <- scan("pi.out")
pghat <- scan("ahcnf.out")
n3 <- length(pi)
SBC.pg <- c(rep(0, 10))
x.pi <- cbind(pi[3:148], pi[2:147], pi[1:146])
y.pi <- pi[4:149]
TT <- n3 - 10
pg1 <- 0
pg2 <- 0
repeat {
  pg1 <- pg1 + 1
  xpg.pi <- cbind(x.pi, pghat[(3 + 1 - pg1):(149 - pg1)])
  ls.pg1 <- lsfit(xpg.pi, y.pi)$residuals
  pg1sum.res <- t(ls.pg1) %*% ls.pg1
  SBC.pg[pg1] <- (TT * log(pg1sum.res)) + ((pg1 + 3 + 1)
    * log(TT))
  if(pg1 == 3)
    break
}
repeat {
  pg2 <- pg2 + 1
  y.pg2 <- pi[(pg2 + 3 + 1):149]
  x.pg2 <- cbind(xpg.pi[2:(146 - pg2 + 1)],
    pghat[1:(146 - pg2)])
  ls.pg2 <- lsfit(x.pg2, y.pg2)$residuals
  pg2sum.res <- t(ls.pg2) %*% ls.pg2
  SBC.pg[pg2 + 3] <- (TT * log(pg2sum.res)) +
    ((pg2 + 3 + 3 + 1) * log(TT))
  if(pg2 == 7)
    break
}
return(SBC.pg)
}
```

The splus program of SBC for RPE

```

"sbc_rpe.prg"<-
function()
{
pi <- scan("pi.out")
rpe <- scan("rpe.out")
n3 <- length(pi)
SBC.rpe <- c(rep(0, 10))
x.pi <- cbind(pi[3:148], pi[2:147], pi[1:146])
y.pi <- pi[4:149]
TT <- n3 - 10
rpe1 <- 0
rpe2 <- 0
repeat {
  rpe1 <- rpe1 + 1
  xrpe.pi <- cbind(x.pi, rpe[(3 + 1 - rpe1):(149 - rpe1)])
  ls.rpe1 <- lsfit(xrpe.pi, y.pi)$residuals
  rpe1sum.res <- t(ls.rpe1) %*% ls.rpe1
  SBC.rpe[rpe1] <- (TT * log(rpe1sum.res)) +
    ((rpe1 + 3 + 1) * log(TT))
  if(rpe1 == 3)
    break
}
repeat {
  rpe2 <- rpe2 + 1
  y.rpe2 <- pi[(rpe2 + 3 + 1):149]
  x.rpe2 <- cbind(xrpe.pi[2:(146 - rpe2 + 1), ],
    rpe[1:(146 - rpe2)])
  ls.rpe2 <- lsfit(x.rpe2, y.rpe2)$residuals
  rpe2sum.res <- t(ls.rpe2) %*% ls.rpe2
  SBC.rpe[rpe2 + 3] <- (TT * log(rpe2sum.res)) +
    ((rpe2 + 3 + 3 + 1) * log(TT))
  if(rpe2 == 7)
    break
}
return(SBC.rpe)
}

```


The splus program of SBC for RPF

```

"sbc_rpf.prg"<-
function()
{
pi <- scan("pi.out")
rpf <- scan("rpf.out")
n3 <- length(pi)
SBC.rpf <- c(rep(0, 10))
x.pi <- cbind(pi[3:148], pi[2:147], pi[1:146])
y.pi <- pi[4:149]
TT <- n3 - 10
rpf1 <- 0
rpf2 <- 0
repeat {
  rpf1 <- rpf1 + 1
  x_rpf1.pi <- cbind(x.pi, rpf[(3 + 1 - rpf1):(149 - rpf1)])
  ls.rpf1 <- lsfit(x_rpf1.pi, y.pi)$residuals
  rpf1sum.res <- t(ls.rpf1) %*% ls.rpf1
  SBC.rpf[rpf1] <- (TT * log(rpf1sum.res)) +
    ((rpf1 + 3 + 1) * log(TT))
  if(rpf1 == 3)
    break
}
repeat {
  rpf2 <- rpf2 + 1
  y_rpf2.pi <- pi[(rpf2 + 3 + 1):149]
  x_rpf2.pi <- cbind(x_rpf1.pi[2:(146 - rpf2 + 1)],
    rpf[1:(146 - rpf2)])
  ls.rpf2 <- lsfit(x_rpf2.pi, y_rpf2.pi)$residuals
  rpf2sum.res <- t(ls.rpf2) %*% ls.rpf2
  SBC.rpf[rpf2 + 3] <- (TT * log(rpf2sum.res)) +
    ((rpf2 + 3 + 3 + 1) * log(TT))
  if(rpf2 == 7)
    break
}
return(SBC.rpf)
}

```

The splus program of SBC for gap

```

"sbcgap.prg"<-
function()
{
pi <- scan("pi.out")
gap <- scan("gap.out")
n3 <- length(pi)
SBC.gap <- c(rep(0, 10))
x.pi <- cbind(pi[3:148], pi[2:147], pi[1:146])
y.pi <- pi[4:149]
TT <- n3 - 10
gap1 <- 0
gap2 <- 0
repeat {
  gap1 <- gap1 + 1
  xgap.pi <- cbind(x.pi, gap[(3 + 1 - gap1):(149 - gap1)])
  ls.gap1 <- lsfit(xgap.pi, y.pi)$residuals
  gap1sum.res <- t(ls.gap1) %*% ls.gap1
  SBC.gap[gap1] <- (TT * log(gap1sum.res)) +
    ((gap1 + 3 + 1) * log(TT))
  if(gap1 == 3)
    break
}
repeat {
  gap2 <- gap2 + 1
  y.gap2 <- pi[(gap2 + 3 + 1):149]
  x.gap2 <- cbind(xgap.pi[2:(146 - gap2 + 1), ],
    gap[1:(146 - gap2)])
  ls.gap2 <- lsfit(x.gap2, y.gap2)$residuals
  gap2sum.res <- t(ls.gap2) %*% ls.gap2
  SBC.gap[gap2 + 3] <- (TT * log(gap2sum.res)) +
    ((gap2 + 3 + 3 + 1) * log(TT))
  if(gap2 == 7)
    break
}
return(SBC.gap)
}

```

The sas program of regression analysis

```

data set1;
infile "~/thesis/ahcnf.dat";
input year q1-q4;
array A{4} q1-q4;
do I=1 to 4;
PG=A{I};
output;
end;
drop q1 q2 q3 q4;

data set2; set set1;
if PG=0.0 then delete;
lagPG1=lag(PG);
GrowthPG=(log(PG)-log(lagPG1))*100;

proc means data=set2;
var GrowthPG;

data PGhat;
set set2;
AVG=0.3924258;
DEV=GrowthPG-AVG;
DEVlag1=lag(DEV);
proc print data=PGhat;

run;

data Mhat;
infile "~/thesis/ambs1.dat";
input date1 ambs11;
input date2 ambs12;
input date3 ambs13;
mambs1=(ambs11+ambs12+ambs13)/3;
mlag1=lag(mambs1);
Growthm=(log(mambs1)-log(mlag1))*100;
Gromlag1=lag(Growthm);
proc print;

run;

data set1;
infile "~/thesis/clf16ov.dat";
input date1 clf16ov;
infile "~/thesis/cnpl6ov.dat";
input date2 cnpl6ov;
LBF=(clf16ov/cnpl6ov)*100;
drop date2 clf16ov cnpl6ov;

run;

data set2;set set1;
id=1;
if mod(_N_,3)=1 then id=(_N_+2)/3;
if mod(_N_,3)=2 then id=(_N_+1)/3;
if mod(_N_,3)=0 then id=_N_/3;

```

```

*****
data LBF;set set2;
by id;
if first.id then QUALBF=0;
QUALBF+LBF/3;
if mod(_N_,3)=0;
LBFlag1=lag(QUALBF);
proc print data=LBF;

run;

data set1;
infile "~/thesis/cpiengsl.dat";
input date1 cpiengsl;
infile "~/thesis/cpilfesl.dat";
input date2 cpilfesl;
RPE=(cpiengsl/cpilfesl)*100;
drop date2 cpiengsl cpilfesl;

run;

data set2;
set set1;
id=1;
if mod(_N_,3)=1 then id=(_N_+2)/3;
if mod(_N_,3)=2 then id=(_N_+1)/3;
if mod(_N_,3)=0 then id=(_N_)/3;

data RPE;
set set2;
by id;
if first.id then QUARPE=0;
QUARPE+RPE/3;
if mod(_N_,3)=0;
drop id RPE ;
RPElag1=lag(QUARPE);
RPElag2=lag(RPElag1);
proc print data=RPE;

run;

data set1;
infile "~/thesis/cpiufdsl.dat";
input date1 cpiufdsl;
infile "~/thesis/cpilfesl.dat";
input date2 cpilfesl;
RPF=(cpiufdsl/cpilfesl)*100;
drop date2 cpiufdsl cpilfesl;

run;

data set2;
set set1;
id=1;
if mod(_N_,3)=1 then id=(_N_+2)/3;
if mod(_N_,3)=2 then id=(_N_+1)/3;
if mod(_N_,3)=0 then id=(_N_)/3;

```

```
data RPF;
set set2;
by id;
if first.id then QUARPF=0;
QUARPF+RPF/3;
if mod(_N_,3)=0;
drop id RPF ;
RPFflag1=lag(QUARPF);
proc print data=RPF;
```

run;

```
data set1;
infile "~/thesis/ophnf.dat";
input year q1-q4;
array A{4} q1-q4;
do I=1 to 4;
W=A{I};
output;
end;
drop q1 q2 q3 q4;
```

```
data wage; set set1;
if W=0.0 then delete;
Wlag1=lag(W);
Growthw=(log(W)-log(Wlag1))*100;
Growlag1=lag(Growthw);
Growlag2=lag(Growlag1);
proc print data=wage;
```

run;

```
data set1;
infile "~/thesis/pgnp2";
input year q1-q4;
array A{4} q1-q4;
do I=1 to 4;
pi=A{I};
output;
end;
drop q1 q2 q3 q4;
```

```
data deflator; set set1;
if PI=0.0 then delete;
PIlag1=lag(PI);
GrowthPI=(log(PI)-log(PIlag1))*100;
GrPIlag1=lag(GrowthPI);
GrPIlag2=lag(GrPIlag1);
proc print data=deflator;
```

run;

```
data un;
infile "~/thesis/unrate.dat";
input datel unratel;
```

```

input date2 unrate2;
input date3 unrate3;
QUNRATE=(unrate1+unrate2+unrate3)/3;

infile "~/thesis/nairu.dat";
input date1 Ubar;
gap=QUNRATE-Ubar;
gaplag1=lag(gap);
gaplag2=lag(gaplag1);
proc print;

run;

data nia;
infile "~/thesis/niaex.dat";
input dateE xpends;
xpenlag1=lag(xpends);
Growthxp=(log(xpends)-log(xpenlag1))*100;
drop dateE;
proc print data=nia;

run;

data set2;
merge Pghat Mhat LBF RPF RPE wage deflator un nia;

data march;
set set2;
if year=71.1 or year=72.1 then DUMMY=1;
Else DUMMY=0;
keep year I devlag1 Growthm Gromlag1 LBFlag1 RPElag1 RPElag2
RPFflag1 Growlag1 Growlag2 GrowthPI GrPilag1 GrPilag2
gaplag1 gaplag2 Growthxp DUMMY;

proc corr;
var devlag1 Growthm Gromlag1 LBFlag1 RPElag1 RPElag2
RPFflag1 Growlag1 Growlag2 GrowthPI GrPilag1 GrPilag2
gaplag1 gaplag2 Growthxp DUMMY;

proc REG;
model GrowthPI=Growthm Gromlag1 Growthxp GrPilag1 GrPilag2
Growlag1 Growlag2 LBFlag1 devlag1 RPElag1 RPElag2
RPFflag1 gaplag1 gaplag2 DUMMY;
proc print data=march;

run;

```

The splus program of predictions for the general model

```

"pifore.gel"<-
function()
{
pi <- scan("pi.out")
mhat <- scan("ambsl.out")
ghat <- scan("xp.out")
wagehat <- scan("wage.out")
lbf <- scan("lbf.out")
pghat <- scan("ahcnf.out")
rpe <- scan("rpe.out")
rpf <- scan("rpf.out")
gap <- scan("gap.out")
A <- matrix(0, 17, 13)
pifore <- pi[1:132]
DD <- c(rep(0, 56), rep(1, 8), rep(0, 68))
k <- 0
repeat {
  k <- k + 1
  xpi <- cbind(pi[3:(130 + k)], pi[2:(130 + k - 1)],
              pi[1:(130 + k - 2)])
  xpi.fore <- cbind(mhat[4:(131 + k)], ghat[4:(131 +
              k)], xpi, wagehat[3:(130 + k)],
              lbf[3:(130 + k)], pghat[3:(130 +
              k)], rpe[3:(130 + k)], rpf[3:(130 +
              k)], gap[3:(130 + k)], DD[4:(131 + k)])
  A[k, ] <- lsfit(xpi.fore, pi[4:(131 + k)])$coef
  pifore[k + 132] <- A[k, 1] + A[k, 2] * mhat[131 + k +
              1] + A[k, 3] * ghat[131 + k + 1] +
              A[k, 4] * pi[130 + k + 1] + A[k, 5]
              * pi[130 + k] + A[k, 6] * pi[130 +
              k - 1] + A[k, 7] * wagehat[130 + k +
              1] + A[k, 8] * lbf[130 + k + 1] +
              A[k, 9] * pghat[130 + k + 1] + A[k,
              10] * rpe[130 + k + 1] + A[k, 11] *
              rpf[130 + k + 1] + A[k, 12] * gap[130 +
              k + 1]

  if(k == 17)
    break
}
MSE.pifore <- sum((pi[133:149] - pifore[133:149])^2)/17
ppl <- ts(pi, start = c(1957.1), frequency = 4)
ppfore <- ts(pifore, start = c(1957.1), frequency = 4)
plot(ppl, xlab = "year", ylab = "inflation", type = "n")
lines(ppl, lty = 1)
lines(ppfore, lty = 2)
abline(v = 1990.1, lty = 2)
legend(1960.1, 2.5, legend = c("observed", "predicted"),
      lty = c(1, 2))
return(list(coef.gel = A, fore.gel = pifore[133:149],
           MSE.pifore.gel = MSE.pifore))
}

```


The splus program of predictions for the monetarist model

```

"pifore.mone"<-
function()
{
pi <- scan("pi.out")
mhat <- scan("ambsl.out")
ghat <- scan("xp.out")
lbf <- scan("lbf.out")
pghat <- scan("ahcnf.out")
rpe <- scan("rpe.out")
rpf <- scan("rpf.out")
A <- matrix(0, 17, 11)
pifore <- pi[1:132]
DD <- c(rep(0, 56), rep(1, 8), rep(0, 68))
k <- 0
repeat {
  k <- k + 1
  xpi <- cbind(pi[3:(130 + k)], pi[2:(130 + k - 1)],
              pi[1:(130 + k - 2)])
  xpi.fore <- cbind(mhat[4:(131 + k)], ghat[4:(131 +
              k)], xpi, lbf[3:(130 + k)],
                  pghat[3:(130 + k)], rpe[3:(130 + k)],
                  rpf[3:(130 + k)], DD[4:(131 + k)])
  A[k, ] <- lsfit(xpi.fore, pi[4:(131 + k)])$coef
  pifore[k + 132] <- A[k, 1] + A[k, 2] * mhat[131 + k +
              1] + A[k, 3] * ghat[131 + k + 1] +
              A[k, 4] * pi[130 + k + 1] + A[k, 5]
              * pi[130 + k] + A[k, 6] * pi[130 +
              k - 1] + A[k, 7] * lbf[130 + k + 1]
              + A[k, 8] * pghat[130 + k + 1] +
              A[k, 9] * rpe[130 + k + 1] + A[k,
              10] * rpf[130 + k + 1]

  if(k == 17)
    break
}
MSE.pifore <- sum((pi[133:149] - pifore[133:149])^2)/17
ppl <- ts(pi, start = c(1957.1), frequency = 4)
ppfore <- ts(pifore, start = c(1957.1), frequency = 4)
plot(ppl, xlab = "year", ylab = "inflation", type = "n")
lines(ppl, lty = 1)
lines(ppfore, lty = 2)
abline(v = 1990.1, lty = 2)
legend(1960.1, 2.5, legend = c("observed", "predicted"),
      lty = c(1, 2))
return(list(coef.mone = A, fore.mone = pifore[133:149],
           MSE.pifore.mone = MSE.pifore))
}

```


The splus program of predictions for the expectations-augmented Phillips-curve model

```

"pifore.ph"<-
function()
{
pi <- scan("pi.out")
wagehat <- scan("wage.out")
lbf <- scan("lbf.out")
pghat <- scan("ahcnf.out")
rpe <- scan("rpe.out")
rpf <- scan("rpf.out")
gap <- scan("gap.out")
A <- matrix(0, 17, 11)
pifore <- pi[1:132]
DD <- c(rep(0, 56), rep(1, 8), rep(0, 68))
k <- 0
repeat {
  k <- k + 1
  xpi <- cbind(pi[3:(130 + k)], pi[2:(130 + k - 1)],
              pi[1:(130 + k - 2)])
  xpi.fore <- cbind(xpi, wagehat[3:(130 + k)], lbf[3:(130 + k)],
                   pghat[3:(130 + k)], rpe[3:(130 + k)],
                   rpf[3:(130 + k)], gap[3:(130 + k)],
                   DD[4:(131 + k)])
  A[k, ] <- lsfit(xpi.fore, pi[4:(131 + k)])$coef
  pifore[k + 132] <- A[k, 1] + A[k, 2] * pi[130 + k + 1]
                    + A[k, 3] * pi[130 + k] +
                    A[k, 4] * pi[130 + k - 1] +
                    A[k, 5] * wagehat[130 + k + 1] +
                    A[k, 6] * lbf[130 + k + 1] +
                    A[k, 7] * pghat[130 + k + 1] +
                    A[k, 8] * rpe[130 + k + 1] +
                    A[k, 9] * rpf[130 + k + 1] +
                    A[k, 10] * gap[130 + k + 1]

  if(k == 17)
    break
}
MSE.pifore <- sum((pi[133:149] - pifore[133:149])^2)/17
ppl <- ts(pi, start = c(1957.1), frequency = 4)
ppfore <- ts(pifore, start = c(1957.1), frequency = 4)
plot(ppl, xlab = "year", ylab = "inflation", type = "n")
lines(ppl, lty = 1)
lines(ppfore, lty = 2)
abline(v = 1990.1, lty = 2)
legend(1960.1, 2.5, legend = c("observed", "predicted"),
      lty = c(1, 2))
return(list(coef.ph = A, fore.ph = pifore[133:149]),
        MSE.pifore.ph = MSE.pifore)
}

```

REFERENCES

- Abel, Andrew, and Ben Bernanke (1992). *Macroeconomics*. Reading, Massachusetts: Addison-Wesley.
- Akkina, Krishna, and Hossein Varamini (1993). "Further evidence on alternative theories of inflation and unemployment: the Scandinavian countries." *Applied Economics* 25, 945-951.
- Andersen, Leonall C., and Denis S. Karnosky (1977). "A Monetary Interpretation of Inflation." in Joel Popkin(ed.) *Analysis of Inflation: 1965-1974*, Cambridge, MA: Ballinger, 11-26.
- Ball, Laurence (1993). "What Causes Inflation?" Federal Reserve Bank of Philadelphia *Business Review*, March, 3-12.
- Barro, Robert J. (1990). *Macroeconomics*, 2nd ed. New York: John Wiley and Sons.
- Barth, James R., and James T. Bennett (1975). "Cost-push Versus Demand-pull Inflation: Some Empirical Evidence." *Journal of Money, Credit, and Banking* 7, August, 391-397.
- Benderly, Jason, and Burton Zwick (1985). "Money, Unemployment and Inflation." *The Review of Economics and Statistics* 67, February, 139-143.
- Brockwell, Peter J., and Richard A. Davis (1991). *Time Series: Theory and Methods*, 2nd ed. New York: Springer-Verlag.
- Dornbusch, Rudiger, and Stanley Fischer (1987). *Macroeconomics*, 4th ed. New York: McGraw-Hill.
- Enders, Walter (1995). *Applied Econometric Time Series*. New York: John Wiley and Sons.
- Fama, Eugene F. (1982). "Inflation, Output, and Money." *Journal of Business* 55, April, 201-231.

- Friedman, Milton (1969). "The Monetary Studies of the National Bureau." *The Optimum Quantity of Money and Other Essays*, Chicago: Aldine, 266-279.
- Garner, C. Alan (1994). "Capacity Utilization and U.S. Inflation." Federal Reserve Bank of Kansas City *Economic Review*, Fourth Quarter, 1-9.
- Hafer, R. W. (1983). "Inflation : Assessing Its Recent Behavior and Future Prospects." Federal Reserve Bank of St.Louis *Review* 65, August/September, 36-41.
- Hafer, R. W. (1984). "Examining the Recent Behavior of Inflation." Federal Reserve Bank of St.Louis *Review* 66, August/September, 29-39.
- Haslag, Joseph H., and D'Ann M. Ozment (1991). "Money Growth, Supply Shocks, and inflation." Federal Reserve Bank of Dallas *Economic Review*, May, 1-17.
- Hill, John K., and Kenneth J. Robinson (1989). "Money, Wages, and Factor Scarcity as Predictors of Inflation." Federal Reserve bank of Dallas *Economic Review*, May, 21-29.
- Mehra, Yash P. (1991). "Wage Growth and the Inflation Process: An Empirical Note." *The American Economic Review* 81, September, 931-937.
- Miller, Roger LeRoy (1986). *The Economics of Macro Issues*, 5th ed. St.Paul: West Publishing.
- Mishkin, Frederic S., (1989). *The Economics of Money, Banking, and Financial Markets*, 2nd ed. New York, NY: HarperCollins.
- Parkin, Michael (1984). *Macroeconomics*. Englewood Cliffs, New Jersey: Prentice-Hall.
- Pindyck, Robert S., and Daniel L. Rubinfeld (1991). *Econometric Models and Economic Forecasts*, 3rd ed. New York: McGraw-Hill.
- Rangazas, Peter, and Dewan Abdullah (1988). "Testing Some Monetarist Propositions." *The review of Economics and Statistics*, 173-177.
- Rea, John D. (1983). "The Explanatory Power of Alternative Theories of Inflation and Unemployment, 1895-1979." *The Review of Economics and Statistics* 65, May, 183-195.
- Stein, Jerome L. (1982). "Monetarist, Keynesian and New Classical Economics." New York: New York University Press.
- Stockton, David J., and Charles S. Struckmeyer (1989). "Tests of the Specification and Predictive Accuracy of Nonnested Models of Inflation." *The Review of Economics and Statistics* 71, May, 275-283.

- Stockton, David J., and James E. Glassman (1987). "An Evaluation of the Forecast Performance of Alternative Models of Inflation." *The Review of Economics and Statistics* 69, February, 108-117.
- Tatom, John A. (1981). "Energy Prices and Short-Run Economic Performance." Federal Reserve Bank of St. Louis *Review*, January, 3-17.
- Weiner, Stuart E. (1994). "The Natural Rate and Inflationary Pressures." Federal Reserve Bank of Kansas City *Economic Review*, Third Quarter, 5-9.