INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI

A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA
313/761-4700 800/521-0600

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CAPACITY UTILIZATION:

PREDICTOR OF INFLATION

William W. Wilkes

A dissertation presented to the
Graduate Faculty of Middle Tennessee State University
in partial fulfillment of the requirements
for the degree of Doctor of Arts

May 1998

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

UMI Number: 9830087

UMI Microform 9830087
Copyright 1998, by UMI Company. All rights reserved.

This microform edition is protected against unauthorized
copying under Title 17, United States Code.

UMI
300 North Zeeb Road
Ann Arbor, MI 48103

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CAPACITY UTILIZATION:

PREDICTOR OF INFLATION

APPROVED:

Dissertation Committee:

Committee Chairman

Committee Member

Bob Womack by Jim Hoffman

Committee Member

Department Chairman of Economics and Finance

Dean of the Graduate School

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

ABSTRACT

Capacity Utilization: Predictor of Inflation

By: William W. Wilkes

The current challenge confronting the Federal Open Market Committee of the Federal Reserve Bank (FOMC) in achieving price stability requires the facility to forecast changes in the rate of inflation and to implement timely corrective measures before the economy experiences a surge in inflation. The need for prompt and appropriate monetary policy is magnified by the existence of lags between changes in the economy (real or monetary) and price inflation. Forces tending to accelerate inflation may already be in place, but price increases may not have materialized.

The purpose of this study is to develop a model comprised of real forces (capacity utilization and other supply/demand proxies) that can be used to predict changes in inflation, thereby, alerting the FOMC of the need to embark on monetary policy aimed at preventing an acceleration of price increases. The model will be examined as to its ability to forecast future inflation using lagged values of the independent variables. The study will also examine the concept of a non-accelerating inflation rate of capacity utilization (NAICU) with respect to its validity as a monetary policy tool.

This study finds that capacity utilization plays a significant role in explaining changes in the rate of inflation. However, it would be naïve to focus strictly on the NAICU as the sole predictor of inflation rate changes. Ignoring other supply/demand variables identified in this study as major contributors in explaining inflation will result in a suboptimal model of the inflation process.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

ACKNOWLDEGEMENTS

This dissertation has been completed through the cooperation and support of my wife, Kennette, and our family. Their encouragement and assistance have been invaluable.

I would like to thank members of my dissertation committee at Middle Tennessee State University—Dr. Joachim Zietz, Dr. Albert Deprince, and Dr. Bob Womack—for their significant contributions and challenges. The scholarly advice and suggestions they offered were instrumental in development of this study and were greatly appreciated.

Five years ago I was given an opportunity by senior administrators of Motlow State Community College, Tullahoma, Tennessee, to make a significant mid-life career change. Part of my commitment to them was to complete the Doctor of Arts degree program. Their encouragement and support during this venture was much appreciated.

The final stage of this dissertation was completed while I was employed as an Assistant Professor by Athens State College, Athens, Alabama. I would like to express my sincere appreciation to Dr. James Haynes, Dean of the College of Business, and my fellow colleagues for their support and encouragement during this process. Their friendship and professional guidance made this difficult task a manageable one

This dissertation is lovingly dedicated to my mother and father, Lila and Durward Wilkes. I wish my father could have been present to enjoy the culmination of my efforts. However, he left the world knowing I was well on my way to completing a journey about which he was very excited.

Lastly, a special thanks is offered to my good friend and fellow Doctor of Arts student, Dr. Mark Wilson, for his moral and emotional support.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE OF CONTENTS

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

LIST OF TABLES

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

LIST OF FIGURES

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CHAPTER 1

INTRODUCTION

> Long-run price stability should be the primary goal of the central bank, with the promotion of full employment and growth being permitted to the extent that they do not conflict with the primary goal. (Fischer, 1996, 29)

> The lags between actions by the central bank in adjusting its policy instrument (the overnight rate or very short-term rate of interest) and the rate of inflation is on the order of one to two years in most countries. Because of these lags, the central bank must take a forward-looking approach in its decision making and focus on the forecast or projected rate of inflation. (Freeman, 1996, 251)

1. OVERVIEW OF THE STUDY

The current challenge confronting the Federal Open Market Committee of the Federal Reserve Bank (FOMC) in achieving price stability requires the facility to forecast changes in the rate of inflation and to implement timely corrective measures before the economy experiences a surge in inflation. The need for prompt and appropriate monetary policy is magnified by the existence of lags between changes in the economy (real or monetary) and price inflation. Forces tending to accelerate inflation may already be in place, but price increases may not have materialized.

The purpose of this study is to develop a model comprised of real forces (capacity utilization and other supply/demand proxies) that can be used to predict changes in inflation, thereby, alerting the FOMC of the need to embark on monetary policy aimed at preventing an acceleration of price increases. The model will be examined as to its ability to forecast future inflation using lagged values of the independent variables. The study will also examine the concept of a non-accelerating inflation rate of capacity utilization (NAICU) with respect to its validity as a monetary policy tool.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2. FOMC POLICY, PRICE STABILITY, AND INTEREST RATE TARGETING

The FOMC has several economic goals, including establishing low unemployment, maintaining stable prices, and promoting economic growth. Price stability, however, appears to be the current overriding consideration. Since the late 1979, the FOMC's goal of monetary policy appears to have progressively shifted toward the reduction of the level and variation of inflation (Cecchetti, 1995, 189). DePrince (1993, 3) observes that United States monetary policy is probably influenced by the decision of European central banks to set price stability as their primary objective, causing the FOMC to adopt a similar goal.

To achieve the goal of price stability, the FOMC currently targets the Federal Funds interest rate at a level deemed appropriate for the desired economic outcome and alters reserves in the banking system to support this rate. Day-to-day open market operations are currently resulting in a perfectly elastic supply of excess reserves to defend the desired Federal Funds rate, regardless of the demand for excess reserves. Previous attempts during the 1960s and 1970s to defend a particular Federal Funds rate have, however, shown that targeting the Federal Funds rate may be procyclical and increase inflationary pressures during an expansion phase of the economy.

The goal of price stability and the use of the Federal Funds rate as an operating target is further complicated by the existence of lags in the economy; hence, the FOMC must exercise vigilance in anticipating inflation. This requires a willingness to alter monetary policy (proactively change the Federal Funds rate) to dampen the growth of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

aggregate demand to curb inflationary buildup, rather than waiting for an acceleration of inflation to occur and then reacting.[1]

In a perfect New Classical world of instantaneously clearing markets, the FOMC could wait until changes in the rate of inflation occurred and then adjust the Federal Funds rate accordingly. In the real world, however, prices are slow to rise in the short-run for reasons which are documented in the New Keynesian literature (e.g., Gordon, 1990). Concepts such as menu costs, efficiency wages, staggered labor and supply price contracts, insider-outsider theory, and market co-ordination failure are the usual reasons given for the hesitancy of prices to increase. The sluggishness of the economy in clearing markets that are in disequilibrium may result in a situation where inflationary pressures are building up, but inflation remains stable. As these internal pressures increase, the economy may reach a point at which the FOMC is confronted with a surge in inflation.

In addition to the lags which may cause a delay of price inflation to manifest itself, the FOMC must also anticipate delays between changes in the Federal Funds rate and when these changes will impact the level of economic activity. With the lags in the effects of altering monetary policy, the FOMC must act in advance of rising inflation to minimize variations in prices and output around desired paths (Cecchetti, 1995)[2].

3. REAL SHOCKS, INFLATION, AND AN EARLY WARNING MECHANISM

Although inflation is generally regarded as a monetary phenomenon in the long run, real forces in the economy, combined with the FOMC's policy of targeting the

[1] As noted by Freemen (1997, 262) such action by the central bank may present a perceptual problem—being criticized for "getting ahead of the curve" and reacting to nonexistent problems.
[2] Included in a written comment by Donald Kohn regarding Cecchetti's article.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Federal Funds rate, may lead to accelerating inflation. Consequently, given the lags in the economy, the FOMC needs to develop an early warning mechanism to anticipate changes in the inflation rate.

Central banks have investigated the use of a wide range of financial and monetary instruments in forecasting changes in inflation. Variables included in these studies have been: 1) foreign exchange rates, 2) shape of the yield curve, 3) price of gold, 4) interest rates, and 5) monetary aggregates. The principal shortcoming of using a financial or monetary instrument to predict changes in inflation relates to the role of inflation expectations in determining its price. This price change may be a result of inaccurate information and not based on any real structural alteration in the economy that might generate accelerating inflation. Using a financial or monetary variable as a proxy for inflation may, therefore, send an incorrect signal to the FOMC, resulting in inappropriate monetary policy.

Although financial and monetary variables can be used as crosschecks for pending changes in inflation, the use of real variables as predictors of future rates of inflation is gaining increasing acceptance by central bankers and economists. Factors such as unemployment, capacity utilization, relative input prices and productivity improvements represent real economic activities that embody structural relationships in the economy. A real change, such as an oil price shock, could cause a structural change in the economy that might result in inflation that would be totally unrelated to changes in monetary aggregates resulting from actions by the FOMC.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The focus of this study on real variables does not challenge the concept that there is a long-run relationship between inflation and the money supply. Instead, it is recognition that, in the short-run, real forces in the economy may have an impact on changes in the rate of inflation.

4. UNEMPLOYMENT AND CAPACITY UTILIZATION

> It is because of the fundamental roles of the path of output relative to capacity in determining the rate of inflation that so much attention is paid (both by the authorities and the financial markets) to information about aggregate demand, especially when an economy is operating near capacity. (Freeman, 1996, 261)

During the 1990s the non-accelerating inflation rate of unemployment (NAIRU) and the non-accelerating inflation rate of capacity utilization (NAICU)[3] are two real factors receiving increased attention, and one or the other is often cited as a key factor in determining monetary policy. In the 1994 episode of interest rate increases engineered by the FOMC, the NAIRU appears to have been the overriding consideration in guiding monetary policy. In 1997, the NAIRU is less prominent due to an apparent inability to precisely measure the stable inflation rate of unemployment. In contrast, capacity utilization now receives more attention as a possible factor in signaling impending changes in inflation. The NAICU appears to remain relatively stable (approximately 82%); whereas, the NAIRU varies considerably (7% during the 1970s to approximately 4.8% during the late 1990s).

[3] The NAIRU and NAICU concepts are fully discussed in Chapter 2.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Both the NAIRU and the NAICU represent measures of resource utilization and serve as proxies for aggregate demand. These two values provide some indication of the slackness/tightness in their respective markets (labor and capital) and may predict changes in the rate of inflation. Economists and policymakers who support NAIRU or NAICU as an inflation indicator suggest that the FOMC alter the Federal Funds rate to slow down the growth of aggregate demand when actual unemployment or capacity utilization indicate a tightening in either resource market. However, as will be demonstrated in this study, use of the NAICU as a sole indicator of accelerating inflation represents sub-optimal use of all the information available to the FOMC.

5. ORGANIZATION OF MATERIAL

The first section of Chapter 2 examines the relationship between inflation and unemployment and how various concepts evolved over the past thirty years. Much attention is given to the empirical nature of the NAIRU and problems associated with the measurement of the rate. Aggregate demand/aggregate supply analysis is used to explain the posited inverse relationship between inflation and unemployment and how different circumstances can generate a positive relationship between the two variables. Departing from the macroeconomic perspective of the NAIRU, the study then examines the microeconomic foundations of the theory and how government policy might alter the rate. This section concludes with a discussion of the unemployment situation in Europe during the past twenty-five years and contrasts it with US experience during the same time period.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The second section of Chapter 2 examines the relationship between capacity utilization and inflation. Some of the theory parallels the discussion concerning inflation versus unemployment, but a more thorough analysis is given to the problems with the measurement of capacity utilization and its use as a proxy for the level of aggregate demand. Other issues concerning the appropriateness of using the non-accelerating rate of capacity utilization (NAICU) to predict changes in the rate of inflation are discussed. Finally, the possibility that the linkage between capacity utilization and inflation may have diminished during the last ten years is examined.

Chapter 2 is written in a narrative form in order to present the material in a logical and sequential manner. Additionally, graphs are used extensively as a tool in an attempt to more clearly illustrate the theory. The content of Chapter 2 is presented in a manner that is intended to facilitate its incorporation into a lesson plan dealing with this complicated and confusing topic, with the material forming the foundation of teaching notes at the principles or intermediate level.

Chapter 3 describes the methodology utilized in the empirical research portion of this study. The basic regression model pertaining to the NAICU concept is introduced, along with a discussion of variables that might be appropriate for inclusion in the model. In addition, the various statistical tests used in this study and the rationale for their selection are discussed.

Empirical research results are presented in Chapter 4. Alternative variables are progressively introduced into the regression model in an attempt to improve its ability to

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

predict inflation. The nine models developed through this process are systematically tested to measure their validity.

Chapter 5 re-examines the educational pedagogy of this study and presents specific applications for classroom use. Special attention is given to the use of technology and how it might be incorporated in the classroom setting.

Chapter 6 is a discussion of conclusions reached after examining the different models and the sample periods under consideration. One model is offered as the most appropriate for using capacity utilization (and other demand/supply variables) to predict changes in inflation. This model is then examined with respect to its ability to forecast changes in the rate of inflation in the future. Comments are made concerning the contributions to the body of literature made by this study and suggestions offered pertaining to other areas of investigation that might be gainfully pursued.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CHAPTER 2

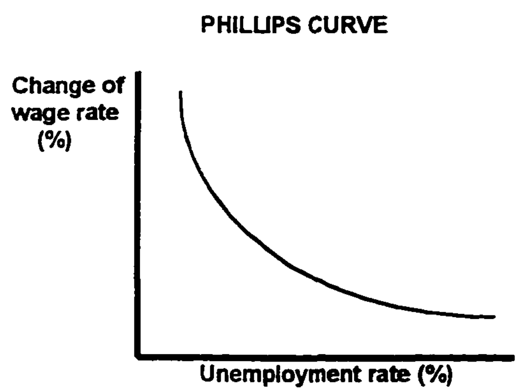
REVIEW OF LITERATURE

1. UNEMPLOYMENT AND INFLATION

1.1. Phillips Curve

Phillips (1958) developed the concept of an empirical relationship between unemployment and wage inflation. By analyzing data for the United Kingdom between 1861 and 1957, he discovered a remarkably stable relationship between the two variables. The original Phillips curve (Figure 1) represents the negative correlation between unemployment and the rate of change in nominal wages.

Figure 1



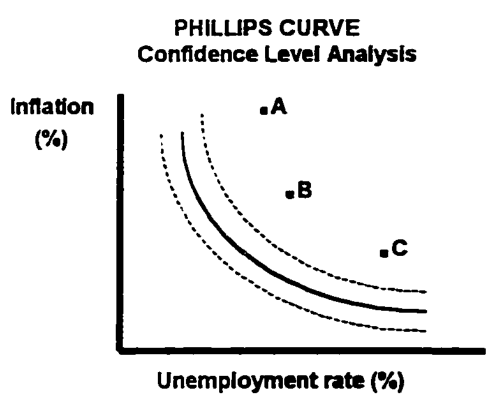
Following the lead of Phillips, economists began examining the relationship between unemployment and wage inflation in other developed countries. Based on work by Samuelson and Solow (1960), the focus of the investigation shifted to the relationship between price inflation (rather than wage changes) and unemployment. As a result of these studies which continued to demonstrate a very stable relationship, economists began

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

to view the Phillips curve as a policy trade-off between unemployment and inflation. Given a high rate of unemployment, the government could stimulate the economy to lower unemployment, but at a cost of higher inflation. Due to the concave shape of the curve, attempts to further lower the rate of unemployment would result in increasingly higher and higher rates of inflation. Nevertheless, the government was thought to be in a position to determine the inflationary impact of lower unemployment and could then make a political decision regarding policy actions to stimulate the economy.

During the late 1960s and 1970s, unemployment and inflation data were observed which fell outside the normal confidence levels established by the empirical studies of the Phillips curve. These points represent high inflation and high unemployment, a positive relationship previously not seen. This situation is demonstrated using Figure 2 which illustrates a Phillips curve, modified to reflect price inflation rather than change in wages, with assumed confidence levels shown by dotted lines. Points **A**, **B**, and **C** represent observations that fall outside the bounds of the confidence levels.

Figure 2



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Persistence of annual data points outside the confidence levels of the established Phillips curve caused economists to question the previously imagined "universally constant" nature of the Phillips curve and to doubt that a simple relationship existed between unemployment and inflation. During the late 1960s and early 1970s accelerating inflation was caused primarily by shocks to the aggregate supply curve. These shocks were generated by higher petroleum costs, price increases resulting from the fixed exchange rate regime of the Bretton Woods agreement, and failure to recognize the role of expectations in determining economic outcomes. These supply-shock inflation episodes contrast with the usual demand-pull inflation that prevailed prior to the 1970s. Economists have since concluded that alterations in the supply determinants of inflation result in a shift of the Phillips curve in the inflation-unemployment space rather than a movement along a stable curve with the *ceteris paribus* assumption imposed.

1.2. Aggregate Demand/Aggregate Supply

1.2.1. *Initial Equilibrium Condition*

Theoretical issues regarding the Phillips curve and the relationship between inflation and unemployment can be explored in the context of aggregate demand (AD) and aggregate supply (AS) curves. Since the concept of AD/AS is covered in most principles and intermediate macroeconomic textbooks, the underlying reasons for the shapes and slopes of the curves will not be discussed; rather, the curves will be used to examine the outcomes of shocks to the economic system. Although the use and interpretation of the AD/AS curves has some theoretical limitations (Colander, 1995), shifts of the curves

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

provide an insight into the reactive tendencies of the economy as it responds to internal or external shocks.

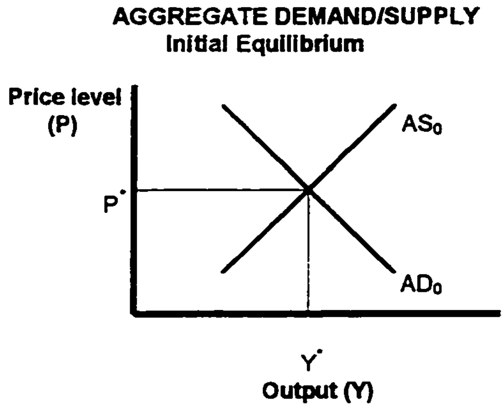
A major criticism of the AD/AS concept concerns the static nature of the graphical analysis rather than an adequate representation of the dynamic nature of inflation. Shifting one of the curves results in a change of the price level. This is, however, a "one-time" adjustment in the price level and not inflation, which is defined as a persistent increase in the general price level. A true representation of inflation using AD/AS curves would require a continual shifting of one of the curves, coupled with accommodating monetary policy that supports the ongoing inflation. Mishkin (1984) provides a very comprehensive illustration of incorporating the dynamic nature of inflation into the AD/AS model.

Despite the static nature of the AD/AS model, the concept of a one-time shift of one curve and the ensuing price increase will be used as an elementary demonstration of inflation for the remainder of this chapter. This decision is based on the fact that the AD/AS analysis is used to examine the relationship between price changes and unemployment following a shock to the economy, rather than to explain ongoing inflation.

Figure 3 shows the basic AD/AS relationship and depicts the initial equilibrium position of the economy (P^* and Y^*). Provided there is no change to the determinants of either AD_0 or AS_0, this equilibrium position will have no tendency to move. In essence, this condition represents a "snap-shot" of the economy at a specific point in time, with fixed levels of resources and technology.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 3



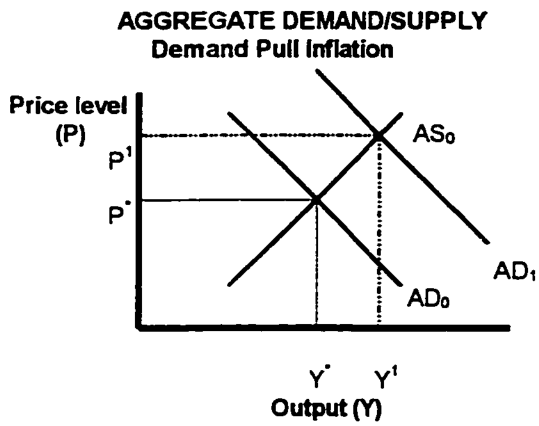
It should be noted that this analysis abstracts from economic growth. Increasing real output of the economy is represented by a movement of Y^* to the right, resulting from increased resources (labor and capital) and/or improvements in technology (Finn, 1995, 2). Economic growth generates continual shifts of both the AD and AS curves to the right. Provided there is balanced growth in the economy (equal shifts in the AD and AS curves), the real output of the economy will increase without any tendency for the price level to deviate from P^*.

1.2.2. *Demand-pull Inflation*

Embedded in the concept of the Phillips curve is the tenet that changes in the rate of inflation are inversely related to unemployment levels. As unemployment declines, the theory posits that inflation will increase. Conversely, increasing unemployment will result in decreasing rates of inflation. This relationship derives from a shift of the AD curve (demand-pull).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 4



In Figure 4, there is a change in one of the determinants of the AD curve that causes the curve to shift from AD_0 to AD_1. It is important to recognize that, since this shift occurs in the short-run, resources and technology are held constant. The increase in real output from Y^* to Y^1 can only occur if there is greater utilization of existing resources, resulting in a reduction in the level of unemployment.

Figure 4 also shows the tendency for the general price level to increase from P^* to P^1 as a result of increased AD. Therefore, when inflation is caused by demand-pull, the inverse relationship between changes in prices and the level of unemployment, as posited by the Phillips curve, is realized. If the stimulus to the AD curve were a result of expansionary monetary or fiscal policy, this government action would generate lower levels of unemployment, but with the consequence of higher prices.

1.2.3. *Cost-push Inflation*

A positive relationship between inflation and unemployment follows if the inflationary pressures are a result of a shift of the AS curve. This was the prevailing

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

situation following the oil crises in the 1970s; a period commonly referred to as "stagflation." Rapidly rising oil prices caused a leftward shift of the AS curve, resulting in both inflation and unemployment increasing; a condition opposite to the theory posited by the Phillips curve.

Figure 5

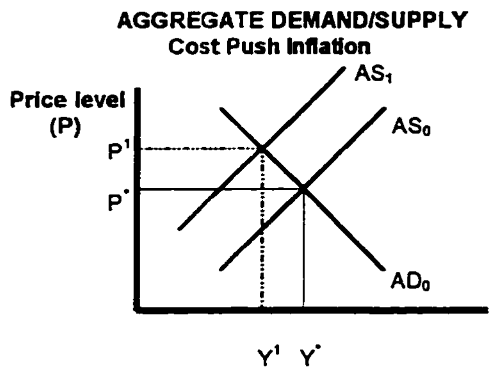


Figure 5 demonstrates the effects of a leftward shift of the AS curve from AS_0 to AS_1 caused, for example, by an increase in the price of oil. This shift does not imply that the economy has become less efficient or productive, only that due to higher input prices (oil), suppliers in the economy must command a higher price to produce the same levels of output. The price level will tend to increase from P^* to P^1. In contrast with Figure 4, real output falls from Y^* to Y^1, resulting in an increase in unemployment.

It should be noted that the Phillips curve was developed prior to the 1970s, when shifts in the AD curve were believed to be responsible for a majority of economic fluctuations. Since that time, two developments have altered the traditional view of inflation. During the 1970s, oil prices became a main source of price inflation in the United States economy and continue to exert a strong influence on price levels. The

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

second development was the emergence of real business cycle theory which asserts that macroeconomic fluctuations are caused primarily by shocks to the aggregate production function, causing the aggregate supply curve to shift (Chang, 1997, 12).

Although supply shocks are usually thought of as unfavorably impacting the economy, it is possible that supply shocks can produce a favorable outcome. Improvements in technology increase the productivity of all resources, shifting the AS curve to the right. This encourages an expansion of output, coupled with a tendency for prices to fall. Chang (1997, 12) uses positive supply shocks to explain the performance of the United States economy during the 1990s when unemployment continued to fall without higher rates of inflation. Chang credits this phenomenon to real prices of oil remaining low for many years and technological developments in computers and communications. In the context of the AD/AS model, this suggests a gradual rightward shift of the AS curve relative to movements of the AD curve, resulting in decreasing unemployment and deflationary pressure in the economy.

1.3. Natural Rate of Unemployment and Adaptive Expectations

During the late 1960s, Phelps (1968) and Friedman (1968) challenged the theoretical underpinnings of the Phillips curve. Independently, they incorporated the concept of adaptive expectations into a model explaining individuals' reactions to an unexpected change in the rate of inflation. The basic tenet of this theory posits the rate of inflation expected for the current period is a function of past inflation. Following an unexpected inflationary shock, the economy will initially experience changes in

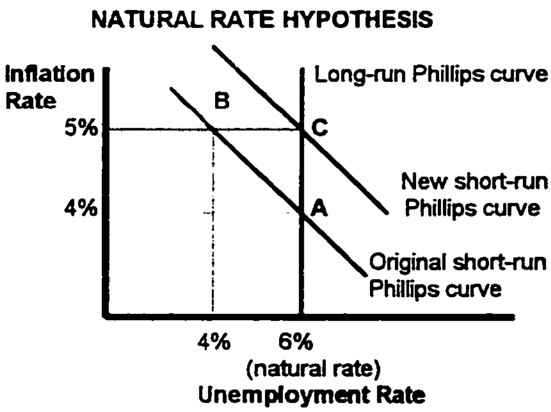
Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

unemployment (short-run), but will eventually return to the natural rate of unemployment as individuals build the new inflation rate into their expectations (long-run).

Cunningham (1994, 31) defines the natural rate of unemployment as the actual rate prevailing when the economy is experiencing only transitory or frictional unemployment. This represents a temporary mismatch in the labor market, a normal consequence of a dynamic economy comprised mainly of individuals changing jobs, or leaving/entering the work force. Unemployment above or below the natural rate is due to cyclical fluctuations in aggregate demand (cyclical unemployment), a reflection of the business cycle. This portion of unemployment may be influenced in the short-term by government policy.

Figure 6 illustrates both the natural rate hypothesis and the concept of adaptive expectations. Starting at point **A** the economy is assumed to be in equilibrium. The original short-run Phillips curve is based on employers and workers fully anticipating an inflation rate of 4%, which is being realized. Additionally, the natural rate of unemployment is assumed to be 6%.

Figure 6



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The economy is then exposed to unexpected expansionary monetary or fiscal policy. Initially the economy moves along the original short-run Phillips curve from point **A** to point **B** since the new rate of inflation (5%) has not been fully incorporated into workers' expectations. As a result of increased aggregate demand, firms increase output by hiring additional labor thereby lowering unemployment. The increased product demand also permits firms to raise prices faster than workers originally anticipated. Therefore, the rate of inflation increases from 4% to 5%, while unemployment falls from 6% to 4% . Even though real wages have fallen due to higher prices, workers are "fooled" by the additional nominal earnings from overtime, slight increases in nominal wages, etc., and are willing to supply more labor which is needed to expand output.

However, in the long-run, workers adjust their expectations to reflect the higher rate of inflation, and demand higher nominal wages to restore their real purchasing power to that level which existed prior to the unexpected inflation. Provided no additional shocks occur and inflation remains at 5%, the original short-run Phillips curve in Figure 6 shifts upward until it intersects the vertical long-run Phillips curve at the new rate of inflation (5%) and unemployment is restored to its natural rate (6%). This new short-run Phillips curve has an inflation rate of 5% built-in as workers' expectation of inflation in the future. In the long-run, therefore, there is no trade-off between unemployment and inflation as suggested by the Phillips curve discussed in Section 1.1.

Friedman (1977, 458), in his Nobel acceptance speech, acknowleges that the natural rate hypothesis is an over-simplification of the real world. The model assumes a single, unanticipated change; whereas, there is always a continuous stream of such

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

changes. Additionally, the model does not deal with lags or overshoots. Furthermore, Rogerson (1997, 90) concludes that Friedman appears to accepts the idea that the economy is generally not operating at a level which realizes the natural rate of unemployment level, but is continually gravitating toward its natural rate.

The values of the coefficients of the lagged inflation variables resulting from a regression analysis of inflation and unemployment provide an insight into the validity of the adaptive expectations hypothesis. Lags of past inflation rates serve as proxies for workers' expectation of the future inflation rate and are independent variables in the regression equation. The current rate of inflation is the dependent variable on the left side. In the simpliest form of the regression model, the coefficient of the rate of inflation lagged one period is constrained to unity (1) with no earlier lags of inflation rates included in the regression. This permits last period's inflation rate to be moved to the left hand side of the regression equation and transforms the dependent variable into the difference between the rate inflation this period and the inflation rate in the previous period.

A more general model contains varying lags of past inflation rates, but the sum of these coefficients must add to unity for the expectations-augmented Phillips curve to hold (Gordon, 1997, 14-15). Conceptually, this can be thought of as how rapidly the economy moves from point **B** to point **C** in Figure 6 (Natural Rate Hypothesis). In the simple model, the adjustment is assumed to occur within one time period. Including additional lags implies the movement from **B** to **C** will take longer than one period. These models usually show that a majority of the movement occurs in the first period, with diminishing weights being given to lags progressively further in the past. However, if the sum of the

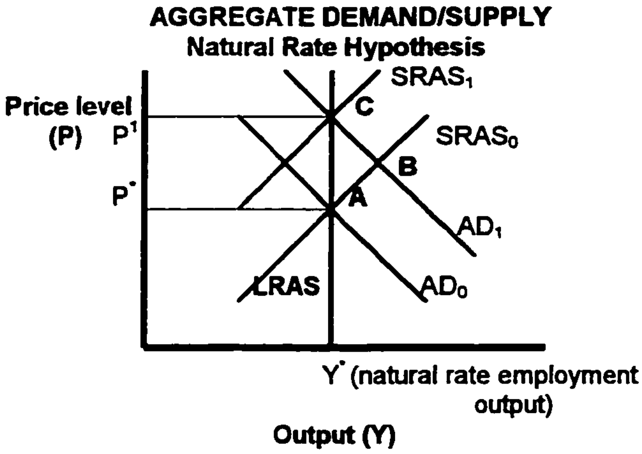
Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

coefficients of lagged inflation rates does not add up to unity, the movement of point **B** will stop short of point **C**, and the long-run Phillips curve will not be vertical. Instead, the long-run curve will have a negative slope that is steeper than any short-run Phillips curve, and the natural rate hypothesis will not hold, suggesting a permanent trade-off between inflation and unemployment in the long-run.

The natural rate hypothesis is demonstrated in Figure 7 using AD/AS curves, with point **A** reflecting initial equilibrium (P^* and Y^*). In this framework, the long-run aggregate supply curve (LRAS) will be perfectly vertical at Y^*, the real output of the economy consistent with the natural rate of unemployment. As resources and technology increase in the long run, the perfectly vertical LRAS curve will move to the right, representing economic growth. In the short-run, following an increase in aggregate demand from AD_0 to AD_1, the inability of workers to immediately adjust nominal wages to unexpected inflation causes real wages to fall. As firms increase production to meet the increased demand, unemployment falls and real output increases as the economy expands along the original short-run aggregate supply curve ($SRAS_0$) from point **A** to point **B**. Eventually nominal wages rise to restore workers' real wages to the original level. Higher wages cause an upward shift of the SRAS curve from $SRAS_0$ to $SRAS_1$ and the economy moves from point **B** to point **C**. The final result at point **C** is that real wages, unemployment, and real output will return to their respective "natural" levels, but at a different price level (P^* to P^1).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 7



Acceptance of the natural rate hypothesis raises various policy considerations:

- There is an infinite number of inflation rates consistent with the natural rate of unemployment.
- In the short-run, government policy may influence the actual rate of employment; however, there is no trade-off between unemployment and inflation in the long-run. Government policy which alters the unemployment rate will eventually be reflected in higher or lower prices with the economy reverting to the natural unemployment rate and the corresponding real output level.

The natural rate hypothesis also raises various questions, many of which were first introduced by Friedman (1968, 1977):

- Are resource and product markets sufficiently flexible to permit unemployment to return to the natural rate by itself following an unexpected change in the rate of inflation?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

- What is the specific level of unemployment that is represented by the natural rate and can it move over time?
- If the natural rate is not "cast in concrete" but can move, what forces in the economy and/or appropriate government policy can alter the natural rate?

1.4. Non-accelerating Inflation Rate of Unemployment (NAIRU)

1.4.1. *Concept*

One of the central tenets of the natural rate hypothesis posits a level of unemployment, which is compatible with a stable rate of inflation. If the economy deviates from this rate of unemployment, there is a tendency for inflation to increase or decrease. Economists usually refer to this rate of unemployment as the non-accelerating inflation rate of unemployment (NAIRU), a concept generally more acceptable than the natural rate hypothesis since it does not imply a specific unemployment rate toward which the economy will inevitably return following a shock to the system (Henderson, 1993, 262).

Although the NAIRU was developed from the theory underlying the natural rate hypothesis, there is a significant difference between the two concepts. Friedman (1968) and Phelps (1968) developed the natural rate as a theoretical equilibrium rate of unemployment that is determined in the labor market. As a result of adaptive expectations following an unexpected change in the rate of inflation, forces in the labor market will eventually return the unemployment level to the original natural rate. The natural rate hypothesis is, therefore, well grounded in economic theory.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

On the other hand, the NAIRU is conceived of as an empirical value determined by historical data rather than an equilibrium value. Furthermore, the NAIRU permits a trade-off between acceleration/deceleration of inflation and unemployment that is independent of the causes of the change in the unemployment rate. This allows for monetary policy to lower unemployment at the expense of increasing inflation, an outcome not possible in the long run with the natural rate hypothesis (Chang, 1997, 6).

The empirical nature of the NAIRU can be demonstrated by Figure 8, which shows year-to-year changes of the rate of inflation and the percentage of actual unemployment at the end of the year. As discussed in the previous section, using the difference between inflation in the current period and inflation in the past period assumes that inflation expectations are fully adapted in one period. Therefore, this empirical model incorporates a major tenet of the adaptive expectations hypothesis.

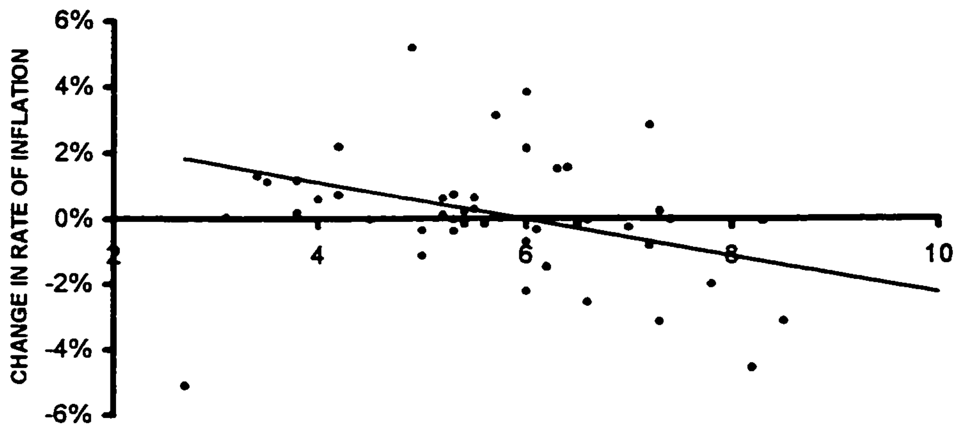
The data points represent actual observations from 1948-1996, and the straight line[1] is the fitted linear regression line. The NAIRU is that level of unemployment where the fitted regression line crosses the zero axis (approximately 6%), implying no tendency for the inflation rate to change. It should be noted that the NAIRU is consistent with any level of inflation since actual inflation rates are not shown, only the change in the rate of inflation from year-to-year.

[1] The linear specification of this relationship is often challenged. Gordon (1997) observes that "None of these differences is statistically significant, indicating that the short-run Phillips curve is resolutely linear, at least within the range of inflation and unemployment values observed over the 1995-1996 period" (26).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 8

NON-ACCELERATING INFLATION RATE OF UNEMPLOYMENT



1.4.2. *Determination of the NAIRU*

There is a large body of literature that deals with empirical models used to measure the NAIRU (Gordon, 1997; Staiger, et al., 1997; Weiner, 1986; Motley, 1990; and Rogerson, 1997). The simple regression model depicted in Figure 8 is the most basic—regressing the change in the rate of inflation from year to year on the percentage rate of unemployment. Gordon (1997) observes that this specification of the model ignores other important determinants of the change in the rate of inflation and creates an obvious problem of omitted variables. More complicated multiple regression models generally include acceleration/deceleration of both oil prices and real exchange rates as proxies for supply shocks, and a dummy variable for the Nixon wage/price control era. Once the regression is performed, the change in the rate of inflation (the dependent variable) and all independent variables, except the rate of unemployment, are set equal to zero. This

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

permits the regression equation to be solved for the unemployment rate that represents the NAIRU for the time period under consideration.[2]

1.4.3. The NAIRU and Monetary Policy

Traditionally, the FOMC has used the comparison between the actual unemployment rate and the NAIRU as a key factor in formulating a decision to alter monetary policy to influence aggregate demand. Use of the NAIRU in guiding the FOMC in monetary policy decisions requires the determination of a unique and precise measure of this rate. One of the basic arguments against this approach lies in the apparent inability to precisely determine the targeted NAIRU. As noted by Rogerson (1997), the linkage between the unemployment rate and future inflation is not precise. If this link were strong and precisely estimated, then unemployment could be an invaluable tool for predicting the course of inflation and thus guiding policymakers.

Staiger, et al. (1997, 47) criticize the NAIRU because of the imprecise measure of the variables included in the regression equation, specifically inflation rates and levels of unemployment. As a result of the lack of perfect measures of inflation and unemployment, they conclude that it is difficult to estimate the level of unemployment at which the downward-sloping Phillips curve predicts a stable rate of inflation.

The more uncertainty concerning the precise measure of the NAIRU, policy makers must become increasing cautious in using this target in guiding monetary policy. The FOMC may be attempting to set employment levels based on an incorrect estimate of the natural rate. This could result in increased inflation or loss of output with all the social

[2] Chapter 3, Section 1.3 presents a mathematical derivation of the formula.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

problems associated with higher unemployment and a larger federal budget deficit. "Given the numerous benefits of accurately estimating the natural rate, further research in this area is clearly warranted" (Weiner, 1986, 17).

As noted by Chang (1997), inclusion of supply shock variables, while improving the regression equation, tends to complicate, or even invalidate, the NAIRU concept in guiding monetary policy. Inclusion of other variables may result in an explanation of the variation in inflation that is unrelated to the deviation of actual unemployment from the NAIRU. Ignoring the influence of supply shocks will result in a sub-optimal model of the inflationary process. His criticism of focusing solely on the NAIRU in establishing monetary policy is summarized as follows:

> . . . concluding that inflation is likely to increase just because the unemployment rate has fallen below the NAIRU ignores useful and available information. Techniques are available for identifying the different shocks that impinge on the economy and cause unemployment to fall. Once these shocks are identified, the deviation of the unemployment rate from the NAIRU provides no additional information for the prediction of changes in inflation. (12)

Despite the above objections concerning the appropriateness and accuracy of using the NAIRU, there are a number of economists who feel the concept is valid. While acknowledging the limitations, they feel the NAIRU is a good building block in attempting to quantify the complex relationship between inflation and unemployment.

Stiglitz (1997) observes that regressing changes in the inflation rate on past values of unemployment, regardless of the specification of other variables, consistently results in t-statistics on lagged unemployment on the order of 4 or 5. "Such results make us just about as certain that unemployment has predictive power for changes in the inflation rate

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

as we can be in empirical research" (4). Gordon (1997, 28) supports the concept of the NAIRU by rejecting the argument that the band of statistical uncertainly surrounding the measurement is so broad as to render the concept unusable for the conduct of monetary policy.

1.4.4. *Does the NAIRU move over time?*

In addition to the problems of precisely measuring the value of the NAIRU, its use in setting monetary policy is complicated by the fact it is not a constant rate, but varies depending on real forces in the economy. During the early stages of the transition from the natural rate hypothesis to the NAIRU, there was confusion about the stability of the natural rate—did it move and, if so, what were the reasons for the movement? The term "natural rate" has a ring of constancy, suggesting the rate is one of the "universal constants" in economy theory. On the contrary, Friedman (1977) recognized from its inception that real forces in the economy determined the natural rate, which was subject to change as these forces varied.

> The "natural rate of unemployment," . . . . . . is not a numerical constant but depends on "real" as opposed to monetary factors—the effectiveness of the labor market, the extent of competition or monopoly, the barriers or encouragement to working in various occupations, and so on. (458)

Early studies of the NAIRU tend to look at the entire time period under consideration and calculate a unique NAIRU based on the entire sample. This approach produces a single estimate with large statistical error terms. When the NAIRU is permitted to move in the empirical studies, the rate tends to shift considerably, but with a corresponding reduction in error terms (Galbraith, 1997, 100).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

There appears to be consensus among economists that the rate does shift (Stiglitz, 1997, 6). Most recent empirical studies have this dynamic feature built into the model and permit the NAIRU to vary over the sample period. There is widespread agreement that in the 1960s the NAIRU varied between 4% and 5%, then increased significantly during the 1970s and early 1980s to approximately 7%, gradually declined to between 5% and 6% in the early/mid 1990s, and continues to decline during the early part of 1997. "The conclusion that the NAIRU is lower today is supported almost unanimously by econometric research in this area" (Stiglitz, 1997, 6).

1.4.5. *Microeconomics and Policy Implications*

Rather than focusing solely on the macroeconomic issue of the value of NAIRU and how can it be measured, economic investigation also attempts to answer the questions of what real forces determine the NAIRU, how these may have altered during the past 40 years, and whether these forces can explain the reasons for the movement of the rate. There are a number of studies that look into the micro-foundations of the NAIRU (Rissman, 1986; Lang, 1990; Blanchard and Katz, 1997; Motley, 1990; Weiner, 1986, 1994, 1995; and Tootel, 1990). A majority of these works have mixed results in their attempts at quantifying the effects of changes in real factors in the United States economy in determining the NAIRU.

In the context of the AD/AS model, this focus of analysis into the microeconomic issues tends to look primarily at permanent shifts, as opposed to one-time shocks, of the AS curve in relationship to the AD curve. There is general agreement that one-time shocks to the system can cause a temporary change in the NAIRU; however, the economy

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

will eventually tend to revert to the original NAIRU. On the other hand, persistent influences shifting the AS curve relative to the AD curve will tend to permanently alter the NAIRU.

Weiner (1994) argues that, whereas monetary policy may be ineffective in permanently lowering the unemployment rate below the NAIRU, the rate itself can be lowered through microeconomic policies aimed at its many sources. These various real factors which may impact the NAIRU are summarized as follows:

- Demographic effects—The assumption here is that each sub-group of the working population has its own natural rate, which does not change. As the mix of these differentiated segments alter in the economy, there should be a corresponding change in the NAIRU due to the differences in weighting. During the 1970s there was a large influx of females and teenagers into the work force, both of which traditionally have a much higher turnover and unemployment rate. Consequently, the NAIRU was expected to increase. Aging of the current population [the baby boomers] should create a decline in the rate (Stiglitz, 1997, 6).
- Productivity growth—Historically there appears to be no long-run effect of the level of productivity on the natural rate of unemployment (Blanchard and Katz, 1997, 56). However, changes in the growth rate of productivity can have temporary effects on the natural rate of unemployment (Stiglitz, 1997). Once this productivity shock works through the economy, workers and employers will adjust their expectations to the higher productivity level and the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

NAIRU should return to the level prevailing prior to the productivity shock. Chang (1997, 12) argues that persistent increase in technology and continual lowering of prices in the computer and information industries do not represent merely a temporary productivity shock. Rather, this is a permanent phenomenon that appears to be partly responsible for the apparent decline of the NAIRU during the 1990s, a gradual rightward shift of the AS curve relative to the AD curve.

- Increasing competitiveness of product and labor markets—As a result of a movement toward freer international trade, much of United States manufacturing now faces potential competition from lower cost regions. Consequently, wage demands have been restrained despite robust employer demand for labor in the United States during the late 1980s and 1990s (Weiner, 1995, 23). As these reduced wage demands work through the labor market, the NAIRU will decrease, permitting the economy to experience higher levels of employment without inflationary pressures building up.
- Decreasing rate of unionization and union membership—Similar to the effects of foreign competition, reduced union pressure on wage demands will tend to lower the NAIRU.
- Structural changes—Rissman (1986) observes that the United States economy has experienced significant structural changes during the past 20 years, resulting in an increase in the NAIRU during the 1980s and a corresponding decrease during the 1990s. Shifts in the relative demand for different labor

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

categories creates a temporary mismatch between skills of workers and those skills demanded by employers. Workers should eventually retrain or move to areas requiring the utilization of their current skills.

- Unemployment benefits—Rissman (1986, 13-14) attributes some of the increase in the NAIRU to expanded social benefits. During the past 20 years, both structural changes and corporate downsizing have increased the number of unemployed, often resulting in extended unemployment benefits. These benefits, while permitting a higher quality job search, increase the average length of time a person voluntarily chooses to remain out of work which will increase the NAIRU.

In addition to stressing government policies aimed at lowering the NAIRU, labor economists are becoming more and more critical of the macroeconomic arguments that suggest the FOMC should intervene when the actual unemployment falls below the NAIRU. Penner (1994) cites two Harvard economists, Lawrence F. Katz and James L. Medoff, who both support the idea that the NAIRU can continue to fall, provided the increase in employment is not too rapid and the FOMC does not intervene. There appears to be an emerging argument that, if the FOMC takes restrictive monetary action when the unemployment falls below the NAIRU, the possibility of the NAIRU gradually moving downwards of its own accord will not be realized. This premise suggests that the FOMC should resist the temptations of reacting to falling unemployment, and not implement restrictive monetary measures—an apparent policy resolve of the FOMC during 1997.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

1.5. Comparison between the United States and Europe

A number of economists have investigated the persistent high rate of unemployment in Europe as compared with the much lower rate in the United States (Tootel, 1990; Blanchard and Katz, 1997; and Lang, 1990). Observing that European inflation rates have been roughly constant during the last five years, Blanchard and Katz (1997, 66) attribute the rise in actual unemployment in Europe to a corresponding increase in the natural rate of unemployment. The primary focus of these studies is to investigate the microeconomic effects (mainly in the labor market) in Europe that might be different than those in the United States and cause the European unemployment rate and NAIRU to remain higher.

The usual conclusion reached by economists investigating high unemployment in Europe generally attributes this phenomenon to "hysteresis" in the labor market. "The term 'hysteresis' has been used to describe theories in which temporary shifts in aggregate demand cause permanent or long-term changes in unemployment" (Lang, 1990, 20). This theory suggests that a fall in aggregate demand resulting in long-term unemployment causes real changes in the labor marker and is the primary reason for the increase of the NAIRU in Europe. In the context of the AD/AS model, this would suggest a slowing down of the growth of the AS curve relative to the AD curve through a reduction in the growth of the labor supply and causing capital/labor resources to become less productive. The reasons cited for this change in the European NAIRU are summarized as follows:

- Wage Rigidities—Real wages are prevented from being fully flexible, even in the long run. Union pressure and the "insider/outsider" model explain the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

downward inflexibility of European wages and have resulted in persistently high levels of unemployment (Tootel, 1990).

- Social/ political factors—Being unemployed becomes socially acceptable and encourages the use of existing benefits to a maximum. Moreover, higher levels of persistent unemployment create pressure for government policies to extend more generous unemployment benefits (Blanchard and Katz, 1997).
- Impact on productivity—The effect of lower aggregate demand and higher unemployment reduces labor's productivity. Prolonged periods of unemployment depreciate the investment in human capital. Being out of work causes people to lose previously acquired skills, moderating the gains from training. High rates of unemployment may discourage new entrants in the labor force from deciding to up-grade their skills (Han, 1994).

While the hysteresis theory is generally accepted as a valid explanation of high unemployment and an increase in the NAIRU in Europe, it is interesting to contrast this situation with the United States experience in the 1990s. It is postulated that improving technology and a declining unemployment rate is causing the AS curve in the United States to shift in a rightward direction, relative to the AD curve. This results in lower unemployment with a tendency for deceleration in the rate of inflation. Therefore, it is possible that the United States is also experiencing a "hysteresis" effect—albeit in a favorable direction. A gradual, but steady, decrease in unemployment in the United States is generating a steady reduction of the NAIRU—a self-fulfilling prophecy.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2. CAPACITY UTILIZATION AND INFLATION

2.1. Concept

McElhattan (1978) is generally credited with the initial introduction of the concept of using capacity utilization, instead of unemployment, as a proxy for excess demand in the final product markets. Much of the theoretical discussion parallels Friedman's development of the natural rate hypothesis in the labor market (1968, 1977). McElhattan argues the price equation used to develop the Phillips curve should contain both unemployment, reflecting excess demand in the labor market, and capacity utilization, reflecting excess demand pressures on existing capacity. However, the use of these two variables in estimating the impact on inflation rates presents two problems (1978, 20):

- Since there is a close historical association between unemployment and capacity utilization, it might be impossible with one equation to statistically separate the effects of these two variables on inflation. This high degree of correlation stems from the fact that labor demand is a derived demand from the final product market. Therefore excess demand in the final market tends to generate excess demand in the labor sector.
- There is limited substitutability between capacity and labor use. More extensive use of capital goods will require more labor. This generates high correlation between movements of unemployment and capacity utilization.

As a result of the high correlation, econometric studies drop one of the variables—usually capacity utilization—and use the other as a proxy for excess demand. McElhattan elects to retain capacity utilization, which is justified on the following grounds (1985, 47):

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

- Capacity utilization provides a more reliable signal of changes in inflation.
- Changes in real factors in the labor market results in shifts of the natural rate of employment. In contrast, the natural rate of capacity utilization has remained steady over time, approximately 82%.
- The difficulty in establishing an accurate measure of the natural rate of unemployment has led to some inflationary bias in policy decisions. There is a tendency to underestimate the unemployment rate consistent with stable inflation, resulting in policies that are too inflationary. Use of capacity utilization to gauge inflationary pressure would serve as an independent check on assessment of inflation based only on unemployment measures.

McElhattan (1985) examines the relative benefits of selecting capacity utilization or unemployment to predict changes in the rate of inflation. Regression analyses are performed with capacity and unemployment alone in separate models and then the two variables are used jointly in a third regression. This permits an assessment of relative contributions of the variables, by themselves and together. The results support the contention that capacity utilization produces a better indication of changes in rates of inflation than is realized when using unemployment data (57).

McElhattan (1978) develops the natural rate of capacity utilization along the same lines as Friedman (1968, 1977)—a perfectly vertical Phillips curve at the natural rate of capacity utilization (equilibrium). This vertical Phillips curve hypothesis is tested by regressing the current inflation rate on the difference between actual capacity and the natural rate of capacity utilization, and lagged values of inflation rates as a proxy for

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

expectations of inflation in the current period. Based on the results, the null hypothesis that the sum of coefficient on lagged inflation is equal to unity cannot be rejected. More specifically, the coefficient of inflation lagged one time period is also statistically equal to one, implying no long run trade-off between inflation and capacity utilization at the natural rate. Actual capacity utilization above or below the natural rate generates a change in the rate of inflation that will be incorporated in the anticipated rate of inflation through adaptive expectations. The economy will tend to revert to the natural rate of capacity utilization following an inflationary surprise, albeit at a different rate of inflation.

2.2. The Non-accelerating Inflation Rate of Capacity Utilization (NAICU)

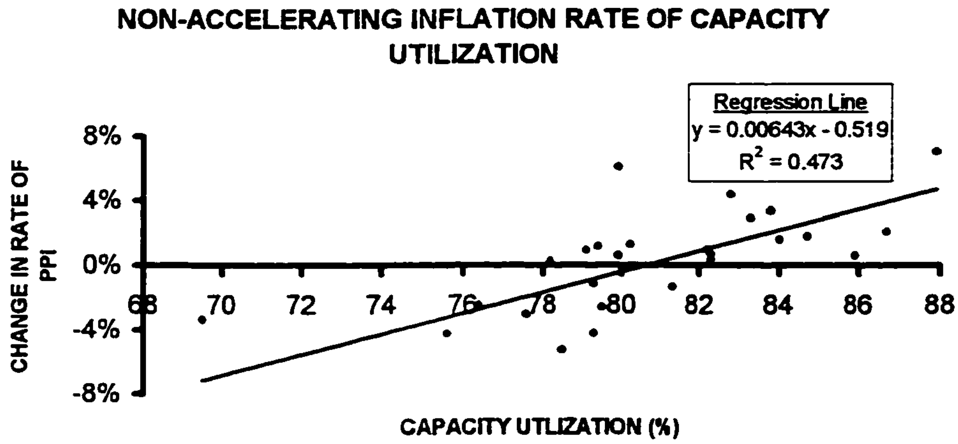
The most basic model examining the linkage between capacity utilization and inflation performs a regression analysis of the annual acceleration of the PPI on actual capacity utilization. Employing actual annual data (1970-1996) that are used during the empirical portion of this study, Figure 9 depicts this relationship. The regression line crosses the "zero inflation" axis at approximately 81%[3], which is defined as the non-accelerating inflation rate of capacity utilization (NAICU).

---

[3] The equation of the fitted line in Graph B is $y = .00643x - 0.519$, which results in a calculated NAICU of 80.7%, and an R-squared value of .47. Refer to Chapter 3, Section 1.3 for the procedure used to calculate the NAICU.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 9



It is important to note that McElhattan (1978) initially develops a regression equation that contains the difference between actual capacity utilization rates and the natural rate of capacity utilization as an independent variable. However, the natural rate is then assumed to be a constant and is incorporated in the regression constant. This equation represents the final form of the model used to calculate the NAICU and predict changes in inflation rates. McElhattan justifies use of a constant NAICU as follows:

> Regarding the capacity-utilization rate, recent theoretical studies suggest that the equilibrium rate of capacity utilization is dependent upon economic costs and the degree of labor-capital substitution, and therefore may vary over time. However, we maintain the hypothesis of a constant CU^* on the basis of our initial estimates of the impact upon that rate of such economic variables as the relative cost of capital to labor which were statistically insignificant. (1978, 22)

The assumption of a constant natural rate of capacity utilization represents a significant difference when compared to the studies relating to the NAIRU. In the unemployment studies, the models first generate a series representing the NAIRU, permitting the NAIRU to vary over time. Once this is accomplished, the difference

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

between the actual unemployment and the NAIRU specific for each year becomes an independent variable in the final equation used to predict changes in inflation.

In a 1985 study, McElhattan expands on the 1978 results by introducing other variables in the determination of the natural rate of capacity utilization. Supply shocks were treated as dummy variables in the first study (1978); however, actual series representing the acceleration of both oil prices and exchange rates, and a dummy variable for Nixon wage/price controls are included in the 1985 regression equations. The effect of using the actual "supply shock" data does not significantly change the NAICU when compared to the 1978 study, but significantly improves the R-squared values and lowers the standard error.

2.3. Measurement of Capacity Utilization

Capacity utilization is defined as the ratio of the actual level of capacity being used as compared to a sustainable maximum level of output that could be produced from the total available capital stock. Accurate determination of capacity utilization involves gathering information on both the actual and maximum sustainable levels of output and capacity, a process that is far from an exact science and subject to the usual problems of data collection and aggregation. Furthermore, most of the data are typically not available from individual firms, but must be collected by sampling (Bauer, 1990, 4). Collection of these data is primarily the responsibility of the Federal Reserve System, and capacity utilization data are published in a bulletin: "G-17 Federal Reserve Statistics Release (Industrial and Capacity Utilization)."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Although capacity and utilization data were first introduced in 1948, regular publications of the data started in 1968 (Koenig, 1996, 17). As noted by Corrado and Mattey (1997), the basic method of capacity measurement developed in the 1960s remains virtually the same, with some minor improvements:

- Initially the survey covered only a few manufacturing sectors, but has been expanded to include about 75 series covering the entire industrial sector (manufacturing, mining, and utilities).
- Definition of capacity has been made more precise by incorporating the idea of sustainable practical capacity as a measure of potential capacity based on the following considerations:
    - Realistic work schedule
    - Normal downtime
    - Sufficient inputs to operate installed machines/equipment
- Originally the Federal Reserve relied on surveys conducted by McGraw-Hill/DRI, but in the 1970s the "Survey of Plant Capacity," introduced by the Census Bureau, was incorporated in the determination of capacity and provides more statistically valid source data. The Federal Reserve also relies on information from Bureau of Economic Analysis, Department of Commerce, and various business and trade organizations to measure both actual and potential capacity (Rost, 1983, 519).
- Recently, more rigorous methods for deriving capital input measures have been implemented as annual indicators for most industries.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Maximum sustainable capacity changes from year to year depending on the difference between acquisition of new capital and depreciation, obsolescence and plant closures. In a growing economy, this difference will be positive, indicating a net growth in the maximum sustainable capacity. It should be noted that high capacity utilization generally results in an increase in maximum sustainable capacity. In the short-run, firms, attempting to increase output with fixed capital, will incur increasing marginal costs as less productive equipment and labor are put to use. In order to bring costs back into line, it is usually necessary to increase manufacturing capacity, which will lower capacity utilization. There are several problems with relying on capital stock expansion as a measure of potential output.

- Stricter pollution controls and OSHA requirements necessitate additions to the capital stock, but usually not to productive capacity. Also, energy conservation resulting from the energy crisis of the 1970s added capital without necessarily increasing potential capacity (Rost, 1983, 520).
- The learning curve of bringing new capacity on-line is usually ignored. If a high growth rate of a manufacturing industry results in a substantial increase of the capital stock, a sizable proportion of the capital may still be in this learning period. Hence an apparent under-utilization may be recorded since the output of new capacity is limited until it is fully integrated into the manufacturing process (Hogan, 1969, 183).
- In the face of increased demand, a firm may perceive potential capacity has increased because it is adopting manufacturing processes that otherwise would

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

have been uneconomical. A bias in favor of increased capacity could occur because much of the information is gathered from plant managers (Butler, 1997, 47).

- In periods of high demand, manufacturers may rely heavily on sub-contractors. In this case, the sub-contractors might report additional capacity utilization and the final manufacturers could perceive their capacity utilization is also increased based on a larger volume of output. This would result in "double counting," much like the inclusion of intermediate goods in determining gross domestic product.

Much of the data on actual and potential capacity are derived from questionnaires completed by manufacturing managers and are, therefore, subject to the usual aggregation problems, sampling errors, and biases (Bauer, 1990, 4). Corrado and Mattey (1997, 152) feel that plant managers have a fairly precise understanding of their facility's capabilities and are able to provide reliable information. However, De Leeuw, et al., note that capacity utilization rates determined from surveys display less volatility over the business cycle than do rates based on the Federal Reserve's index of industrial production (1979, 532). Several reasons are cited for this difference:

- There is a tendency for respondents to report "no change."
- Many respondents base capacity utilization on labor inputs rather than outputs. Swings in employment tend to vary less than changes in output.

Periodic revisions by the Federal Reserve to capacity utilization data cause an additional concern. If "wrong" information were used in developing the estimated stable-

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

inflation capacity utilization rate, the FOMC might be using this incorrect NAICU to develop monetary policy. Review of the literature (Raddock 1993, Raddock 1995, and Raddock 1996) reveals at least three such revisions were made by the Federal Reserve since 1993. Raddock (1993) attempts to dispel concern of these revisions by stating that the changes generally apply to both potential capacity and actual capacity (numerator and denominator of the capacity utilization ratio), resulting in a minimal change to the Federal Reserve rates of capacity utilization. Garner (1994) observes that the capacity utilization statistics are revised for only a small part of the sample period, suggesting that revisions to past capacity utilization rates might have a small effect on the estimated stable-inflation capacity utilization rate.

It should be noted that the gathering of data by the Federal Reserve and other agencies is accomplished during the fourth quarter of each year. Since the data are collected on an annual basis, the true pattern of monthly capacity utilization is unobserved, but extrapolated from the annual data (Corrado and Mattey, 1997, 152). As noted by Koenig (1996, 16), variations of capacity utilization within a year largely reflect monthly changes in output, rather than changes in capacity. Therefore, when performing calculations that incorporate capacity utilization, monthly data should be avoided. Most studies reviewed use annual data reported for the fourth quarter to determine the NAICU. One exception is Emery and Chang (1997) who use monthly, quarterly, and semi-annual data.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2.4. Capacity Utilization and Price Increases

The linkage between increased capacity utilization and the firm's need to increase prices is fully grounded in the microeconomic theory of the firm. As firms attempt to increase output, increasing marginal costs will necessitate a higher product price to cover the additional costs. Lucas (1970, 27) notes that increasing marginal costs can be a result of either diminishing returns in a productive sense, or due to a rising schedule of premium wages as overtime hours increase. Therefore, as the plant manager utilizes resources at higher operating levels, unit labor costs will increase. Additionally, production bottlenecks and material shortages will become more prevalent, also pushing up costs.

During periods of high capacity utilization, producers tend to have more pricing power in the product market since the supply of the final product is scarce relative to demand. This increased market power generally allows firms to increase profit margins and pass on the higher operating costs to buyers. Therefore, not only do producers have a need to increase prices, but market conditions make such a pricing strategy possible (de Kock, 1996, 5).

De Kock (1996, 6) feels investment spending provides another, more indirect, linkage between high capacity utilization and increasing inflation. As firms experience capacity constraints, with the associated higher operating costs, they will be motivated to expand their productive capacity by investing in new plant and equipment. Since profits are generally higher during periods of high capacity utilization, producers have the financial means to make these capital investments. Increased demand in the capital goods

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

and construction industries will put further inflationary pressure on the manufacturing sector, eventually spilling onto the economy as a whole.

2.5. The NAICU and Monetary Policy

Arguments against using the NAICU as a sole determinant of monetary policy parallel the discussion in Section 1.4.3 regarding the NAIRU. Critics feel capacity utilization, when used as a sole indicator of changes in inflation, tends to oversimplify the formulation of monetary policy and the process of inflation. The correlation between capacity and inflation rates was high during the 1970s and early 1980s; however, this correlation has tended to break down during the past 10 years. Therefore, critics maintain that capacity utilization, by itself, should not be used by the FOMC as a predictor of accelerating inflation when developing monetary policy. Corrado and Mattey (1997, 154) state that using only capacity, as a single indicator for monetary policy, would be naïve and wrong for the following reasons:

- A simple relation between the two variables does not appear to exist.
- Other variables and their influence on rates of inflation appear in most econometric models.
- Some of the past high inflation periods appear to have been made worse, even caused, by supply shocks. Specifically, economic developments abroad (oil prices) and exchange rate variations affect domestic inflation through import prices.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Additionally, Corrado and Mattey (1997) observe that selecting capacity over the next best indicator of changes in inflation or adding capacity to a well-specified multivariate model will result in a relatively small reduction in the size of the prediction error. However, in multivariate time series models, capacity utilization tends to be among the most important indicator of inflation suggesting that a strong correlation still exists between capacity utilization and rates of inflation. They further observe that the predictive power of factory operating rate for changes in inflation has endured because capacity utilization in manufacturing is indicative of the cyclical state of over-all aggregate demand. Most of the fluctuation in aggregate output comes from changes in the demand for goods and new structures; by comparison, final demand for services is relatively stable.

2.6. Capacity Utilization and Structural Changes in the United States Economy

It is argued that structural changes in the United States economy will tend to weaken the linkage between capacity utilization and rates of inflation. Specifically, increased international trade, productivity growth, and rapidly expanding service sectors will result in the inability of capacity utilization in the manufacturing sectors to predict changes in the rate of inflation. The following is a brief discussion of each of the areas of debate:

1. *Increased International Trade*—In time of high domestic demand, imported goods will be substituted, moderating inflationary pressure. This suggests that "global resource utilization" rather than domestic capacity should be used in predicting changes in inflation. This idea is dismissed through the following observations:

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

- International business cycles are usually synchronized and the proportion of foreign penetration in the United States markets is fairly small for most industries (Corrado and Mattey, 1997, 157).
- Slackness in manufacturing is generally felt in "upstream" producers of intermediate materials, not producers of final goods (Corrado and Mattey, 1997, 157).
- A large part of domestic output is non-traded (Garner, 1994, 6).
- Goods produced in the United States and those manufactured overseas are not perfect substitutes, suggesting domestic suppliers have some ability to raise prices of domestic goods relative to foreign imports (Garner, 1994, 7).
- Higher United States demand for imported goods increases the demand for foreign currency that in turn lowers the value of the United States dollar. As a result, import prices will rise and, therefore, increase the United States inflation rate (Garner, 1994, 7).

2. *Productivity Growth*—Garner (1994) examines the effects of rapid productivity gains in the United States and questions whether this is weakening the link between capacity utilization and inflationary pressures. Garner looks specifically at structural changes, new computer and telecommunications technology, and high levels of investment in business equipment that were occurring during the 1994 time period. His conclusions are as follows:

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

- Business productivity had not changed that radically during the period under examination.
- Economic recovery in 1994 resulted in increased spending in plant and equipment and faster growth of labor productivity—both cases typical of previous expansions.
- Current statistics available at the time of the study might not reflect the most recent data and might understate manufacturing capacity since increases resulting from strong business investment and productivity gains may not have been recognized. This could result in a lower capacity utilization rate when the potential capacity levels are revised upward.

3. *Rapidly Expanding Service Sectors*—Corrado and Mattey (1997) address the question of whether a rapidly growing service sector destroys the linkage between capacity utilization and inflation; specifically, do prices and employment in goods and services behave differently, resulting in instability in the aggregate inflation model? They minimize this impact with the following arguments:

- Due to the wage and price expectation components of inflation, core measures of goods and services consumer price inflation demonstrate similar cyclical patterns.
- While the growth in services has resulted in much larger employment in that sector, the change in output mix has not been as large.

> Moreover, as in the past, the output share of durable goods and structures stands at about 33 percent, and, much as in the past, spending for items in these segments of final demand is most likely to be affected by monetary policy. Thus, spending on goods and, to a lesser extent, new structures remain significant components of United States real final demand. The product mix

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

> has changed steadily over time, but not in a way that would cause a structural break in an aggregate inflation model. (Corrado and Mattey, 1997, 159)

The above discussion suggests that these structural changes have had a minimal effect in altering the linkage between capacity utilization and inflation. Consequently, capacity utilization should remain a significant factor in predicting rates of inflation. Therefore, the level of capacity utilization could be useful as one of many variables used by the FOMC in implementing monetary policy aimed at price stability. The results of this study indicate that capacity utilization continues to be a significant variable in predicting inflation.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CHAPTER 3

METHODOLOGY OF EMPIRICAL STUDY

1. REGRESSION MODEL

1.1. Specification of the Model

The basic regression model investigating the relationship between capacity utilization and changes in the rate of inflation follows the specification initially developed by McElhattan (1985). Subsequent studies investigating the relationship between rates of inflation and either unemployment or capacity utilization (Emery and Chang, 1997; Garner, 1994; Corrado and Mattey and Strongin, 1997; Staiger, et al., 1997; Chang, 1997; Blanchard and Katz, 1997) adopt a similar structure. This basic relationship is expressed as follows:

$$\Pi_t - \Pi_{t-1} = \beta_0 + \beta_1 CU_t + \gamma \mathbf{Z}_t + \varepsilon_t$$

Where:

Π = rate of inflation
CU = actual capacity utilization
Z = a vector of additional variables representing supply shocks, demand proxies, and cost changes

Eckstein and Fromm (1968, 1164) provide an insight into other variables that should be included in the **Z** vector used to develop a model to predict changes in the rate of inflation.[1] These are summarized as follows:

1. Demand proxies such as changes in unfilled orders.

[1] Eckstein and Fromm include capacity utilization in their model and calculate a stable inflation rate of capacity utilization of 82%. This study was much earlier than McElhattan's (1978) which is regarded as the seminal article concerning the natural rate of capacity utilization.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2. Variables influencing production costs, such as unit material cost and unit labor costs.

Dumenil (1987) analyzes the empirical relationship between product prices and changing demand/supply conditions faced by the individual firm. Although this study examines changes in relative prices rather than changes in the general level of prices, these issues are consistent with the two points suggested by Eckstein and Fromm (1968). A microeconomic model is developed to examine economic agents' reactions to disequilibrium conditions relating to both inventory and capacity utilization levels. A build-up of inventories indicates a mismatch between demand and supply, usually resulting in a price increase to ration excess demand. Additionally, capacity utilization outside the normal range provokes adjustments to both the capital stock of the firm and price changes in order to maximize profits.

Lee (1994) studies the issue of pricing practices by initially looking at individual business operations, and ultimately developing a general pricing model which covers all industrial, wholesale, and retail enterprises. One main conclusion of the study is that, in a capitalist economy, a significant proportion of industrial and consumer products have prices based on mark-up, normal cost, and target rate of return pricing procedures (319). This study is consonant with the second idea mentioned by Eckstein and Fromm (1968) that cost changes such as wage inflation, productivity improvements, and input prices play an important role in the determination of product prices.

Garner (1994) adopts the basic regression model suggested by McElhattan consisting of: 1) a dummy variable representing the Nixon wage/price control era,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2) acceleration of the relative price of oil, and 3) the acceleration in the real exchange rate. Also included in the specification of Garner's regression model are interaction variables representing the capacity utilization rate multiplied by: 1) non-oil merchandise imports, 2) the share of traded goods in gross domestic product, and 3) the Canadian capacity utilization rate. These additional variables are introduced by Garner to investigate the impact of increased openness of the United States economy to international trade and to provide an insight into alternative data series that can be incorporated in the regression models developed in this study.

1.2. Testing Down of the Models

As the different regression models are developed using additional supply/demand variables, it is necessary to utilize a method of comparing one model (unconstrained) with an alternative model (constrained). This process will permit the testing down of a more general model to one that is parsimonious without diminishing the predictive power of the model.

The basic procedure for testing down a model when there is more than one restriction in the constrained form is based on the log-likelihood ratio test. An ordinary least squares regression produces maximum-likelihood estimators that are both consistent and asymptotically efficient (Pindyck and Rubinfield, 238-239). The log of the likelihood can then be used to compare two regression models (one unconstrained and one constrained) when testing down the model. This procedure involves starting with an unconstrained model and introducing constraints on the second model. Regressions are

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

performed on each model and a test statistic (LR) is then calculated using the following formula:

$$LR = 2(\text{Log-likelihood}_{unconstrained} - \text{log-likelihood}_{constrained})$$

This statistic is tested against a chi-squared distribution. When there is no statistically significant difference between the two models (p-value >. 05), the constrained version of the model is accepted and becomes the basis for testing down the next regression.

In the event there is only one restriction on the constrained model, a simple F-test is used to determine the acceptability of the constrained model relative to the unconstrained one. This procedure is used in this study as a means of determining which structural form of a variable should be used or selecting between two similar variables. It is possible to determine which of the two variables contributes to the predictive power of the regression and which can be eliminated with little loss of the model's ability to predict the dependent variable.

The F-test involves running two regressions, one unconstrained and one with the single constraint, and calculating a test statistic according to the following formula (Pindyck and Rubinfield, 1991, 111):

$$\text{Test statistic} = \frac{(ESS_R - ESS_{UR})/q}{ESS_{UR}/(N-k)}$$

Where: ESS_R = Error sum of squares for restricted form
ESS_{UR}= Error sum of squares for unrestricted form
q = number of restrictions
(N – k) = degrees of freedom

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The calculated test statistic is then compared to an F-distribution with "q" degrees of freedom in the numerator and "(N – k)" degrees of freedom in the denominator. A p-value greater than .05 indicates the constrained form is accepted over the unconstrained form and the omitted variable can be eliminated from the model.

1.3. Calculation of the NAICU

As noted previously in section 1.1, all regression models to be developed have the following structural form:

$$\Pi_t - \Pi_{t-1} = \beta_0 + \beta_1 CU_t + \gamma \mathbf{Z}_t + \varepsilon_t$$

Once the regression is run and the coefficients determined, the resulting non-accelerating inflation rate of capacity utilization (NAICU) can be calculated. This outcome can then be used to judge whether re-specifying the model alters the computed NAICU. Staiger, et al. (1997, 36)[2] states the NAICU can be calculated by setting all independent variables, except CU_t, equal to zero, *ceteris paribus.* The equation is then solved assuming no change in the inflation rate. The resulting value for CU_t (NAICU) will be the level of capacity utilization that predicts no tendency for inflation to accelerate or decelerate. The formula is developed as follows:

$$0 = \Pi_t - \Pi_{t-1} = \beta_o + \beta_1 CU^*$$

$$\text{Therefore:} \quad CU^* = NAICU = -\beta_0/\beta_1$$

[2] Staiger's calculations relate to the NAIRU; however, this approach is considered appropriate by others (i.e. McElhattan, 1985; Garner, 1994) for the calculation of the NAICU.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

1.4. Unit Root Tests

When working with aggregate time series data, it is important to determine if the various data series follow a random walk process or can be considered stationary. If the data are determined to be a random walk process, a regression of one data series against another can lead to spurious results (Pindyck and Rubinfield, 1991, 459). In particular, the correlation between the two may be quite high, when in fact the only connection between the variables is that they both contain a common trend.

When conducting time series investigations, therefore, the various data series must be tested for the presence of a unit root (non-stationary). If the unit root hypothesis cannot be rejected, taking first differences of the data[3] will generally result in a series that can be considered stationary (rejection of the unit root hypothesis). Once the various series are determined to be stationary, ordinary least squares regressions will produce consistent parameter estimates.

As a result of the interest in the unit root hypothesis, there is a large body of literature pertaining to various tests that have been developed to investigate the characteristics of economic time series data. Three different unit root tests will be used in this study to determine if a series is stationary: 1) Augmented Dickey-Fuller (ADF), 2) Phillips-Perron, and 3) Weighted Symmetric (WS). A brief description of each test is provided in the footnotes to Table 3, Chapter 4.

[3] Provided the first difference makes economic sense.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2. VARIABLES USED IN THE EMPIRICAL STUDY

To fully examine the relationship between inflation and capacity utilization, additional supply/demand variables that might improve the statistical adequacy of the regression model must be identified and integrated into the models. Several studies cited in Section 1.1 provide some insight into alternative variables. Below is a discussion of these variables and the economic logic for considering them as independent variables in the models. The basic variables are defined on Table 1, which also includes the data sources.

Although much of the data are available back to 1948, several data series only go back to 1961. Consequently, the initial sample period selected for the study is 1961-1996. It is necessary to apply this restriction to all regression models, since during the testing down of the models some of the regressions (if the sample period is not restricted) might include data earlier than 1961. This would cause problems making comparisons between two models covering different time periods.

The sample period of the study (1961-1996) contains many of the major economic events which have occurred in the recent past and should provide an adequate test of the regression models. Significant events include:

- Acceleration of inflation during the 1960s in the United States encouraged outflows of official gold holdings. Suspension of gold payments by the United States ultimately resulted in the collapse of the Bretton Woods agreement in the early 1970s and abandonment of the gold standard (Meulendyke, 1989, 38-39).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE 1 – Variable Definition/Source

VARIABLE	DEFINITION	SOURCE
PPI	Producer Price Index [Finished Goods]	FRED[1] data bank [PPIFGS]
CAP[2]	Capacity Utilization [Manufacturing, % of Capacity]	FRED data bank [CUMFG]
ROIL[3]	Real Price of Oil [Domestic Price, West Texas Crude, $/Bbl]	FRED data bank [OILPRICE]
NIXON	Nixon Wage/Price Controls [Dummy variable, 1 -1972 to 1975, 0 -otherwise]	N/A
XRAT[4]	Real Trade-Weighted Exchange Rate [Foreign currency units/$'s]	FRED data bank [TWEXMTHY] MPS model FRB[5] [FPX10R]
IMPP	Import Penetration—Durable Goods [Value of Durable imports/Expenditures on durables(consumer and business sectors)]	FRED data bank [NIRIPDC92 & PCEDC92] BEA[6] data bank [Table 2]
PROD	Productivity, manufacturing [Output per hour, all persons in private mfg]	FRED data bank [MFGOPH]
DURA	Productivity, durable manufacturing [Output per employee, durable manufacturing]	BLS[7] data bank [#PRS31006043]
NMFG	Nominal wages, manufacturing [average earnings/hour, all manufacturing]	BLS data bank [EEU30000006]
NDUR	Nominal wages, durable manufacturing [average earnings/hour, durable manufacturing	BLS data bank [EEU31000006]
SIX	Percentage of employed labor force between sixteen and nineteen [males and females]	BLS data bank [LFS11000800]/[LFS11000000]
UNFIL	Value—unfilled orders [durable manufacturing]	INFORUM—U. of Maryland [alm092]
DIFMFG	Difference—acceleration of nominal wages and productivity [all manufacturing]	NMFG and PROD data series listed above
DIFDUR	Difference—acceleration of nominal wages and productivity [durable manufacturing]	NDUR and DURA data series listed above

NOTES:

[1] Federal Reserve Bank—St. Louis

[2] G.17 Federal Reserve Statistical Release (Industrial Production & Capacity Utilization)

[3] OILPRICE series is nominal price of oil. ROIL = OILPRICE/PPI

[4] Last three years of TWEXMTHY (1994-1996) were "spliced" into FRX10R by re-indexing both series to 1993. This was necessary to provide a series covering 1961-1966

[5] Federal Reserve Bank—Board of Governors

[6] Bureau of Economic Analysis—Department of Commerce

[7] Bureau of Labor Statistics—Department of Labor

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

- The establishment of wage and price controls by the Nixon administration in August 1971.
- The "stagflation" period of the 1970s caused by oil price shocks.
- The Volcker disinflation era of the early 1980s.
- Significant changes in the real exchange rate of the United States dollar during the 1980s.
- Corporate downsizing of the late 1980s and early 1990s.
- Increasing openness of the United States economy to foreign competition.
- Significant productivity improvements during the 1990s, mainly in the computer and information sectors.

2.1. Inflation

Intuition suggests that manufacturing capacity utilization is more closely related to the producer price index (PPI) than the consumer price index (CPI) since the PPI excludes the services sector, which is not reflected in the data for capacity utilization. Bauer (1990), McElhattan (1985), and Emery and Chang (1997) find a better regression fit between capacity utilization and PPI, rather than CPI. Accordingly, the PPI (all finished goods) is used as the measure of inflation in the models developed in this study.

One problem with using the PPI (all finished goods) relates to the weights of food (23.6%) and energy (14.7%)[4] prices within this index. Logically, the core PPI (excluding

[4] Bureau of Labor Statistics—December 1997.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

food and energy), which reflects prices more closely related to the manufacturing sector, should provide a better regression fit with capacity utilization. As discussed in Chapter 4, Section 6.3, the preferred model linking capacity utilization to changes in the rate of inflation would predict changes of consumer prices due to the more general acceptance of the CPI in measuring the rate of inflation. However, since the linkage between the core PPI and the CPI is more tenuous than the linkage between the PPI (all finished goods) and the CPI, use of the PPI (all finished goods) represents a compromise in the selection of one of these two producer price indices in this study.[5]

2.2. Capacity Utilization

This series represents the ratio of actual capacity used as compared to the maximum sustainable output. Although capacity utilization data are available on a monthly basis, only annual data (4th quarter) will be used in the models. This decision is based on the following considerations:

- Capacity data are collected on an annual basis during the 4th quarter of each year. The monthly data are then extrapolated from this information. Since industrial production data are collected on a monthly basis, changes in capacity utilization, on a month to month basis, represent swings in industrial production, rather than alterations in long-run capacity growth.

[5] Garner (1994, 12) observes that using either the PPI or the core PPI results in the same calculated NAICU. However, these is a significant reduction in the R-squared value when using the core PPI instead of the PPI, a result attributed to different sample periods.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

- Monthly capacity utilization would "force" the model to look at short-run adjustments (short-run Phillips curve) rather than investigating long-term trends between inflation and capacity utilization. This short-run adjustment problem is noted by Emery and Chang (1997) who found that regressions using monthly or quarterly data displayed a very unstable relationship, but the stability of the linkage was greatly improved by using semi-annual data.

The expected sign of the coefficient is positive. Higher resource utilization will likely result in increasing costs that are passed onto customers.

2.3. Price of Oil

This variable typically appears in all models investigating changes in the rate of inflation and capacity utilization, and is always statistically very significant. Increases in the price of oil will cause domestic prices (both PPI and CPI) to accelerate as higher prices of energy are reflected in manufacturing costs. Conversely, falling oil prices should result in a deceleration in the rate of inflation. The available data, domestic price of West Texas Intermediate Crude[6], are stated in nominal dollars. In order to convert this oil price series to real prices, the data are divided by the PPI series described in Section 2.1 of this chapter. The expected sign of the coefficient is positive.

[6] Ideally the refinery acquisition cost, reflecting the prices of different sources of crude and their weighting, should be used. It is assumed that the West Texas Intermediate Crude represents a valid approximation of the input cost of refineries.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2.4. Nixon Wage/Price Controls

This series enters into the regression as a dummy variable (1, 1972 to 1975; and 0, otherwise) and reflects the time during which wage/price controls were in place. The expected sign of the coefficient is negative, indicating a deceleration of price inflation during 1972-1975.

2.5. Real Exchange Rate

Changes in the trade-weighted real exchange rate will impact the cost of imported/exported goods, and ultimately alter inflationary pressure in the economy as changes in import costs are passed on to domestic producers. The effect of changes in the real exchange rate on the price of imports is referred to as the "pass-through" effect and generated a large body of literature during the 1980s following significant swings in the real exchange value of the United States dollar. Feinberg (1991) and Woo (1984) find the estimated degree of pass-through is surprisingly small. When comparing the relative impacts of pass-through on different economic sectors, Feinberg (1989) concludes capital-intensive industries have exhibited much smaller changes in import prices than industries heavily reliant on imported inputs or producing goods highly substitutable for imports.

Mann (1986) concludes the smaller than expected change in import prices following changes in the real exchange rate is accounted for by variations in foreign profit margins in the short-run. There appears to be a two-year lag before the full impact of the change in real exchange rate is reflected in import prices. Goldberg (1997, 1250) states

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

that time lags for the pass-through using micro data might be less than one year for most products. However, aggregate studies show a longer adjustment process.

Once the change in the real exchange rate is reflected in import prices, the adjustment process of domestic producer prices follows the usual linkage between changes in input prices and the extent to which they are passed on to the producer (both amount and timing). Hence, variations in the real exchange rate that result in a change in import prices and ultimately lead to a change in domestic prices can represent a lengthy process. McElhattan (1985, 54) suggests it will take the economy three years to fully adjust to a one-time real exchange rate shock.

To develop a real trade-weighted exchange rate series that extended back in time to the early 1960s, it was necessary to utilize two different series and "splice" the data from one into the other. One series (FPX10R) is extracted from the MPS model of the Federal Reserve, but only covers a time span from 1961 to 1994. The current real exchange rate series available from the Federal Reserve (TWEXMTHY) covers a period from 1967 to the present. To develop a series that covers from 1961 to 1996, both series were re-indexed to 1993 and the three most recent years for TWEXMTHY (1994-1996) were added to the FPX10R series. The expected sign of the coefficient of the real exchange rate is negative "implying that a real appreciation of the dollar reduces inflation" (Motley, 1990, 11). An appreciation in the real exchange rate will reduce strain on manufacturing resources and lower inflationary pressures as imported goods are substituted for domestically produced goods.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2.6. Import Penetration

To exclude the pass-through effect resulting from changes in the exchange rate, a series calculating the ratio of imported durable goods to domestic expenditures on durables (private consumption and investment) is developed in this study. This series should capture the impact of increasing or decreasing imports on price changes without having to account for the lag resulting from the pass-through effect. A higher percentage of imports should have a more timely and direct effect on relieving inflationary pressure during times of expanding aggregate demand and higher capacity utilization. Therefore, the expected sign of the coefficient is negative.

2.7. Nominal Wages Versus Productivity

Microeconomic theory states that a profit maximizing firm will utilize a resource up to a level where the marginal cost is equal to the marginal revenue product. For a firm hiring labor in a perfectly competitive labor market, this relationship can be expressed as:

nominal wage (W) = product price (P) x marginal physical product of labor (MPP_l),

or: $W/P = MPP_l$

Taking logs and second differences, the above equation becomes:

$$\Delta\Delta \ln P = \Delta\Delta \ln W - \Delta\Delta \ln MPP_l$$

Although this formula pertains to the profit-maximizing behavior of individual firms operating in a perfectly competitive labor market, the relationship can be

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

approximated at the macroeconomic level as the following expression, which forms one of the relationships investigated in this study:

$$\Delta\Delta \ln P = f(\Delta\Delta \ln W - \Delta\Delta \ln MPP_l)$$

Indexes for nominal wages and productivity[7] are available for both the manufacturing sector (durable and non-durable goods) and the durable manufacturing sector (excluding non-durable goods). Since the durable sector of manufacturing is more volatile than the non-durable sector, much of the variation in capacity utilization is likely to be a direct result of changes in the durable sector rather than the non-durable sector. Accordingly, changes exclusive to the durable manufacturing sector are more likely to have an impact on the acceleration or deceleration of the PPI rather than changes in the manufacturing sector.

To utilize available data, the following transformations are performed.

- Both nominal wage and productivity data are converted to logs.
- First and second differences of each variable are calculated.
- Another series is created by subtracting the second difference of the productivity variable from the second difference of the nominal wage variable, which becomes one of the independent variables in the models.

Initially, the regression analysis will be performed using data for the durable manufacturing sector (DIFDUR). Once the basic regression model is developed, data for the entire manufacturing sector (DIRMFG) will be examined to determine the relative

[7] This series represents average physical product rather than marginal physical product and is used as an approximation of the marginal physical product of labor for which no aggregate data are available.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

effects of both variables and test the assertion that the durable manufacturing sector has more influence on the PPI. The expected sign of the coefficients of these variables is positive. If the second difference of nominal wages increases faster than the second difference of productivity, there is acceleration of inflation.

2.8. Young People in Employment

During the mid-1960s and early 1970s there was a significant increase in the percentage of young people (16-19) working as compared to the total number employed. The increase was due to the "baby boomers" coming into the labor force and finding employment. As they progressed in age and the "baby boomer" bubble worked through the economy, the percentage of young employees has declined. Economic theory suggests as this younger population became a larger proportion of the work force, their inexperience and lack of job skills may have caused a decline in productivity, resulting in an acceleration of inflation. Therefore, the expected sign of the coefficient of this variable is positive.

2.9. Demand Proxies

Eckstein and Fromm (1968) suggest two demand proxies should be included in a model attempting to predict price changes: 1) unfilled orders, and 2) inventories. The economic rationale for the inclusion of unfilled orders is straightforward—acceleration of unfilled orders would represent increasing demand for the product, placing upward pressure on prices.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Using the rationale developed in Section 2.8, data for unfilled orders of durable goods, rather than all manufacturing, is included in the analysis. The expected sign of the coefficient is positive.

As noted by Eckstein and Fromm (1968), statistical tests on data representing the acceleration of inventories "become insignificant, and sometimes take on the wrong sign, when included in the equation with the operation rate" (1177). Economic behavior resulting from an inventory buildup is very difficult to predict. The decision to alter production levels to accommodate changes in inventory levels is influenced by the difference between actual inventory and desired levels rather than the actual level of inventory. However, it is impossible to determine the desired level of inventory from the data. Additionally, a buildup of inventories may be a result of increasing unfilled orders, resulting in multicollinearity between the two variables. Based on Eckstein and Fromm's comments and the unpredictability of the economic influence of inventories, this variable is not included the study.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CHAPTER 4

EXAMINATION OF RESULTS

1. ANALYSIS OF VARIABLES

All variables (including logs, first differences, and second differences) and their basic statistics are shown in Table 1. Taking the first difference of the logs (ΔL) of each variable calculates the annual growth rate. The second difference of the logs (ΔΔL) represents the change in the annual growth rate of each variable, also referred to as the acceleration/deceleration of the variable. Whereas the second difference of demand or supply shock variables is generally used in the regression models, capacity utilization appears as a percentage level rather than as a first or second difference.

It should be noted that the general specification of the basic model described in Chapter 3, Section 1.1 refers to the ***level*** of capacity utilization as an independent variable in the regression. In order to retain a similar structural specification for all variables, the ***log of the level*** of capacity utilization is used as an independent variable in the models developed in this chapter. This insures consistency with the interpretation of the statistical adequacy tests since the choice of the functional form of the variables has an impact on the results. Kennedy (1995, 14) observes that use of the log of capacity utilization, instead of the level of capacity utilization, does not alter the outcome of his various models.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE 1 – Basic Statistics of Variables

VARIABLE	MEAN	STD. DEV.	MIN.	MAX.
PPI	80.67	35.66	33.40	133.40
LPPI[1]	4.28	0.50	3.51	4.89
ΔLPPI[2]	0.04	0.04	-0.02	0.17
ΔΔLPPI[3]	0.00	0.03	-0.11	0.07
CAP	81.92	4.57	69.50	90.60
LCAP	4.40	0.06	4.24	4.51
ΔLCAP	0.00	0.05	-0.11	0.11
ΔΔLCAP	0.00	0.06	-0.12	0.19
ROIL	0.18	0.09	0.08	0.40
LROIL	-1.86	0.50	-2.49	-0.91
ΔLROIL	0.02	0.23	-0.50	0.78
ΔΔLROIL	0.01	0.34	-0.85	0.75
XRAT	93.96	17.94	71.02	120.54
LXRAT	4.53	0.19	4.26	4.79
ΔLXRAT	-0.01	0.08	-0.17	0.15
ΔΔLXRAT	0.00	0.09	-0.25	0.20
IMPP	3.18	1.21	1.47	5.89
LIMPP	1.09	0.38	0.39	1.77
ΔLIMPP	0.04	0.06	-0.18	0.15
ΔΔLIMPP	0.00	0.09	-0.23	0.27
PROD	75.30	19.84	46.20	115.00
LPROD	4.29	0.27	3.83	4.74
ΔLPROD	0.03	0.02	-0.01	0.06
ΔΔLPROD	0.00	0.02	-0.04	0.06
DURA	76.99	22.46	39.40	125.00
LDURA	4.30	0.30	3.67	4.83
ΔLDURA	0.04	0.06	-0.11	0.14
ΔΔLDURA	0.00	0.07	-0.14	0.20
NMFG	7.09	3.50	2.45	12.78
LNMFG	1.82	0.56	0.90	2.55
ΔLNMFG	0.05	0.02	0.02	0.09
ΔΔLNMFG	0.00	0.01	-0.03	0.03
NDUR	7.50	3.66	2.63	13.34
LNDUR	1.88	0.56	0.97	2.59
ΔLNDUR	0.05	0.02	0.01	0.10
ΔΔLNDUR	0.00	0.01	-0.04	0.03
SIX	6.83	1.26	4.78	8.58
LSIX	1.90	0.19	1.56	2.15
ΔLSIX	-0.01	0.04	-0.10	0.10
ΔΔLSIX	0.00	0.04	-0.13	0.06
UNFIL	350390.00	101275.70	136160.50	511013.80
LUNFIL	12.72	0.34	11.82	13.14
ΔLUNFIL	0.03	0.09	-0.18	0.22
ΔΔLUNFIL	0.00	0.09	-0.33	0.17
DIFMFG	0.00	0.03	-0.09	0.06
DIFDUR	0.00	0.07	-0.21	0.15

NOTES:
[1] LPPI—log of PPI, same specification on other variables.
[2] ΔLPPI—First difference of log of PPI (annual growth rate), same specification on other variables.
[3] ΔΔLPPI—Second difference of log of PPI (change in annual growth rate), same specification on other variables.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2. UNIT ROOT TESTS

Table 2 presents the results of the different unit root tests performed on all the variables, logs, first differences, and second differences.[1] Series which are determined to be stationary by the respective tests[2] (p-value ≤ .05) are shown as boldface. The number of lags of the variable required to make the residuals of the unit root regressions stationary are not included in the table. It should be noted that second difference of every variable is shown to be stationary [I(0)] by at least one of the three different tests.

Although LCAP (log of capacity utilization) is not stationary[3], this form of the variable, rather than the first or second difference (ΔLCAP or ΔΔLCAP, which are stationary), is included in the initial regression models in order to retain consistency with other studies. A model using ΔLCAP (first difference) will then be tested to determine if LCAP or ΔLCAP is the appropriate form of this variable. It is possible that the non-stationarity of LCAP is the result of structural changes that are captured by other variables in the regressions and makes the use of LCAP completely viable. Moreover, the unit root concept for capacity utilization has a different economic meaning than for PPI or other variables that grow over time. Capacity utilization is bounded by a practical upper and lower limit. High capacity utilization will result in additional capital investment that will reduce the utilization ratio. Alternatively, low capacity utilization results in capital

---

[1] Refer to Chapter 3, Section 1.4, for analysis of the concept of a stationary time series.
[2] The different unit root tests are briefly explained in the notes in Table 2.
[3] This finding is in direct contrast with Koenig (1996) who states "Revision procedures are designed quite consciously, to smooth capacity and to ensure that utilization is a stationary series (16)."

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE 2 – Unit Root Tests

UNIT ROOT TESTS	VARIABLES							
	PPI	LPPI	ΔLPPI	ΔΔLPPI	CAP	LCAP	ΔLCAP	ΔΔLCAP
Wtd. Symmetric[1]	-0.27	-0.27	-2.29	**-4.96**[5]	-2.33	-2.34	**-4.20**	-2.80
	1.00[4]	*1.00*	*0.44*	***0.00***	*0.41*	*0.40*	***0.00***	*0.14*
Dickey-Fuller[2]	-2.07	-1.21	-2.23	-2.71	-2.24	-2.24	**-3.77**	**-3.61**
	0.56	*0.91*	*0.48*	*0.23*	*0.47*	*0.47*	***0.02***	***0.03***
Phillips-Perron[3]	-7.04	-2.37	-10.70	-20.11	-12.26	-12.38	-16.04	**-24.16**
	0.66	*0.96*	*0.39*	*0.07*	*0.30*	*0.30*	*0.15*	***0.03***
	ROIL	LROIL	ΔLROIL	ΔΔLROIL	XRAT	LXRAT	ΔLXRAT	ΔΔLXRAT
Wtd. Symmetric	-1.94	-1.93	**-3.37**	-2.55	-2.51	-2.64	-2.72	-2.36
	0.69	*0.70*	***0.03***	*0.26*	*0.28*	*0.21*	*0.18*	*0.38*
Dickey-Fuller	-1.63	-1.60	-3.11	-2.35	-2.46	-2.24	-1.71	-2.16
	0.78	*0.79*	*0.10*	*0.41*	*0.35*	*0.47*	*0.75*	*0.51*
Phillips-Perron	-5.16	-4.59	**-34.84**	**-43.36**	-4.60	-4.68	-11.97	**-29.43**
	0.81	*0.85*	***0.00***	***0.00***	*0.85*	*0.84*	*0.32*	***0.00***
	IMPP	LIMPP	ΔLIMPP	ΔΔLIMPP	PROD	LPROD	ΔLPROD	ΔΔLPROD
Wtd. Symmetric	-1.13	-2.34	-2.60	**-4.76**	-0.08	-2.21	**-3.73**	**-3.36**
	0.96	*0.40*	*0.23*	***0.00***	*1.00*	*0.49*	***0.01***	***0.03***
Dickey-Fuller	1.05	-2.40	-3.22	**-4.52**	-0.18	-2.48	**-3.40**	**-5.40**
	1.00	*0.38*	*0.08*	***0.00***	*0.99*	*0.34*	***0.05***	***0.00***
Phillips-Perron	0.68	-9.14	**-28.68**	**-51.81**	0.16	-9.29	**-26.76**	**-37.92**
	1.00	*0.50*	***0.01***	***0.00***	*1.00*	*0.49*	***0.02***	***0.00***
	DURA	LDURA	ΔLDURA	ΔΔLDURA	NMFG	LNMFG	ΔLNMFG	ΔΔLNMFG
Wtd. Symmetric	-2.28	-2.74	**-3.90**	-2.51	1.65	2.96	-1.02	-2.91
	0.44	*0.17*	***0.00***	*0.29*	*1.00*	*1.00*	*0.97*	*0.11*
Dickey-Fuller	-1.61	**-3.52**	-2.71	-2.00	-2.38	-1.32	-1.87	-0.77
	0.79	***0.04***	*0.23*	*0.60*	*0.39*	*0.88*	*0.67*	*0.97*
Phillips-Perron	-9.69	-13.16	-12.14	**-21.13**	-7.32	-0.63	-4.50	**-31.51**
	0.46	*0.26*	*0.31*	***0.05***	*0.64*	*0.99*	*0.86*	***0.00***
	NDUR	LNDUR	ΔLNDUR	ΔΔLNDUR	SIX	LSIX	ΔLSIX	ΔΔLSIX
Wtd. Symmetric	1.15	2.36	-1.13	-2.80	-0.82	-0.70	-2.68	**-4.11**
	1.00	*1.00*	*0.96*	*0.14*	*0.98*	*0.99*	*0.19*	***0.00***
Dickey-Fuller	-2.95	-2.75	-2.01	-2.54	-3.08	-1.60	-2.40	**-3.89**
	0.15	*0.21*	*0.60*	*0.31*	*0.11*	*0.79*	*0.38*	***0.01***
Phillips-Perron	-7.55	0.02	-4.41	**-31.27**	-5.59	-5.66	-14.72	**-21.91**
	0.62	*1.00*	*0.86*	***0.00***	*0.78*	*0.77*	*0.19*	***0.05***
	UNFIL	LUNFIL	ΔLUNFIL	ΔΔLUNFIL	DIFMFG	DIFDUR		
Wtd. Symmetric	-2.03	-1.11	**-3.94**	**-4.91**	**-4.49**	-2.35		
	0.63	*0.96*	***0.01***	***0.00***	***0.00***	*0.39*		
Dickey-Fuller	-2.01	-1.53	-2.71	-3.21	**-4.22**	**-4.08**		
	0.60	*0.82*	*0.23*	*0.08*	***0.00***	***0.00***		
Phillips-Perron	-4.60	-4.68	-14.03	-17.76	**-38.58**	**-21.90**		
	0.85	*0.84*	*0.22*	*0.11*	***0.00***	***0.05***		

NOTES:

[1] Weighted Symmetric—A weighted double-length regression that appears to outperform the Dickey-Fuller test. Pantula, et al., (1994, 451-453) describe the advantages of this process.

[2] Dickey-Fuller—Developed by Dickey and Fuller (1979, 1981), this is the most widely used unit root test. Failure to reject the null hypothesis of nonstationarity is weak evidence in favor of a random walk process. Additionally, this test assumes the sequence of innovations is independent with a common variance, a strong assumption in most econometric work.

[3] Phillips-Perron—Uses the same regression variables as the Dickey-Fuller test, but with no augmenting lags. This test allows for quite general weakly dependent and heterogeneously distributed innovations. Refer to Phillips (1987) and Phillips and Perron (1988) for more details.

[4] P-values are shown in italics.

[5] Boldface indicates rejection of the null hypothesis "non-stationarity" (p-value ≤ .05).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

depreciation or obsolescence, which will lower the amount of capital in place and increase the capacity utilization ratio.

3. RESULTS OF BASIC MODELS

3.1. Model 1

The structural form of Model 1 is consistent with McElhattan's 1985 model and includes the same independent variables (LCAP, ΔΔLROIL, ΔΔLXRAT, ΔΔLPROD, and NIXON). The results are show in Table 3, Column 1. Only LCAP and ΔΔLROIL have coefficients that are statistically significant. All variables display the expected sign. The NAICU is calculated to be 81.7%[4].

Model 1 has an R-squared of .66, but contains several problems with the diagnostic tests (shown in italics in Table 3). The LM heteroscedasticity test has a p-value of .01, suggesting the error term does not have a constant variance. The Chow test indicates a structural break around 1980, which is the mid-point of the sample data. This is the period (1979-1982) during which the FOMC altered the target for monetary policy decisions from the federal funds rate to the level of money and non-borrowed reserves in the banking system.

[4] Refer to Chapter 3, Section 1.3, for the procedure to calculate the NAICU.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE 3 – Results of Regressions

VARIABLES/ ADEQUACY TESTS	MODEL 1	MODEL 3	MODEL 4	MODEL 5	MODEL 6
Variables					
C	**-1.09**[9] **(-3.4)**	-0.58 (-1.8)	**-0.74 (-2.6)**	0.00 (-.0)	**.85 (-2.5)**
LCAP	**0.25 (3.4)**	0.13 (1.8)	**0.17 (2.6)**		**0.19 (2.5)**
ΔLCAP				0.15 (1.1)	
NIXON	0.00 (0.7)	0.00 (0.5)			
ΔΔLROIL	**0.06 (5.1)**	**0.05 (4.5)**	**0.05 (4.9)**	**0.05 (4.7)**	**0.05 (4.6)**
ΔΔLXRAT	-0.03 (-0.7)	-0.03 (-0.7)	-0.02 (-0.5)	0.00 (-0.0)	-0.03 (-0.7)
ΔΔLIMPP		0.02 (0.4)			
ΔΔLPROD	-0.1 (-0.5)	-0.22 (-1.0)			
ΔΔLSIX		0.05 (0.5)			
DIFDUR		**0.20 (2.8)**	**0.15 (2.8)**	**0.24 (3.3)**	
DIFMFG					0.1 (0.6)
ΔΔLUNFIL		**0.15 (3.1)**	**0.16 (3.3)**	**0.18 (3.4)**	0.07 (1.7)
NAICU [CU*]	81.7%	81.8%	82.1%	N/A	N/A

- Adequacy tests are shown on the following page.
- Notes are shown on the following page.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE 3 – Results of Regressions (cont.)

VARIABLES/ ADEQUACY TESTS	MODEL 1	MODEL 3	MODEL 4	MODEL 5	MODEL 6
Adequacy Tests					
R-squared	0.66	0.78	0.76	0.71	0.69
Adjusted R-squared	0.61	0.69	0.71	0.66	0.63
LM het. Test[3]	*6.69 [.01]*[10]	0.73 [.39]	.39 [.53]	.11[.75]	1.55[.21]
Durbin-Watson[4]	2.37 [.53,.99]	2.57 [.38,1.00]	2.24 [.37,.96]	2.15 [.27,.93]	2.40 [.56,.99]
ARCH test[5]	1.89[.17]	1.53[.22]	2.03[.15]	2.86[.09]	.67[.41]
Chow test[6]	*4.58 [.00]*	*2.75 [.04]*	1.06 [.42]	.98[.46]	*3.09 [.02]*
Jarque-Bera test[7]	.10[.95]	.23 [.89]	.07 [.97]	1.09[.58]	.04[.98]
F (zero slopes)	11.02[.00]	9.27[.00]	17.38 [.00]	13.68[.00]	12.47[.00]
Log likelihood	86.35	93.33	91.86	88.88	87.77
Log-likely ratio test[8]		5.5 (8)[11] [.70][12]	2.9 (4) [.57][13]		

NOTES:

[1] T-statistics are in parenthesis ( ) below their coefficients.

[2] P-values are in bracket [ ] beside or below their test value.

[3] A special case of the Breusch-Pagan heteroscedasticity test. The test performs a regression of the squared residuals on the squared fitted values and a constant term.

[4] Upper and lower bounds for probability of seeing the observed serial correlation under the null hypothesis [*plow, phigh*].

[5] Originally developed by Engle (1982), this test examines the model for auto-regressive conditional heteroscedasticity by regressing the squared residuals on the lagged squared residuals.

[6] Originally developed by Chow (1960), this test checks the stability of regression coefficients over two or more subsets of data. As reported in the table, the Chow test is performed at the mid-point of the sample period.

[7] This test is a joint LaGrange Multiplier test of the residuals' skewness and kurtosis.

[8] This test is described in Chapter 3, Section 1.2.

[9] Significant coefficients are shown as boldface (t-statistic ≥ | 2.0 |).

[10] Statistical adequacy tests which indicate problems (p-values < 0.05) are shown in italics.

[11] Degrees of Freedom of the Chi Squared Test are in parenthesis ( ).

[12] Model 3 compared to Model 2 (results not shown for Model 2).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

To further examine the structural break in 1980 and the pattern in the years before and after, a series of Chow tests are performed on this model using annual breakpoints between 1970 and 1990. The results of these tests are shown on Figure 1, which illustrates that the p-values are below .05 for the period 1974-1980, indicating structural changes that are not accounted for by this model.

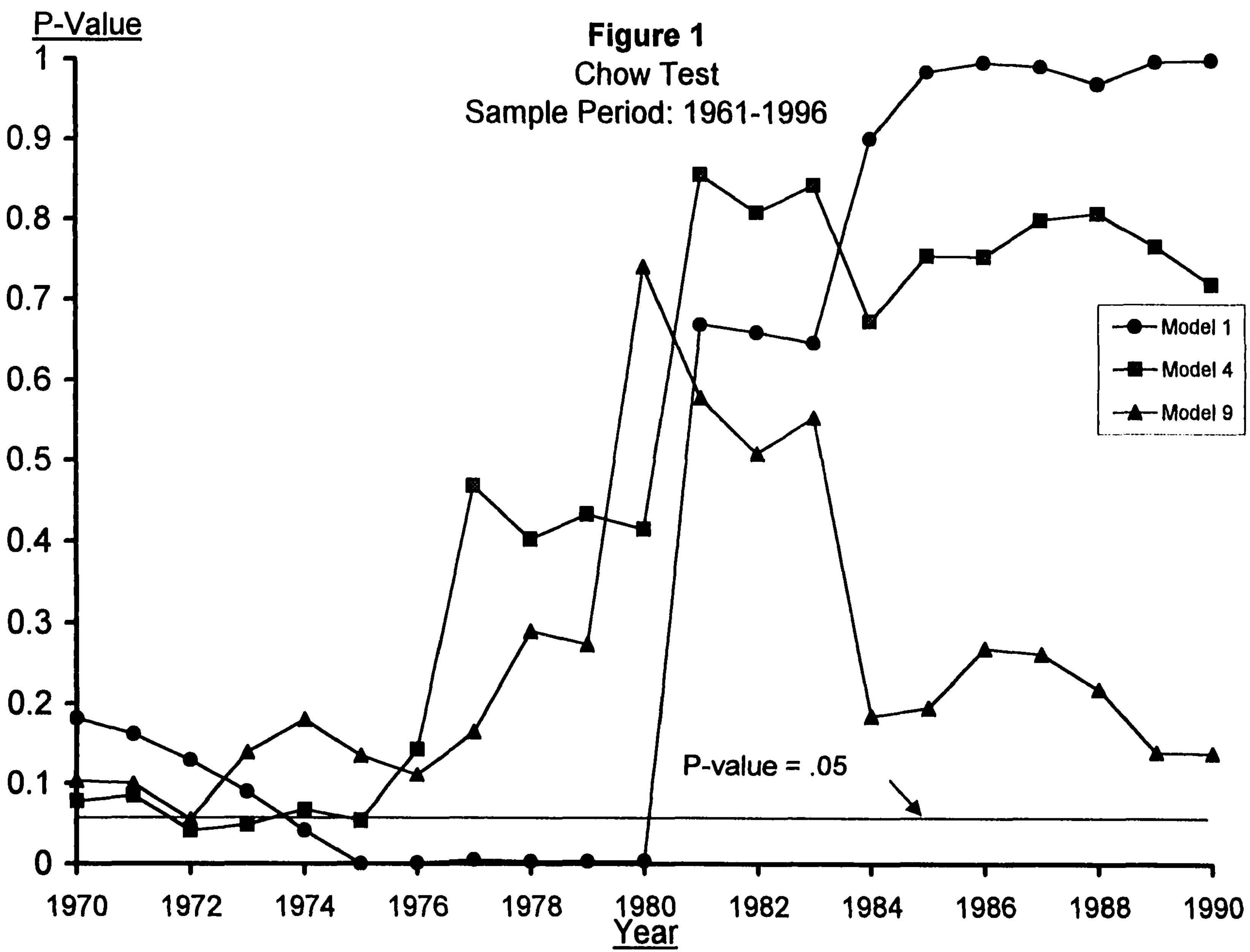
3.2. Model 2

Model 2, not shown in Table 3, includes the independent variables of Model 1, plus additional independent variables discussed in Chapter 3, Section 2: 1) ΔΔLIMPP, 2) ΔΔLSIX, 3) ΔΔLDUR, and 4) ΔΔLUNFIL. This model also includes a one period lag of all variables except NIXON. The intent of this model is to include all possible demand or supply variables previously rationalized in Chapter 3, Section 2, and their lags as a means of establishing the most general model, and then testing down the models as the various statistical data suggest.

The results for this model are not reported on Table 3. As expected, due to the increased number of independent variables, the R-squared value increases from .66 for Model 1 to .84 for Model 2. The adjusted R-squared improves from .61 for Model 1 to .67 for Model 2, a much smaller percentage change than the increase in the R-squared value. The diagnostic tests indicate no statistical adequacy problems with this model. However, none of the lagged variables are statistically significant, indicating that they should be eliminated from the model when testing down the general model.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 1
Chow Test
Sample Period: 1961-1996



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3.3. Model 3

Model 3 discards all the lagged variables and becomes the constrained form of Model 2 for testing down using the log likelihood ratio test[5]. The results of this model are shown on Table 3, Column 2.

The log likelihood ratio test (p-value of .70) indicates the constrained model (no lagged variables) can be accepted relative to the unconstrained form. The R-squared value decreases from .84 for Model 2 to .78; whereas, the adjusted R-squared value improves from .67 to .69. The improvement in the adjusted R-squared confirms that many of the lagged values made little, if any, contribution to the regression. The benefit of increasing the degrees of freedom in the constrained regression is greater than the loss of the contribution of the omitted variables. The Chow Test indicates a structural break around 1980. The statistically significant variables are ΔΔLROIL, DIFDUR, and ΔΔLUNFIL and have the expected signs. However, LCAP is not significant (t-statistic of 1.8), but has the expected sign on the coefficient.

The NAICU is calculated at 81.8% which is consistent with Model 1 (81.7%). It is interesting to note that the additional variables, while improving the R-squared and adjusted R-squared over Model 1, result in virtually no change in the calculated NAICU. McElhattan (1985) and Garner (1994) make the same observation that adding independent variables in the regression equation improves the R-squared value, but the computed NAICU does not change.

---

[5] Refer to Chapter 3, Section 1.2 for a description of the testing down process and the log likelihood ratio test.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The following variables display t-statistics less than the absolute value of 1.5 and are excluded from further investigation:

- NIXON—While earlier studies found this variable significant, results of this model indicate the variable is now insignificant. It is likely that this variable has lost its significance since more current data are included in this study, lessening the impact of the Nixon wage/price period. It also carries the wrong sign.
- ΔΔLIMPP—As mentioned in Chapter 3, Section 2.5, Feinberg (1989) concludes capital-intensive industries exhibit much smaller changes in import prices following a real exchange rate change than do industries heavily reliant on imported inputs or producing goods highly substitutable for imports. Since durable goods are used to compute ΔΔLIMPP, Feinberg's observation about capital goods (a large portion of the durable goods sector) suggests this variable should not play a strong role in determining changes in the rate of inflation of the PPI. It also carries the wrong sign.
- ΔΔLSIX—There are several reasons why this variable is not significant. Since young people have traditionally entered employment through the service sector, the percentage increase in this lower productive labor force should not have a strong impact on prices. Additionally, the change in productivity resulting from this demographic change in the workforce should be captured in the productivity data that are also included in the study.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3.4. Model 4

Model 4 is a refinement of Model 3. Variables whose t-statistics are less than the absolute value of 1.5 in Model 3 are eliminated in the constrained form, and tested down. To retain consistency with previous studies, the real exchange rate variable is also included in the constrained model. The results are shown in Table 3, Column 3.

The log-likelihood ratio test (p-value of .57) indicates that the constrained form of the model can be accepted relative to Model 3. The R-squared is .76 (a slight decrease from .78 for Model 3); however, the adjusted R-squared improves from .69 to .71. This suggests that the variables eliminated from the unconstrained model, while contributing to the predictive ability of the model, add little to the explanation of the regression model. Again, the benefit from increasing the degrees of freedom in the regression is greater the loss of the contribution of the omitted variables. None of the diagnostic tests indicates a problem with the model. All variables are significant (except the real exchange rate) and have the correct sign. The NAICU is computed to be 82.1%. This value is not materially different than the NAICU calculated for Models 1 and 3.

Model 4, which includes variables representing 1) the difference between nominal wages and productivity in the durable goods sector and 2) unfilled orders in the durable sector, results in a considerable improvement over the model as originally specified by McElhattan (1985). Although the reported Chow test does not indicate a structural break at 1980, a more thorough examination of the structural stability is performed using breaks between 1970 and 1990. The results are shown on Figure 1 and indicate that the p-values fall below .05 for 1972 (.041) and 1973 (.048). Nevertheless, this specification of the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

model appears to have captured the structural break at 1980 which is probably attributable to the change in targets used by the FOMC in setting monetary policy.

3.5. Model 5

As noted in Section 2 of this chapter, LCAP is not stationary [I(0)] and, hence, represents a structural inconsistency in the regression equations and may result in spurious results as discussed in Chapter 3, Section 1.4. In order to investigate this problem, the first difference of the log of capacity utilization (ΔLCAP) is substituted for LCAP in Model 4 to determine the outcome of using a capacity related variable in the regression that has the same level of stationarity (order of integration) as the other variables. As observed by Kennedy (1995), the first difference of LCAP accounts for the speed effect, "that is, it may not only be the level of resource utilization that matters, but also the magnitude of the changes" (15).

Model 5 re-specifies capacity utilization as the first difference (ΔLCAP) which becomes an independent variable instead of LCAP, with the results reported in Table 3, Column 4. This model displays a significant decrease in the R-squared value (.71 vs. .76) as compared to Model 4 and ΔLCAP is now insignificant (t-statistic of 1.15). All coefficients carry the correct sign and there are no statistical adequacy problems.

Furthermore, F-tests[6] are performed to determine the relative impact of each variable in predicting changes in the inflation rate. This is accomplished by including

---

[6] Refer to Chapter 3, Section 1.2 for discussion of this test.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

both LCAP and ΔLCAP in a modified Model 4 as the benchmark regression, and then re-running the regressions with a single constraint—alternatively eliminating LCAP and ΔLCAP. The results of the regressions are not reported. The F-test computes an F-statistic of .03 and a p-value of .85 when eliminating DLCAP in the constrained equation, suggesting DLCAP is providing little additional information to the regression and can be excluded from the model. On the other hand, an F-statistic of 5.22 and a p-value of .01 indicate that vital information is lost when LCAP is excluded from the regression.

The conclusion is that Model 4 (containing LCAP) can be accepted over a model that contains both LCAP and ΔLCAP with little loss in the model's ability to predict inflation. Based on these results, it appears that using the level of capacity utilization rather than the first difference is justified, even though a stationarity problem exists.

3.6 . Model 6

In the discussion of the variables in Chapter 3, Section 2.7, it was noted that data concerning nominal wages and productivity in the durable manufacturing sector, rather than all manufacturing industries (durable and non-durable sectors), should provide a better fit in the regression equations. To test this assertion, Model 6 is developed by re-running Model 4 using DIFMFG rather than DIFDUR, and the results are reported in Table 3, column 5. Although all coefficients carry the proper sign, DIFMFG and ΔΔLUNFIL are insignificant. The R-squared value decreases to .69, a significant

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

reduction from .76 calculated for Model 4. In addition, there is an indication of a structural break around 1980.

Again, a modified Model 4 is re-specified using both DIFDUR and DIFMFG, alternatively eliminating each variable in the constrained regression, and using an F-test to measure the impact of each variable. Results of the F-tests indicate DIFDUR (F-statistic of 10.67 and p-value of .00) should be retained instead of DIFMFG (F-statistic of 2.61 and p-value of .11). Based on these results, it is concluded that the use of durable manufacturing nominal wage and productivity data provides a better explanation of changes in the rate of inflation as measured by the PPI.

4. ADDING LAGS TO THE REAL EXCHANGE RATE VARIABLE

4.1. Model 7

Chapter 3, Section 2.5 references studies that demonstrate smaller than expected impact from changes in the real exchange rate due to the pass-through effect, and the possibility of lags, up to 2 or 3 years, before the ultimate impact on changes in domestic prices are realized. Consequently, it is not surprising that contemporaneous data concerning the acceleration or deceleration of real exchange rates consistently yield insignificant coefficients.

To further explore this matter, additional lags of ΔΔLXRAT are added to the model using a polynomial distributed lag specification. This procedure constrains the coefficients of the lags of ΔΔLXRAT to lie on a polynomial of the degree specified. This

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

model assumes a 3rd order polynomial (current value, plus 3 years lags), with no constraints imposed on the beginning or end of the polynomial series.

The results of Model 7 are shown on Table 4, Column 2. The first column of Table 4 is a replication of the results from Model 4 (Table 3, Column 3) which is considered the "best" of the models as yet developed, and will serve as a benchmark against which to compare models containing lags of the real exchange rate.

The R-squared value is .83, adjusted R-squared is .77 and diagnostic tests indicate no problems with the statistical adequacy of the model. All variables except ΔΔLXRAT(-1) carry the proper sign. It should be noted that ΔΔLXRAT(-2) and ΔΔLXRAT(-3), while not significant at the 95% level, have the highest t-values (-1.9 and –1.3 respectively) of the exchange rate variable and its lags, and will be included in the constrained form when testing down this regression. LCAP is now insignificant at the 95% level, but will be retained in the constrained model in order to maintain structural consistency with the other models.

4.2. Model 8

The above specification of Model 7 is tested down by excluding ΔΔLXRAT and ΔΔLXRAT(-1), and the results are shown as Model 8 on Table 4, column 3. The The log-likelihood ratio test (p-value of .36) indicates the constrained model can be accepted relative to Model 7. The R-squared value decreases slightly (.82 vs. .83) as compared to Model 7, and the adjusted R-squared remains constant at .77. All diagnostic

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE 4 – Results of Regressions [Lags of ΔΔLXRAT]

VARIABLES/ ADEQUACY TESTS	MODEL 4	MODEL 7	MODEL 8	MODEL 9
Variables				
C	**-0.74**	-0.45	-0.45	0.00
	(-2.6)	(-1.5)	(-1.5)	(.2)
LCAP	**0.17**	0.10	0.10	
	(2.6)	(1.5)	(1.5)	
ΔΔLROIL	**0.05**	**0.04**	**0.04**	**0.04**
	(4.9)	**(3.9)**	**(4.3)**	**(3.9)**
ΔΔLXRAT	-0.02	-0.02		
	(-0.5)	(-.7)		
ΔΔLXRAT(-1)		0.03		
		(.7)		
ΔΔLXRAT(-2)		-0.08	**-0.08**	**-0.08**
		(-1.9)	**(-2.1)**	**(-2.2)**
ΔΔLXRAT(-3)		-0.05	-0.04	
		-1.3)	(-1.2)	
DIFDUR	**0.15**	**0.19**	**0.18**	**0.20**
	(2.8)	**(3.5)**	**(3.5)**	**(3.8)**
ΔΔLUNFIL	**0.16**	**0.23**	**0.21**	**0.25**
	(3.3)	**(4.4)**	**(4.4)**	**(5.7)**
NAICU [CU*]	82.1%	81.4%	82.4%	N/A

- Adequacy tests shown on the following page.
- Notes are shown on the following page.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE 4 – Results of Regressions [Lags of ΔΔLXRAT] (cont.)

VARIABLES/ ADEQUACY TESTS	MODEL 4	MODEL 7	MODEL 8	MODEL 9
Adequacy Tests				
R-squared	0.76	0.83	.82	.77
Adjusted R-squared	0.71	0.77	.77	.73
LM het. Test	.39 [.53]	.04[.85]	.08[.78]	.02[.89]
Durbin-Watson	2.24 [.37,.96]	1.96 [.02,.97]	2.04 [.10,.04]	2.06 [.25,.85]
ARCH test	2.03[.15]	1.26[.26]	1.79[.18]	.15[.70]
Chow test	1.06 [.42]	.37[.93]	.45[.85]	.78[.58]
Jarque-Bera test	.07 [.97]	1.00[.61]	.35[.84]	1.30[.52]
F (zero slopes)	17.38 [.00]	13.36[.00]	17.93[.00]	22.67[.00]
Log likelihood	91.86	88.17	87.15	86.50
Log-likely ratio test	2.9 (4) [.57] [12]		2.5 (2) [.36] [13]	1.3 (2) [.52] [14]

NOTES:
[1] Refer to Table 3 for common notes: 1-11.
[12] Model 4 compared to Model 3 (see Table 3).
[13] Model 8 compared to Model 7.
[14] Model 9 compared to Model 8.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

tests indicate the model is statistically adequate. All variables carry the proper sign, with LCAP and ΔΔLXRAT(-3) being insignificant at the 95% level.

4.3. Model 9

In order to measure the impact of the two insignificant variables in Model 8, the model is again tested down by excluding LCAP and ΔΔLXRAT(-3). Since capacity utilization is still insignificant at this stage, it was deemed appropriate to exclude this variable in the constrained regression. The results are shown on Table 4, Column 4.

The log-likelihood ratio test (p-value of .52) indicates the constrained form can be accepted relative to Model 8. The R-squared value has decreased to .77 as compared to .82 for Model 8. All the coefficients are significant and carry the proper sign. The diagnostic tests indicate no problems with the adequacy of the model.

A Chow test analysis is performed using this model to examine the structural stability between 1970 and 1990, and the results are plotted on Figure 1. Although the p-value falls to .054 in 1972, at no time does the p-value drop below .05 indicating that this specification of the model is structurally sound during the entire period.

Comparison of Model 9 with Model 4 which is deemed to be the "best" using only contemporaneous values of ΔΔXRAT in the regressions provides the following comparisons:

- The R-squared value for Model 9 is slightly higher than for Model 4 (.77 vs. .76), and the adjusted R-squared value is slightly higher (.73 vs. .71).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

- A more thorough Chow test analysis (1970-1990) on both models shows Model 4 to experience a structural break in 1972 and 1973. Model 9 does not display a structural break during this time period.
- All variables in Model 9 are stationary [I(0)].
- The fact that LCAP does not appear in Model 9 indicates that this variable may ***not*** be instrumental in predicting the rate of inflation, but another variable ΔΔLXRAT(-2) could be used as a substitute which "pushes" LCAP out of the regression model. This suggests that increased globalization and the exchange rate effect become more important than domestic capacity utilization in this model.

5. ALTERING THE TIME PERIOD

Chow Tests covering the period 1970-1990 (Figure 1) demonstrate all three models (1, 4, and 9) experience structural shifts around 1980, probably due to the change in targets used by the FOMC between 1979 and 1982 in establishing monetary policy. The initial presumption might be that this is caused by the oil price supply-side shocks of the 1970s. However, inclusion of the real price of oil as an independent variable in the models should allow for this event.

Further investigation of the data suggests the structural problems with the models occurred during the 1960s rather than the 1970s. It was during the late 1960s that the traditional Phillips curve analysis started breaking down, suggesting structural changes in the economy. Also, increasing inflation after 1964 was beginning to put serious pressure on the system of fixed exchange rates established by the Bretton Woods Agreement. The

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

fixed exchange regime and the gold standard were ultimately abolished in the early 1970s (Henderson, 1993, 129). These events suggest that the sample period might be shortened to exclude some of the earlier years.

One other justification for possibly limiting the sample period is provided by Koenig (1996, 17), who notes that, although capacity utilization data extends back to 1948, regular publication of this information did not begin until 1968. Additionally, data prior to 1967 are not consistent with later data due the changing of weights given to physical-unit capacity data in determining capacity utilization. The Bureau of Economic Analysis also treats investment estimates before and after 1967 in a different manner. Hence, Koenig limits the sample period to 1968-1996 in his study.

It is interesting to note that Bauer (1990) selects 1970-1989 as one sample period in his study. No economic justification for this span is offered. However, it is notable that the R-squared value for this sample period is significantly higher (.41 vs. .25) when compared to the entire sample period (1950-1989).

Based on the above justifications, Models 1, 4, and 9 are re-run limiting the sample period to 1970-1996. The results are shown on Table 5, which also includes results for Models 1, 4, and 9 covering the 1961-1996 time span as comparisons. The only statistical adequacy tests reported are R-squared and adjusted R-squared. None of the diagnostic tests indicate a problem with the models.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE 5 – Analysis using 1961-1996 and 1970-1996 Time Periods

VARIABLES/ ADEQUACY TESTS	Model 1		Model 4		Model 9	
	1961-1996	1970-1996	1961-1996	1970-1996	1961-1996	1970-1996
Variables						
C	**-1.09**	**-2.05**	**-0.47**	**-0.98**	0.00	0.00
	(-3.4)	**(-4.7)**	**(2.6)**	**(-2.5)**	(0.2)	(-0.4)
LCAP	**0.25**	**0.47**	**0.17**	**0.22**		
	(3.4)	**(4.5)**	**(2.6)**	**(2.6)**		
NIXON	0.00	0.00				
	(0.7)	(0.3)				
ΔΔLROIL	**0.06**	**0.05**	**0.05**	**0.05**	**0.04**	**0.04**
	(5.1)	**(4.8)**	**(4.9)**	**(5.0)**	**(3.9)**	**(4.0)**
ΔΔLXRAT	-0.03	0.00	-0.02	-0.02		
	(-0.7)	(-0.1)	(-0.5)	(-0.6)		
ΔΔLXRAT(-2)					**-0.08**	**-0.08**
					(-2.2)	**(-2.5)**
ΔΔLPROD	-0.1	0.37				
	(-0.5)	(1.3)				
DIFDUR			**0.15**	**0.19**	**0.20**	**0.22**
			(2.8)	**(3.5)**	**(3.8)**	**(4.5)**
DIFUNFIL			**0.16**	**0.18**	**0.25**	**0.28**
			(3.3)	**(3.3)**	**(5.7)**	**(6.6)**
NAICU [CU*]	81.7%	80.8%	82.1%	80.8%	N/A	N/A
Adequacy Tests						
R-squared	0.66	0.76	0.76	0.85	0.77	0.84
Adj. R-squared	0.61	0.70	0.71	0.81	0.73	0.81

NOTES:
[1] T-statistics are in parenthesis ( ) below their coefficients.
[2] Statistically significant coefficients are shown in boldface (t-statistics ≥ |2.0|).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

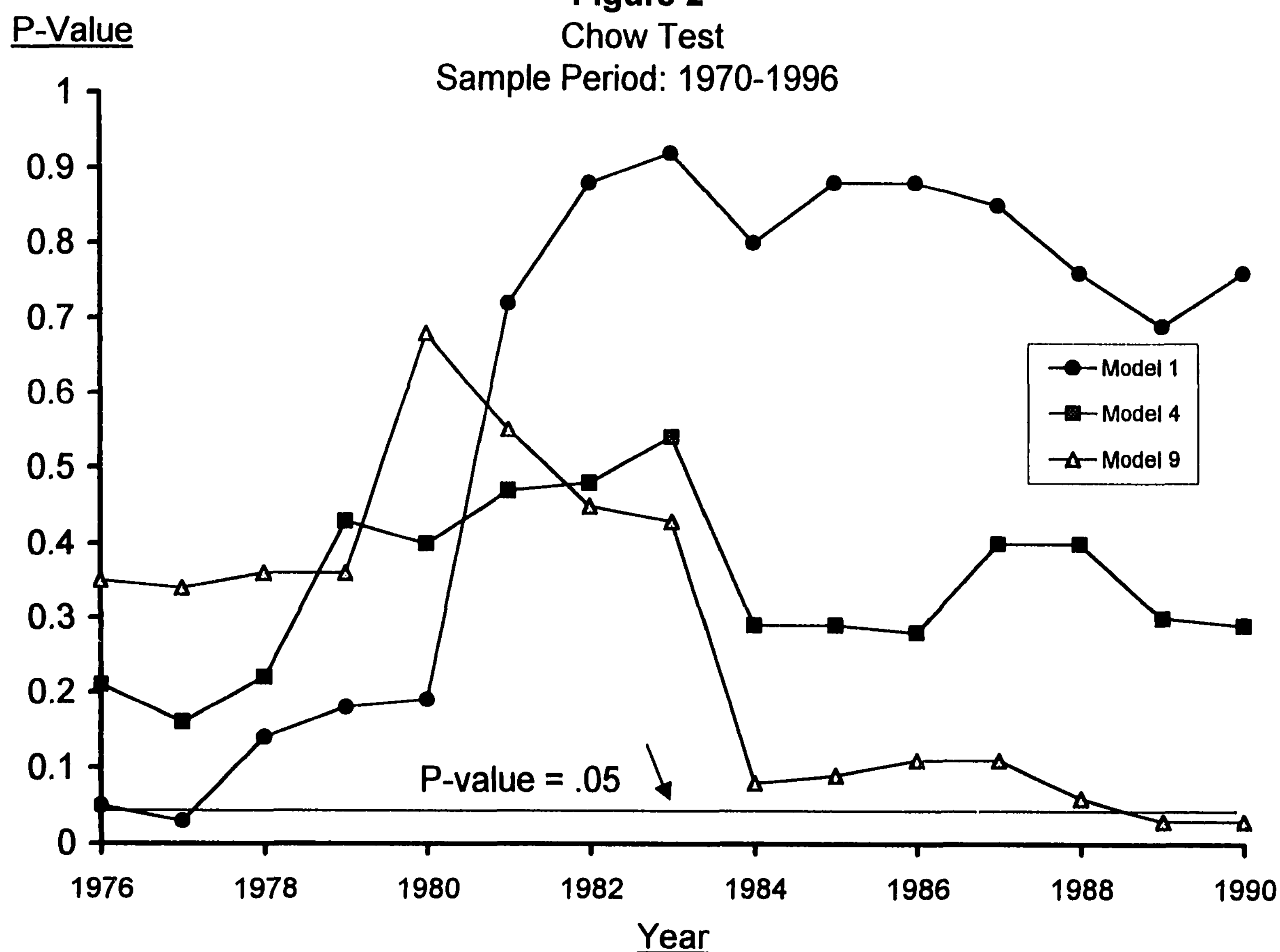
Inspection of Table 5 provides the following conclusions:

- All variables significant in the 1961-1996 analysis are also significant in the 1970-1996 time span. Likewise, any variables that are insignificant during the longer period are still insignificant.
- The R-squared and adjusted R-squared statistics are greatly improved for each model, indicating restricting the time period to 1970-1996 produces models that are better predictors of changes in the inflation. This is consistent with Bauer's findings discussed in the preceding paragraph.
- The NAICU is reduced to 80.8% for Model 1 and Model 4 using the shorter time period in contrast to a NAICU of 81.7% and 82.1%, respectively, for the longer time period. Garner (1994) also observes that the NAICU in his study is 81.8% for sample period 1964-1993; but drops to 80.8% for sample period 1974-93. He attributes the reduction to problems with earlier data (pre-1968) and inaccuracies in measuring capacity utilization.

A series of Chow Tests is performed on Model 1, 4, and 9 using the shorter-time span (1976-1990) with annual break points between 1976-1990. The results shown in Figure 2 indicate both Model 1 and Model 9 contain structural breaks. However, P-values for Model 4 using the short time span do not drop below .05, and the fluctuations are reduced, implying no structural shifts when using 1970-1996 data.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Figure 2
Chow Test
Sample Period: 1970-1996



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

6. SELECTION AND EXTENSION OF THE MODEL

6. 1. The Model and the Sample Period

Two candidates emerge as possibilities for a model which best predicts changes in the rate of inflation, and could perhaps be extended to forecast changes in inflation rates: 1) Model 4 (with a sample period restricted to 1970-1996) and 2) Model 9 covering the entire sample period. In order to select the model, it is necessary to analyze the issues regarding the sample period under consideration. Once the question of the sample period is resolved, selection of the appropriate model follows from the results shown in Tables 4, 5, and 6, as well as Figures 1 and 2.

Table 5 illustrates the significant improvement in the R-squared and adjusted R-squared values by reducing the sample period from 1961-1996 to 1970-1996 for Models 1, 4, and 9. This improvement, by itself, is not a valid reason for limiting the time period to 1970-1996. However, Section 5 in this chapter provides economic reasoning for limiting the sample period to 1970-1996 in order to justify the selection of this time period.

From a conceptual perspective, it would appear reasonable for researchers to pursue a model that includes data as far back in time as possible. Upon achieving this, the "ideal" model becomes as robust as possible, and captures all the major economic events during the extended sample period. In reality, however, situations change and events that occurred during the 1960s may not be relevant when attempting to model inflation in the late 1990s. Chapter 3, Section 2, describes the major economic events that occurred during the initial sample period under consideration (1961-1996). By limiting the sample

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

period to 1970-1996, the events relating to the breakdown of the traditional Phillips curve and increasing inflation in the 1960s, which resulted in the abolishment of the Bretton Woods Agreement and the gold standard, are not covered by the reduced span of years. The shortened time span does include the oil shocks of the 1970s, coupled with high inflation and interest rates; the Volcker disinflation era; corporate downsizing; productivity increases during the 1990s; rapid swings in real exchange rates; enormous growth in data processing and telecommunications; and the expanding global economy. These are events still relevant in today's economy, and they must be accounted for when modeling inflation in the late 1990s.

Consequently, limiting the sample period to 1970-1996 appears a fully justifiable position from an economic, empirical, and conceptual perspective. Based on this rationale, Model 4 emerges as the appropriate choice. It has the highest R-squared value, and none of the statistical adequacy tests suggest problems with the model. Figure 2, in this chapter, shows that the p-value of the various Chow-tests for this model never falls below the .15 value, indicating no structural breaks during this period.

The mathematical specification of the regression model used as a benchmark in the remainder of this chapter is as follows, with results presented in Table 5, Column 4:

$$\Delta\Delta LPPI_t = \alpha_0 + \alpha_1 LCAP_t + \alpha_2 \Delta\Delta LROIL_t + \alpha_3 \Delta\Delta LXRAT_t + \alpha_4 DIFDUR_t + \alpha_5 DIFUNFIL_t + \mu_t$$

Sample period: 1970-1996, annual data

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

6.2. Out-of-Sample Prediction

One test of the adequacy of the model involves making an out-of-sample prediction using a dummy variable in a linear regression and comparing this estimate with the actual data. This procedure entails setting the value of the dependent variable (ΔΔLPPI) for the specified time period (1997) equal to zero, introducing a dummy variable (-1, 1997; 0, otherwise), and including actual 1997 year-end data for the independent variables. A linear regression is then performed on the entire sample period. The estimated coefficient of the dummy variable [-0.033] is the out-of-sample prediction for ΔΔLPPI(1997), and the standard error of the dummy variable [0.018] is the standard error of the prediction. Using a 95 percent confidence interval, the actual value of ΔΔLPPI(1997) is predicted to fall between –0.068 and 0.002. The measured acceleration of the PPI between 1996 and 1997 was –0.044, indicating Model 4 provides an acceptable out-of-sample prediction for change of inflation during 1997.

6.3. Use of Contemporaneous Data

Since all independent variables enter into the regression model contemporaneously with the dependent variable, Model 4 should signal when inflationary pressures were building up in the economy, but could not be used to forecast inflation rates in the future. In order to examine this limitation of the model, a regression is performed in which all the independent variables are lagged one period. The results are shown on Table 6, Column 2. As a benchmark, Column 1 of this table displays Model 4, using contemporaneous values of the variables.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE 6 – Using ΔΔLPPI as the Dependent Variable;

Comparison between Contemporaneous and Lagged Independent Variables

Variables/ Adequacy Tests	Model 4 (ΔΔLPPI) Contemporaneous Independent Variables	Model 4 (ΔΔLPPI) Lagged Independent Variables
Variables		
C	**-0.98**	**-1.29**
	(-2.5)	**(-2.1)**
LCAP	**0.22**	**0.29**
	(2.6)	**(2.1)**
ΔΔLROIL	**0.05**	**-0.04**
	(5.0)	**(-2.6)**
ΔΔLXRAT	-0.02	-0.00
	(-0.6)	(-0.1)
DIFDUR	**0.19**	**-0.19**
	(3.5)	**(-2.1)**
ΔΔLUNFIL	**0.18**	0.07
	(3.3)	(0.8)
NAICU	80.8%	80.9%
Adequacy Tests		
R-squared	0.85	0.58
Adj. R-squared	0.81	0.48

Notes:
[1] T-statistics are in parenthesis ( ) below their coefficients.
[2] Variables with statistically significant coefficients are boldfaced (t-statistic ≥ | 2.0 |).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The impact of lagging the independent variables one time period significantly lowers the R-squared and adjusted R-squared values when compared to the use of contemporaneous values (.85 versus .58, and .81 versus .48, respectively). The only significant variables are LCAP, ΔΔLROIL, and DIFDUR; however, only LCAP carries the expected sign. This indicates that a high capacity utilization rate would tend to lead to a higher rate of inflation in the following year. The statistical adequacy tests (results not shown) do not indicate any problems with this model. Interestingly, the NAICU when lagging the independent variables one time period is 80.9%, not materially different than the NAICU of 80.8% when using contemporaneous values.

Emery and Chang (1997) specifically attempt to develop an inflation-forecasting model using lagged values of capacity utilization. Also included in their model are the acceleration/deceleration of oil prices and a dummy variable for the Nixon wage/price control years. Rather than using annual data, Emery and Chang utilize monthly, quarterly, and semiannual data, and when using PPI as the dependent variable, generate the following R-squared values: 1) 0.43—monthly, 2) 0.50—quarterly, and 3) 0.36—semiannual. The R-squared value of .58 for Model 4 containing lagged independent variables is significantly higher than any of the values calculated by Emery and Chang.

6.4. Use of the Consumer Price Index Instead of the Producer Price Index

Policymakers would probably be more comfortable using capacity utilization as a predictor of impending changes in inflation if there were a strong link between capacity utilization and the consumer price index (CPI)—the preferred measure of inflation in

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

communicating pricing information to the general public. The FOMC would also prefer to use an indicator of inflationary pressures such as the NAICU, provided this proxy is not sensitive to the choice of the measure of inflation (Garner, 1994, 12).

As discussed in Chapter 3, Section 2.1, the linkage between capacity utilization and the PPI has economic justification. Additionally, empirical analysis confirms a much stronger correlation between capacity utilization and PPI rather than between capacity utilization and the CPI.

De Kock (1996, 15) suggests that for capacity utilization to explain movements in the CPI, two conditions must be met:

1. Changes in capacity utilization must have predictive power for the PPI.
2. Producer prices must account for a significant portion of the movement in consumer prices.

Based on the results of this study, it appears that the first condition is met—capacity utilization is a significant variable in predicting changes in the PPI. De Kock (1996, 17) also finds that capacity utilization predicts producer price inflation in the United States.

In order for the second condition to be met, there must be a correlation between movements in the PPI and CPI. The usual expectation is that changes in the PPI generally precede movements in the CPI (Edgmand, 1983, 242). However, the PPI and CPI can behave differently due to differences in composition (Carnes and Slifer, 1991, 76). Also, there will be a time delay, one or even two years, between changes in the PPI and the impact on the CPI (Henderson, 1993, 212). Nevertheless, de Kock (1996), while examining the linkage between capacity utilization and the CPI, notes, "Overall, the results

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

confirm that producer prices account for a significant fraction of the variation in inflation, whether gauged by the consumer price index or the GDP deflator" (17).

In an attempt to explore this matter within the context of this study, Model 4 is re-run with the acceleration/deceleration of the CPI (ΔΔLCPI) as the dependent variable, and alternatively using contemporaneous and lagged values of the independent variables in two different regressions. The results are shown in Table 7.

Examination of Table 7 reveals the following:

- As compared to Table 6, attempts to predict the CPI, rather than the PPI, result in a slight decrease in the R-squared value (.81 vs. .85 for contemporaneous data and .52 vs. .58 for lagged variables).
- The NAICU using contemporaneous CPI data is calculated to be 80.8%, the identical value computed for the PPI. However, when lagging the independent variables by one period, the NAICU falls to 80.3%.
- The statistical adequacy test for both regressions on Table 7 (not shown) reveal problems with the Chow Test, suggesting a structural break at the mid-point (1983).
- Using contemporaneous data, all coefficients, except ΔΔLXRAT and ΔΔLUNFIL, are significant and carry the proper sign. Using lagged variables, only ΔΔLROIL is significant.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE 7 – Using ΔΔLCPI as the Dependent Variable; Comparison between Contemporaneous and Lagged Independent Variables

Variables/ Adequacy Tests	Model 4 (ΔΔLCPI) Contemporaneous Independent Variables	Model 4 (ΔΔLCPI) Lagged Independent Variables
Variables		
C	**-1.11**	-0.75
	(-4.0)	(-1.8)
LCAP	**0.25**	0.17
	(4.0)	(1.8)
ΔΔLROIL	**0.02**	**-0.02**
	(3.7)	**(2.0)**
ΔΔLXRAT	-0.02	-0.02
	(-0.7)	(-0.6)
DIFDUR	**0.10**	-0.06
	(2.7)	(-1.0)
ΔΔLUNFIL	0.06	0.08
	(1.6)	(1.4)
NAICU	80.8%	80.3%
Adequacy Tests		
R-squared	0.81	0.52
Adj. R-squared	0.75	0.41

Notes:
[1] T-statistics are in parenthesis ( ) below their coefficients.
[2] Variables with statistically significant coefficients are boldfaced (t-statistic ≥ | 2.0 |).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Despite the rather tenuous linkage between the PPI and the CPI, using contemporaneous values of the independent variables provides a high R-squared value (.81) when Model 4 is used to predict changes in the CPI. The fact that capacity utilization is statistically significant indicates that this variable is instrumental in predicting changes in . However, Model 4 breaks down when using the independent variables lagged one time period, seriously limiting capacity utilization in forecasting the CPI when looking at a one year horizon.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CHAPTER 5

EDUCATIONAL PEDAGOGY

> If we teach Principles of Economics as though it is the first course for every student's initial step toward earning a Ph.D. in economics, it will probably be their last. However, if we teach the course as if it is the last course of economics for each student, it could be the first course toward earning a Ph.D. in economics for several students.[1]

1. RELEVANCY OF THE "REAL WORLD"

One of the essential ingredients of presenting economics in an engaging manner at the undergraduate level is the inclusion of real world issues that are currently challenging policy makers and will ultimately have an impact upon students' lives. There is no doubt that inflation and monetary policy are topical and important issues as the global economy enters the next millenium. Topics discussed in this study—unemployment, capacity utilization, inflation, monetary policy, and the FOMC—are subjects to which every college or university student enrolled in economics courses, at both the undergraduate and graduate levels, should be exposed.

A further contemporary concept that students should be familiar with relates to actions of the FOMC in achieving stable prices. Utilizing information presented in this study, students can be made aware of the use of leading indicators, such as capacity utilization and unemployment, to assist the FOMC in predicting acceleration of inflation and implementing appropriate monetary policy. Additionally, the trade-off faced by the FOMC in slowing down economic growth and possibly creating an increase in

---

[1] Paraphrased from a message that appeared on an economics educators' discussion group on the Internet.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

unemployment is an excellent discussion topic. A classroom debate of these conflicts has the potential to reveal economics as the multi-dimensional field it is—theoretical, empirical, practical, and societal.

The narrative nature of Chapter 2 presents the concepts of unemployment, capacity utilization, and inflation in an integrative manner that should be understood by undergraduates. The material in Chapter 2 is composed purposefully for incorporation into a lesson plan encompassing the many facets of this complicated and confusing topic.

2. USE OF GRAPHS

Aggregate demand/aggregate supply curves in Chapter 2, section 1.2, provide a visual representation of theoretical concepts, mainly the two different types of inflation—demand-pull and cost-push—and describes how each type of inflation relates to the relationship between inflation and unemployment posited by the Phillips curve. Because graphs provide an excellent vehicle for explaining economic concepts to students, aggregate demand/aggregate supply curves (though fraught with theoretical problems) are extremely useful as a teaching aid at all levels of economic study. Graphical representations of the natural rate hypothesis and the non-accelerating inflation rate of capacity utilization in Chapter 2, coupled with the verbal descriptions, should assist the students in understanding these two complex topics. This writer has found ample opportunity to incorporate graphs, along with much of the knowledge acquired during this study, in the explanation of inflation, unemployment, and monetary policy to students in Modern Economics, Labor Economics, and Money and Banking—courses currently taught at Athens State College, Athens, Alabama.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3. RESEARCH TOOLS

As a student of the 1960s who was dwarfed by huge mainframes, punched IBM cards, and experienced the frustration of a 24-hour turn-around cycle from the computer lab; the writer of this study found today's technology offered a completely different perspective to research. A task that is accomplished today with the click of a mouse in the past often consisted of thumbing through library card catalogues and occasionally making the journey to other libraries to locate relevant material to include in a term paper. The advent of personal computers, plus associated software, and the Internet has dramatically changed how research is conducted. This study provided this writer the opportunity to expand computer skills and develop a much better understanding of the capabilities of computers and their applications.

Business students in today's colleges and universities must have a good understanding of this new technology before receiving their degrees and entering the work force. It is incumbent upon professors to assist students to become competent with the current technological advances in their disciplines.

Consequently, this writer's course syllabi for Modern Economics, Labor Economics, and Money and Banking taught at Athens State College have been re-written to include activities that will acquaint uninitiated students with the versatility of computers and electronic transfer of data. Specific examples of changes made to the syllabi included:

1. Requiring students in Modern Economics and Money and Banking to produce a two-page paper written from an article downloaded from the Internet.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2. Having students in Money and Banking and Labor Economics search the World Wide Web to locate articles pertaining to specific economic issues.
3. Assisting students in Money and Banking and Labor Economics to download data from the Internet and place in an electronic spreadsheet. The data are then manipulated to produce monetary or labor statistics.
4. Where possible, requiring students to draw graphs "electronically" for incorporation into take-home exams. Learning to perform this task was a skilled acquired during this study.
5. A brief presentation of this study has been made to several classes to make students aware of this type of research. Students planning on pursuing a graduate degree have found this discussion helpful.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CHAPTER 6

DISCUSSION AND CONCLUSIONS

1. CAPACITY UTILIZATION AND INFLATION

The FOMC's concern with inflation gives rise to a multitude of theories and practices intended to anticipate, defend against, or otherwise manage inflation. This study examines the question, "Can capacity utilization be used by the FOMC as a predictor of changes in the rate of inflation, and is the concept of a NAICU valid as a policy tool?"

Capacity utilization, as the single variable in a simple linear regression (Chapter 2, Figure 9), explains less than half (46%) of the change in the inflation rate. Following the line of reasoning developed by Stiglitz (1997, 5), it would be wrong to ignore a parsimonious concept that, by itself, predicts this percentage of change in the rate of inflation. However, this percentage is also a reminder that the inflation process is much more complicated than a simple link between the NAICU and inflation.

Limiting the independent variables in the regression solely to capacity utilization ignores other available information, resulting in a suboptimal prediction of changes in the rate of inflation. Corrado and Mattey (1997, 154) note that basing monetary policy on a single indicator would be naïve. In addition to capacity utilization, economic models routinely include other influences on inflation

Model 4 includes additional real variables that serve as supply/demand proxies (acceleration of both oil prices and unfilled durable orders, and the difference between the acceleration of wages and productivity in the durable sector) and results in a significant improvement in the ability to predict inflation. The model has an R-squared value of .85

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

and capacity utilization remains a statistically significant variable in explaining the inflation process. Hence, the empirical results suggest that capacity utilization (with the inclusion of other relevant real variables) is an important variable in predicting a change in the rate of inflation in the PPI and the model captures a large percentage of the variation in the rate of inflation.

Despite the importance of capacity utilization in predicting changes in inflation, the exclusive use of the NAICU in setting monetary policy is not justified. The calculated value of the NAICU for Model 4 is 80.8%. If the NAIRU were the sole focus of policymakers in establishing monetary policy, any actual capacity above 80.8%[1] would theoretically call for tightening of monetary policy. By ignoring all other explanatory variables, the policymakers would implicitly be assuming *ceteris paribus* for the other variables and ignoring vital predictive information contained within the other data series. In the fourth quarter of 1997, capacity utilization was 82.2%. When compared to the calculated NAICU of 80.8% for Model 4, this level of capacity utilization suggests inflation should have been accelerating at a significant rate; however, the PPI actually declined during between 1996 and 1997 (133.4 versus 131.4).

The out-of-sample prediction achieved in Chapter 4, Section 6.2, demonstrates the need to include the other independent variables of Model 4 when predicting changes in the rate of inflation and illustrates the danger of relying on the NAICU as a trigger-point

[1] The standard error of this NAICU is 1.1%. This suggests policymakers who rely solely on the NAICU as a predictor of inflation would consider 81.9% as the "trigger point" for accelerating inflation.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

for monetary policy. These findings are consistent with an important point established by Chang (1997, 12) that techniques are available for identifying the different causes of unemployment and acceleration of inflation. Once these shocks are identified, use of the NAIRU or NAICU provides no additional information for predicting changes in inflation.

Lagging the independent variables one year would permit Model 4 to forecast a PPI inflation rate over a one-year horizon. However, this form of the regression equation results in a significant deterioration in the ability of the model to predict changes in the rate of inflation. Nevertheless, capacity utilization remains a statistically significant variable in the model, suggesting that an increase in capacity utilization in one year would lead to an increase in inflation, as measuring by the PPI, in the next year.

Emery and Chang (1997, 19) advocate that capacity utilization cannot be used after 1983 as a valid forecaster of the inflation rate. However, they suggest there is still evidence of a significant positive predictive relationship between capacity utilization and inflation rate changes of the PPI when using forecast horizons of six months. Although the use of annual data was justified in Chapter 3, Section 3.2, it is possible that semiannual data might be equally justified as a good compromise between monthly/quarterly and annual data. The use of semiannual data in Model 4 to determine the impact of more frequent samples and a shorter forecast horizon suggests one possible avenue for future research.

Using Model 4 to predict the change in the rate of inflation for the CPI provides mixed results. Using contemporaneous data, the model performs quite satisfactorily, explaining approximately 81% of the inflation process. Capacity utilization remains a very significant variable is this model.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The model becomes statistically inadequate, however, when the independent variables are lagged one year. Capacity utilization is now insignificant. The inability of the model to predict changes in the CPI is contrary to the findings of Cecchetti (1995), who observes that increases in capacity utilization and inflation [CPI-U] are closely correlated at horizons of up to 3 years (197). Re-examining Model 4 in terms of its ability to model inflation as measured by the CPI provides an opportunity for additional research.

2. ADDITION OF MONETARY AGGREGATES

Developing a model to predict changes in the inflation rate using only real variables ignores any impact resulting from changes in monetary policy. Ideally, Model 4 should model changes in inflation using real variables, with monetary policy remaining constant throughout the entire time period. Because this is an unrealistic situation in the real world, it is impossible to explain the behavior of the FOMC in the context of this model. As noted by Kohn in his comments on Cecchetti's article (1995, 232), any model predicting changes in the inflation rate using real variables unavoidably contains a reaction function of the FOMC's response to these real variables and their changes. For example, because of the assumed time delay between movements of the PPI and the CPI, the FOMC might react to early inflationary signals and implement monetary policy that prevents a transmission of the acceleration of inflation from the PPI to the CPI. The present model will not capture such a scenario.

Cecchetti (1995) suggests any possible deterioration of capacity utilization, as a predictor of changes in inflation, may be a result of alterations in the conduct of monetary policy. Balke and Emery (1994) argue that during the 1980s and 1990s the FOMC has

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

been more forward-looking and quicker to respond to inflationary pressures than it was in the late 1960s and 1970s. If the FOMC responds to inflationary signals such as capacity utilization in a more timely manner, the resulting tighter monetary policy will prevent the anticipated change in inflation from occurring. Such a change in policy will weaken the linkage between capacity utilization and inflation, requiring the addition of monetary aggregates to the model. However, Cecchetti's statement of a possible deterioration in the linkage is not supported by this study since Model 4 finds that capacity utilization remains a significant predictor of changes of the rate of inflation, both the PPI and CPI, even without the inclusion of monetary aggregates.

A perceived weakening of the relationship between capacity utilization and changes in inflation does not mean that the FOMC should cease monitoring capacity utilization. Emery and Chang (1997, 19) attribute stable inflation in the United States to the Federal Reserve's monitoring of the utilization rate as an indicator of rising inflation pressures, an observation that supports the primary focus and outcome of this study.

It is possible the more responsive monetary policy during the 1980s and 1990s provides a partial explanation for the unexpected empirical outcome of a lower NAICU when the sample period is restricted to 1970-1996 (80.8% versus 82.1% for the 1961-1996 sample period). By intervening more quickly to keep inflation in check, the FOMC slows down aggregate demand growth, thereby restraining further increases in capacity utilization. Such a policy may result in a leftward shift of the fitted line (Chapter 2, Figure 9) that is generated by the linear regression of the acceleration/deceleration of inflation against capacity utilization, causing a reduction in the value of the NAICU. The result may be an apparent lowering of the NAICU; whereas, if the FOMC had not altered its

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

response in the 1980s/1990s, the empirical value of the NAICU may have remained closer to the 82% level.

The "shift" hypothesis is further strengthened by the fact that the NAICU, given a specified sample period, is remarkably consistent regardless of the number of independent variables included in the multiple regression model. Adding independent variables improves the R-squared value, but has virtually no effect on the calculated value of the NAICU. Also, using the CPI rather than the PPI seems to have little impact on the value of the NAICU. As previously observed, this characteristic of the NAICU is seen in other studies. When the sample period in this study is altered from 1961-1996 to 1970-1996, there is a lowering of the NAICU, but it again remains constant regardless of the specification of the regression model.

3. CONCLUSIONS

This study makes several contributions to the body of literature concerning capacity utilization as a predictor of changes in the inflation rate:

- The present study examines the stationarity of all variables and discusses the issue of non-stationarity of capacity utilization and its implications, something absent in other studies. Only one study (Mustafa and Rahman, 1995) makes an attempt to examine the stationarity issue. Although their study finds capacity utilization to be non-stationary, an error-correction model is developed using cointegration techniques.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

- None of the literature reviewed for this study develops a "general" model using alternative variables and one period lags, and then "tests down" the model to its simplest form. This study uses both log-likelihood ratio tests and F-tests to determine the appropriate specification of the model.
- The inclusion of a calculated variable representing the difference between the changes in the growth rates of nominal wages and productivity appears unique to this study. When combined with capacity utilization, this variable makes a very significant contribution in predicting changes in the inflation rate. Likewise, the change in the growth of unfilled orders was not observed in other studies and significantly increases the model's ability to predict inflation.

Based on the empirical results of Model 4, using the 1970-1996 time span, this study finds that capacity utilization plays a significant role in explaining changes in the rate of inflation. However, it would be naïve for the FOMC to focus strictly on one proxy such as capacity utilization (NAICU) as the sole predictor of inflation rate changes. According to Cecchetti (1995, 231), policy makers prefer to examine a broad array of data and explicit forecasts made in the context of a structural model—econometric or judgmental—when deciding on an appropriate adjustment in monetary policy. This study suggests that capacity utilization should remain high on the list of items to be monitored. By focusing strictly on real factors such as capacity utilization, it appears possible to predict impending inflationary pressure buildup and suggest that the FOMC should take action to prevent future acceleration of inflation. The result of a change in monetary policy, however, cannot be quantified until monetary aggregates are added to the model.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

BIBLIOGRAPHY

Aizorbe, Ana M. "Procyclical Labour Productivity, Increasing Returns to Labour and Labour Hoarding in Car Assembly Employment." The Economic Journal. Vol. 102 (July 1992): 860-873.

Allen, Donald S. "Where's the Productivity Growth (from the Information Technology Revolution)?" Economic Review, Federal Reserve Bank of St. Louis. (March/April 1997): 15-25.

Balke, Nathan S., and Kenneth M. Emery. "Understanding the Price Puzzle." Economic Review, Federal Reserve Bank of Dallas. (4th Quarter 1994): 15-26.

Ball, Laurence. "What Causes Inflation?" Business Review, Federal Reserve Bank of Philadelphia. (March/April 1993): 3-12.

Bauer, Paul W. "A Reexamination of the Relationship between Capacity Utilization and Inflation." Economic Review, Federal Reserve Bank of Cleveland. (3rd Quarter 1990): 2-12.

Brynjolfsson, Eric, and Lorin Hitt. "Paradox Lost? Firm-level Evidence on the Returns to Information Systems Spending." Management Science. Vol. 42, No. 4 (April 1996): 541-558.

Blanchard, Olivier, and Lawrence F. Katz. "What We Know and Do Not know About the Natural Rate of Unemployment." The Journal of Economic Perspectives. Vol. 11, No. 1 (Winter 1997): 51-72.

Bresnahan, Timothy F., and Valerie A. Ramey. "Output Fluctuations at the Plant Level." Quarterly Journal of Economics. Vol. 109, No. 3 (August 1994): 593-624.

Brockway, George P. "What Greenspan really told Congress." The New Leader. Vol. 78, No. 6 (July 17, 1995): 13-14.

Butler, Larry. "Unemployment, Unused Capacity and the Business Cycle." Economic Review, Federal Reserve Bank of San Francisco. (Spring 1977): 46-52.

Carnes, W. Sansbury, and Stephen D. Slifer. The Atlas of Economic Indicators. HarperBusiness, 1991.

Cecchetti, Stephen. "Inflation Indicators and Inflation Policy." NBER Macroeconomics. Vol. 10 (1995): 189-219.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chang, Roberto. "Is Low Unemployment Inflationary?" Economic Review, Federal Reserve Bank of Atlanta. (First Quarter 1997): 2-13.

Cheung, Yin-Wong, and Kon S. Lai. "Lag Order and Critical Values of the Augmented Dickey-Fuller Test." Journal of Business & Economic Statistics. Vol. 13, No. 3 (July 1995): 277-280.

Chow, Gregory C. "Tests of Equality between Sets of Coefficients in Two Linear Regressions." Econometrica. Vol. 28 (July 1960): 591-605.

Colander, David. "The Stories We Tell: A Reconsideration of AS/AD Analysis." The Journal of Economic Perspectives. Vol. 9, No. 3 (Summer 1995): 169-188.

Corrado, Carol, Charles Gilbert, and Richard Raddock. "Industrial Production and Capacity Utilization: Historical Revision and Recent Developments." Federal Reserve Bulletin. Vol. 83, No. 2 (February 1997): 67-92.

Corrado, Carol, and Joe Mattey. "Capacity Utilization." The Journal of Economic Perspectives. Vol. 11, No. 1 (Winter 1997): 151-167.

Cunningham, Thomas. *Review Essay*—"Structural Slumps: The Modern Equilibrium Theory of Unemployment, Interest, and Assets," by Edmund S. Phelps. Economic Review, Federal Reserve Bank of Atlanta. Vol. 79, No. 6 (November/December 1994): 30-33.

de Kock, Gabriel S. P., and Tania Nadal-Vicens. "Capacity Utilization-Inflation Linkages: A Cross-country Analysis." Research Paper, Federal Reserve Bank of New York. No. 9607. (1996).

de Leeuw, Frank, Frank E. Hopkins and Michael D. Sherman. "A Revised Index of Manufacturing Capacity." Federal Reserve Bulletin. Vol. 52, No. 11 (November, 1966): 1605-1615.

de Leeuw, Frank, et al. "Measurement of Capacity Utilization: Problems and Tasks." Federal Reserve Bulletin. Vol. 65, No. 7 (July 1979): 532-533.

DePrince, Albert E. "Greater Price Stability: Implication for Business Behavior And Credit Quality." Paper presented to International Atlantic Economic Conference, Atlantic Economic Society, Philadelphia, PA. (October 7-10, 1993).

Dickey, D. A., and W. A. Fuller. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." Journal of American Statistical Association. Vol. 74 (1979): 427-431.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

__________. "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root." Econometrica. Vol. 49 (1981): 1057-1072.

Dumenil, Gerard. "The Macroeconomics of Disequilibrium." Journal of Economic Behavior and Organization. Vol. 9, No. 3 (September 1987): 377-395.

Eckstein, Otto, and Gary Fromm. "The Price Equation." The American Economic Review. Vol. 58, No. 5, Part 1 (December 1968): 1159-1183.

Edgmand, Michael R. Macroeconomics—Theory and Policy. 2nd Edition, Prentice-Hall, Inc. 1983.

Emery, Kenneth M., and Chih-Ping Chang. "Is There a Stable Relationship Between Capacity Utilization and Inflation." Economic Review, Federal Reserve Bank of Dallas. (1st Quarter 1997): 14-20.

Engle, Robert F. "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of U.K. Inflation." Econometrica. Vol. 50 (1982): 987-1008.

Espinosa-Vega, Marco A., and Steven Russell. "History and Theory of the NAIRU: A Critical Review." Economic Review, Federal Reserve Bank of Atlanta. (2nd Quarter 1997): 4-25.

Feinberg, Robert M. "The Effects of Foreign Exchange Movements on U.S. Domestic Prices." Review of Economics and Statistics. Vol. 71 (August 1989): 505-511.

__________. "The Choice of Exchange-Rate Index and Domestic Price Passthrough." The Journal of Industrial Economics. Vol. 39, No. 4 (June 1991): 409-420.

Finn, Mary. "Is High Capacity Utilization Inflationary?" Economic Quarterly, Federal Reserve Bank of Richmond. Vol. 81 (Winter 1995): 1-16.

__________. "A Theory of the Capacity Utilization/Inflation Relationship." Economic Quarterly, Federal Reserve Bank of Richmond. Vol. 82, No. 3 (Summer 1996): 67-86.

Fischer, Stanley. "Why Are Central Banks Pursuing Long-Run Price Stability." Achieving Price Stability, Symposium sponsored by The Federal Reserve Bank of Kansas City. (August 29-31, 1996): 7-34.

"Five Times Foolish." The Economist. Vol. 332, No. 7880 (September 10, 1994): A27.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Freeman, Charles. "What Operating Procedures Should Be Adopted to Maintain Price Stability?—Practical Issues." Achieving Price Stability, Symposium sponsored by The Federal Reserve Bank of Kansas City. (August 29-31, 1996): 241-284.

Friedman, Milton. "The Role of Monetary Policy." American Economic Review. Vol. 58, No. 1 (March 1968): 1-17.

__________. "Nobel Lecture: Inflation and Unemployment." Journal of Political Economy. Vol. 85, No. 3 (June 1977): 451-472.

Galbraith, James K. "Time to Ditch the NAIRU." The Journal of Economic Perspectives. Vol. 11, No. 1 (Winter 1997): 93-108.

Garner, C. "Capacity Utilization and U.S. Inflation." Economic Review, Federal Reserve Bank of Kansas City. Vol. 79, No. 4 (1994): 5-21.

Goldberg, Pinelopi Koujianou, and Michael M. Knetter. "Goods Prices and Exchange Rates: What Have We Learned?" Journal of Economic Literature. Vol. 35 (September 1997): 1243-1272.

Gordon, Robert J. "What is New-Keynesian Economics?" Journal of Economic Literature. Vol. 28 (September 1990): 1115-1171.

__________. "The Time-Varying NAIRU and its Implication for Economic Policy." The Journal of Economic Perspectives. Vol. 11, No. 1 (Winter 1997): 11-32.

Greene, William H. A Guide to Econometrics. 3rd Edition, MIT Press, 1992.

Hall, Robert E. "The Relation between Price and Marginal Cost in the U.S. Industry." Journal of Political Economy. Vol. 95, No. 5 (1988): 921-947.

Hallman, J. J., R. D. Porter, and D. H. Small. "M2 per Unit of GNP as an Anchor for the Price Level." Staff Study #157, Board of Governors of the Federal Reserve System. (1989).

Han, Sang. "Why the Natural Rate of Unemployment Has Risen." Milken Institute for Job and Capital Formation, Santa Monica, California. Vol. 3 (Fall 1994): 1-7.

Hauver, James H. and Jet Yee. "Morrison's Measure of Capacity Utilization." Journal of Econometrics. Vol. 52 (1992): 403-406.

Henderson, David R., ed. The Fortune Encyclopedia of Economics. New York: Warner Books, Inc., 1993.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Hogan, W. P. "Some New Results in the Measurement of Capacity Utilization." American Economic Review. Vol. 59, No. 1 (March 1969): 183-184.

Hulten, Charles R. "Productivity Change, Capacity Utilization, and the Sources of Efficiency Growth." Journal of Econometrics. Vol. 33 (1986): 31-50.

Issing, Otmar. "Commentary: What Operating Procedures Should Be Adopted to Maintain Price Stability?—Practical Issues." Achieving Price Stability, Symposium sponsored by The Federal Reserve Bank of Kansas City. (August 29-31, 1996): 287-296.

Kahn, George A., and Stuart E. Weiner. "Has the Cost of Disinflation Declined?" Economic Review, Federal Reserve Bank of Kansas City. Vol. 75 (May/June 1990): 5-21.

Kennedy, James E. "An Analysis of Time-series Estimates of Capacity Utilization." Finance and Economics Discussion Series--No. 95-37, Board of Governors of the Federal Reserve System. (1995).

Koenig, Evan F. "Capacity Utilization as a Real-Time Predictor of Manufacturing Output." Economic Review, Federal Reserve Bank of Dallas. (3rd Quarter 1996): 16-23.

King, Mervyn. "How Should Central Banks Reduce Inflation?—Conceptual Issues." Achieving Price Stability, Symposium sponsored by The Federal Reserve Bank of Kansas City. (August 29-31, 1996): 53-91.

Kohn, Donald L. "Commentary: What Operating Procedures Should Be Adopted to Maintain Price Stability?—Practical Issues." Achieving Price Stability, Symposium sponsored by The Federal Reserve Bank of Kansas City. (August 29-31, 1996): 297-306.

Kuttner, Kenneth N. "Inflation and the growth rate of money." Economic Perspectives, Federal Reserve Bank of Chicago. Vol. 14, No. 1 (January/February 1990): 2-11.

Kuttner, Robert. "The Natural Rate of Inflation isn't Carved in Stone." Business Week. (June 6, 1994): 20.

Lang, William W. "Is there a Natural Rate of Unemployment?" Business Review, Federal Reserve Bank of Philadelphia. (March 1990): 13-22.

Lee, Frederic S. "From Post-Keynesian to Historical Price Theory, part I: Facts, Theory and Empirically Grounded Pricing Model." Review of Political Economy. (July 1994): 303-336.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Lucas, Robert E., Jr. "Capacity, Overtime, and Empirical Production Functions." American Economic Review, Papers and Proceedings. Vol. 60 (May 1970): 23-27.

Mangum, Garth, Ken Jensen, John Mathews, and Don Perkins. "What's so Natural about the Natural Rate of Unemployment?" Challenge. Vol. 38, No. 4 (July/August 1995): 52-54.

Mann, Catherine L. "Prices, Profit Margins, and Exchange Rates." Federal Reserve Bulletin. Vol. 72, No. 6 (June 1986): 366-379.

Mark, Jerome A. "Problems Encountered in Measuring Single and Multifactor Productivity." Monthly Labor Review. Vol. 119 (December 1996): 3-11.

"Markets soar on Fed chief's testimony." Money Daily. Online. Internet. July 23, 1997. Available: http://www.pathfinder.com/@SkoW7AY.../money/daily/latest/index.html.

Mattey, Joe, and Steve Strongin. "Factor Utilization and Margins for Adjusting Output: Evidence from Manufacturing Plants." Finance and Economics Discussion Series—No. 95-12, Board of Governors of the Federal Reserve System. (1995).

__________. "Factor Utilization and Margins for Adjusting Output: Evidence from Manufacturing Plants." Economic Review, Federal Reserve Bank of San Francisco. No. 2 (Summer 1997): 3-17.

McElhattan, Rose. "Estimating a Stable-Inflation Capacity-Utilization Rate." Economic Review, Federal Reserve Bank of San Francisco. (Fall 1978): 20-30.

__________. "Inflation, Supply Shocks and the Stable-Inflation Rate of Capacity Utilization." Economic Review, Federal Reserve Bank of San Francisco. No. 1 (Winter 1985): 45-63.

Meulendyke, Ann-Marie. U.S. Monetary Policy and Financial Markets. Federal Reserve Bank of New York, 1989.

Mishkin, Frederic S. "The Causes of Inflation." Price Stability and Public Policy, Federal Reserve Bank of Kansas City. (1984): 1-32.

__________. The Economics of Money, Banking, and Financial Markets. 5th Edition, Addison Wesley, 1997.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Motley, Brian. "Has There Been a Change in the Natural Rate of Unemployment?" Economic Review, Federal Reserve Bank of San Francisco. No. 1 (Winter 1990): 3-16.

Mustafa, Muhammad, and Matiur Rahman. "Capacity Utilization in the USA and Inflation: Testing for Cointegration and Granger Causality." Applied Economics Letters. Vol. 2, No. 10 (October 1995): 355-358.

Oum, Tai H., Michael W. Tretheway, and Yimin Zhang. "A Note on Capacity Utilization and Measurement of Scale Economies." Journal of Business & Economic Statistics. Vol. 9, No. 1 (January 1991): 119-123.

Pantula, Sastry G., Graciela Gonzalez-Farias, and Wayne J. Fuller. "A Comparison of Unit-Root Test Criteria." Journal of Business and Economic Statistics. Vol. 12 (October 1994): 449-459.

Pindyck, Robert S., and Daniel L. Rubinfeld. Econometric Models and Economic Forecasts. 3rd Edition, McGraw-Hill, 1991.

Pennar, Karen. "Unemployment: The Natural Rate isn't Natural." Business Week. (November 14, 1994): p.94.

Phelps, Edmund. "Money Wage Dynamics and Labor Market Equilibrium." Journal of Political Economy. Vol. 76, No. 4 (July/ August 1968): 678-711.

__________. Structural Slumps: The Modern Equilibrium Theory of Unemployment, Interest, and Assets. Cambridge, Massachusetts: Harvard University Press, 1994.

Phillips, A. William. "The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957." Economica. Vol. 26 (November 1958): 283-99.

Phillips, P. C. B. "Time Series Regressions with a Unit Root." Econometrica. Vol. 55, No. 2 (March 1987): 277-301.

Phillips, P. C. B., and Pierre Perron. "Testing for a Unit Root in Time Series Regression." Biometrika. Vol. 75 (1988): 335-346.

Price, Simon. "Aggregate Uncertainty, Capacity Utilization and Manufacturing Investment." Applied Economics. Vol. 27 (1995): 147-154.

Raddock, Charles. "Industrial Production, Capacity, and Capacity Utilization Since 1987." Federal Reserve Bulletin. Vol. 79, No. 6 (June 1993): 590-605.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

__________. "Industrial Production and Capacity Utilization: A Revision." Federal Reserve Bulletin. Vol. 81, No. 1 (January 1995): 16-26.

__________. "A Revision to Industrial Production and Capacity Utilization, 1991-1995." Federal Reserve Bulletin. Vol. 82, No. 1 (January 1996): 16-25.

Risen, James. "Feds Base Interest Rates on 'Natural' Unemployment." Los Angeles Times. Vol. 114, No. 34 (August 29, 1994): 3.

Rissman, Ellen R. "What is the Natural Rate of Unemployment?" Economic Perspectives, Federal Reserve Bank of Chicago. Vol. 10 (September 1986): 3-17.

Ritter, Lawrence S., and William L. Silber. Principles of Money, Banking, and Financial Markets. 3rd Edition, HarperColllins, 1993.

Rogerson, Richard. "Theory Ahead of Language in the Economics of Unemployment." The Journal of Economic Perspectives. Vol. 11, No. 1 (Winter 1997): 73-92.

Rost, Ronald F. "New Federal Reserve Measures of Capacity and Capacity Utilization." Federal Reserve Bulletin. Vol. 69, No. 7 (July 1983): 515-521.

Samuelson, Paul A., and Robert M. Solow. "Analytical Aspects of Anti-Inflation Policy." American Economic Review. Vol. 50 (May 1960): 177-194.

Spiers, Joseph. "Don't Let the Expanding Economy Raise your Inflation Fears." Fortune. Vol. 129, No. 12 (June 13, 1994): 19-20.

Staiger, Douglas, James H. Stock, and Mark W. Watson. "The NAIRU, Unemployment and Monetary Policy." The Journal of Economic Perspectives. Vol. 11, No. 1 (Winter 1997): 33-50.

Steindel, Charles. "Industry Capacity and Industrial Investment." Research Paper, Federal Reserve Bank of New York. No. 9510 (1995).

Stiglitz, Joseph. "Reflections on the Natural Rate Hypothesis." The Journal of Economic Perspectives. Vol. 11, No. 1 (Winter 1997): 3-10.

Taylor, John B. "How Should Monetary Policy Respond to Shocks while Maintaining Long-Run Price Stability—Conceptual Issues." Achieving Price Stability, Symposium sponsored by The Federal Reserve Bank of Kansas City. (August 29-31, 1996): 181-195.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Tootel, Geoffrey M. B. "How Natural is the Natural Rate of Unemployment in Europe?" New England Economic Review, Federal Reserve Bank of Boston. (January 1990): 23-36.

"Unemployment." United Kingdom Department of the Treasury, Online. Internet. February 19, 1997.
Available: http://www.hm-treasury.gov.uk/pub/html/top/top6/une.html.

Walsh, Carl. E. "Nobel Views on Inflation and Unemployment." Economic Letters--No. 97-01, Federal Reserve Bank of San Francisco. (January 10, 1997).

Weiner, Stuart E. "The Natural Rate of Unemployment: Concepts and Issues." Economic Review, Federal Reserve Bank of Kansas City. Vol. 75 (January 1986): 11-24.

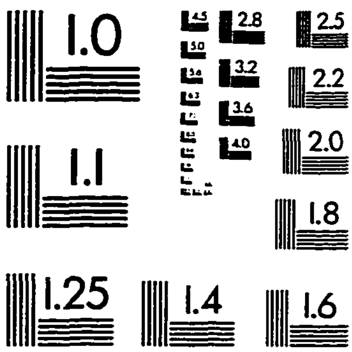
__________. "The Natural Rate and Inflationary Pressures." Economic Review, Federal Reserve Bank of Kansas City. Vol. 79, No. 3 (Summer 1994): 5-9.

__________. "Challenges to the Natural Rate Framework." Economic Review, Federal Reserve Bank of Kansas City. Vol. 80, No. 2 (2nd Quarter 1995): 19-25.

Woo, Wing T. "Exchange Rates and the Prices of Nonfood, Nonfuel Products." Brookings Papers on Economic Activity. Vol. 2 (1984): 511-530.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

IMAGE EVALUATION TEST TARGET (QA-3)



150mm

6"

APPLIED IMAGE . Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989

© 1993, Applied Image, Inc., All Rights Reserved

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.