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Explaining the Recent Behavior of Inflation and Unemployment in the United States[1]

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Abstract

Low rates of inflation have been recorded in recent years, despite a decline in the unemployment rate. This phenomenon could be the result of a series of transitory shocks or of a permanent change in the structure of the economy leading to a lower NAIRU. The paper suggests that, while the NAIRU may have fallen slightly, it has not fallen by an amount sufficient to explain the recent behavior of inflation. A leading explanation for recent inflation performance appears to be favorable price shocks; in particular, the cost of imports has fallen sharply as the dollar has appreciated.

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[1]The working paper was written while Mr. Hogan was an economist at the International Monetary Fund.

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Summary

Low rates of inflation have been recorded in recent years, despite a decline in the unemployment rate to levels that previously would have been associated with rising inflation. Indeed, since 1990, there has been a positive correlation between the inflation rate and the unemployment rate. This indicates that more than the traditional Phillips curve relationship is at work. The phenomenon could be the result of a series of fortuitous, transitory shocks or a permanent change in the structure of the economy leading to a lower natural rate of unemployment (NAIRU).

The results presented suggest that the NAIRU may have fallen slightly, but not enough to explain the recent history of inflation. The main explanation for recent inflation in the United States appears to be the unexpected declines in some cost variables. In particular the cost of imports since 1995 has fallen owing to the appreciation of the dollar, a decline in commodity prices, and the Asian crisis.

I. INTRODUCTION

Historically, U.S. inflation has followed a fairly predictable course in relation to the business cycle. Typically, inflation rises during an economic expansion. It reaches its maximum slightly after the end of the boom, declines during the recession, and starts to increase again when the economy has been in recovery for a year or two. It appears, however, that recent history has departed from this pattern. Over the period since the end of the last recession, there has been a prolonged expansion, unemployment has fallen, but inflation has not increased.

The Phillips curve, the traditional model used by economists to study the link between inflation and unemployment, worked well in the past. But it has difficulty explaining the recent behavior of unemployment and inflation. The basic Phillips curve posits a negative relationship between inflation and unemployment in excess of the natural rate. But, over the period since 1990, there has been a positive correlation between the inflation rate and the unemployment rate. This suggests that more than the basic Phillips curve relationship is at work.

This phenomenon has two important implications. Firstly, the traditional Phillips curve has systematically overpredicted inflation since 1994. This makes the task of the Federal Reserve more difficult. Secondly, the apparent breakdown of the traditional relationship between inflation and unemployment may be a symptom of more fundamental changes in the economy, which themselves could have profound implications for policy.

The purpose of this paper is to attempt to explain this recent history. In particular, we wish to determine what modifications need to be made to the traditional Phillips curve model in order that it can improve its ability to explain recent history. Two possible alternative explanations are examined in detail. The first, and perhaps most obvious, potential explanation is that the NAIRU has fallen sufficiently to enable unemployment to remain at an historical low even as inflation is falling. The alternative explanation is that the NAIRU has not really changed, but the United States has been fortunate in recent years to have been hit by some positive supply shocks that have overwhelmed inflationary pressures caused by unemployment being below its natural level.

These alternative explanations have dramatically different policy implications. If the NAIRU has truly fallen, it is very good news for the U.S. economy. A fall in the NAIRU implies that there has been a change in the structure of the economy that would tend to keep unemployment low in the long run without the danger of rising inflation. If, however, it is true that recent inflation performance is the result of temporary shocks, then there has been no permanent change in the structure of the economy. Inflationary pressures will re-assert themselves once the temporary supply shocks have ceased.

We investigate the question as follows. In section one we show that the traditional Phillips curve has systematically overpredicted inflation since 1994. In section two we explore the possibility that the natural rate of unemployment may have changed. We present estimates which suggest that the natural rate may have fallen to below 5.5 percent in recent years. But

we also show that this change, on its own, is not sufficient to explain the recent behavior of inflation. In section three, we examine the possibility that low inflation is the result of a series of fortuitous shocks. We find that recent inflation performance of the United States can be best explained by changes in the dollar price of imported goods. Forecasts of inflation based on estimates of a Phillips curve that includes import prices as a regressor do not overpredict inflation. Interestingly, we also find that changes in the cost of labor do not contribute much to the explanation of recent inflation performance. Rising productivity and/or falling (nonwage) labor costs appear not to have been critical factors in explaining recent inflation.

II. THE PROBLEM

We begin the analysis by estimating a standard Phillips curve model. The basic Phillips curve is given in equation (1), where U is the unemployment rate, U^N is the NAIRU, π is the rate of inflation and $\alpha(L)$ and $\beta(L)$ are polynomials in the lag operator.

$$\pi_t=\alpha(L)\pi_{t-1}+\beta(L)(U_t-U_t^N)+\varepsilon$$

Equation (1) posits a negative relationship between unemployment and inflation in the short run. More precisely, it predicts that inflation will accelerate if the economic activity is above potential (i.e., if the unemployment rate is below the NAIRU). The NAIRU is a similar concept to Friedman's natural rate of unemployment. Both concepts are intended to capture the notion that there is a rate of unemployment that is determined by the fundamental microeconomic structure of the country. The unemployment gap (defined as the difference between actual unemployment and the NAIRU) captures the effect of excess demand on inflation. Thus, if the economy is operating above potential, labor (and other resources) will be in short supply. This scarcity will cause prices to be bid up leading to inflation. The inclusion of lagged variables captures the inertia in this process.

Economic theory imposes two restrictions on the model. Firstly, there should be no constant term in the regression, and secondly, the sum of the α coefficients should be unity. When these two conditions are met inflation will be stable, if the actual unemployment rate is equal to the NAIRU.

We estimate equation (1) using quarterly U.S. data over the period 1960:1 to 1993:4. The inflation variable is the annualized percentage change in the CPI for urban consumers excluding food and energy costs. (This is often referred to as "core" inflation.) The NAIRU is assumed constant over the period at 6 percent which, until recently, was widely agreed to be approximately its true level. Four lags of each variable and the contemporaneous unemployment gap are included in the regression. These four lags were sufficient to eliminate serial correlation in the estimated residuals, thus ensuring the consistency of the estimators. The inclusion of the contemporaneous unemployment gap variable could, in principle, cause a degree of simultaneity bias. However, Saiger et. al. (1997) reported that, in practice, this bias

was not significant. The results presented here are qualitatively unchanged if the contemporaneous value of the variable is excluded.

The first column of Table 1 shows the results. Each cell in the table shows the sum of the coefficients, and in parentheses, the p value on a Wall test that the sum of the coefficients are equal to zero.[2] The estimated coefficients take on plausible values. The coefficients on the lagged inflation variables sum to unity as expected and the sum of the coefficients on the employment gap are significantly different from zero.

We can use these estimated coefficients to make out-of-sample forecasts of inflation.[3] If the estimated model is a correct representation of the true behavior of inflation, we would expect that any difference between the predicted and actual inflation rates would turn out to be random. The first panel of Figure 1 shows the actual and predicted inflation for the period 1994–97. It is clear that the Phillips curve has consistently overpredicted the rate of inflation. The last two rows of Table 1 show the mean and standard deviation of the forecast error. The mean forecast is greater than zero although only by two-thirds of a standard deviation. A formal Chow test of the forecast error cannot reject the hypothesis that the forecast error is zero. However, a Chow test focuses on the average size of the forecast errors and not on their sign. The phenomenon of positive shocks has been too pervasive to have been the result of random shocks or measurement error. If the observed forecast errors are truly random draws from a symmetric distribution, the probability that 10 of them are positive is 0.5^{10} which is less than 1 out 1,000. We must conclude, therefore, that the estimated model does not accurately account for the behavior of inflation and unemployment during the late 1990s.

III. Has the NAIRU Fallen?

The most obvious, potential explanation for recent inflation performance is that the NAIRU has fallen to less than the 6 percent that was assumed previously. This would explain why inflation is falling even as unemployment is much less than 6 percent.

Broadly speaking, two methods have been employed in the literature to estimate the NAIRU. One method, exemplified by Adams and Coe (1990), involves estimating a structural model of the economy, with the NAIRU being a function of one or more of the estimated parameters. The model includes variables that might be expected to influence the structure of the labor

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[2]If, for example, the p value is 0.04, the null hypothesis of zero effect cannot be rejected at the 1 percent significance level, but it can be rejected at the 5 percent significance level. Thus, the lower the p value, the lower the probability that the variable has no effect on inflation.

[3]The forecasts shown in this paper are static as opposed to dynamic forecast. In other words, when forecasting in to the future, the lagged actual values of the inflation variable are used rather than the values previously predicted by the model.

market, as well as the standard macro variables. In practice, there are three serious problems with this procedure. First, it is very difficult to account for all the changes in the structure of the labor market. Second, as the choice of variables and functional form are not clear a priori and as these models involve consideration of expectations (at least implicitly), they are highly vulnerable to the Lucas critique. Third, the models often make ad hoc assumptions regarding the time path of the NAIRU or equivalently potential GDP.

The alternative method is to estimate the NAIRU from within the Phillips curve itself. This is the method adopted by Gordon (1997) and Staiger, Stock, and Watson (1997). In a sense, this method reverses the logic of the Phillips curve. The econometrician finds that NAIRU is implied by the behavior of inflation and unemployment over a given time period (i.e., find the U^N that would solve equation (1)). The procedure can be repeated for a different period, and thus a time series for the NAIRU can be calculated. Of course, if that was all that was done, the exercise would be trivial and worthless. By definition, the estimated NAIRU would explain recent behavior and the problem discussed in the previous section could never be observed. Furthermore, one would doubt that changes in the NAIRU measured in this way would correspond to underlying changes in the structure of labor markets which is what most economists have in mind when they talk about a change in the NAIRU. In order to accommodate this criticism, the authors restrict the degree to which the estimated NAIRU can move from year to year.[4] Nevertheless, these models are fundamentally unidentified in the sense that the imposition of the restriction on the variability of the NAIRU is essentially arbitrary. It is also the case that these models not attempt to identify the causes of any change in the NAIRU.

For reasons of simplicity, we estimated a semi-structural model of the NAIRU. The model is semi-structural because observed unemployment is regressed on variables that may be assumed to affect it, but without attempting to identify behavioral relationships. In terminology of simultaneous equation models, the estimated equation is in reduced form. The model is structural in the sense that it does not follow the procedure of Gordon (1997) and Staiger, Stock, and Watson (1997) discussed above. The actual rate of unemployment was regressed on quadratic time trend, several structural and several cyclical variables. The structural variables included the dependency ratio, an index of minimum wages, and an index of unionization. The cyclical variables included a dummy variable reflecting the NBER's definition of recession, an index of coincident indicators, and a variable representing the deviation of capacity utilization from its trend. The model was estimated using the Cochrane-Orcutt method to correct for serial correlation in the residual. The results are shown in Table 2. Of the structural variables, only the index of unionization turned out to be significant, but all the cyclical variables are significant. Also note that the coefficient on the autoregressive residual is highly significant. This reflects the tendency of the natural rate not to stray too far

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[4]Gordon (1997) forces the NAIRU to follow a stochastic trend with a restriction on the variance of its first difference. Staiger, Stock, and Watson (1997) force it to follow a cubic spline.

from its previous value. As was noted earlier, Gordon (1997) and Staiger et. al. (1997) achieved this by restricting the NAIRU to follow a stochastic or deterministic trend.

An estimate of the NAIRU can be calculated by setting the cyclical variables equal to zero and simulating the estimated equation. The estimated NAIRU and the two standard deviation error bands are shown in the second panel of Figure 2. Figure 2 also shows the actual level of unemployment and a Holdrick-Prescott filtered unemployment series. The Holdrick-Prescott filter is equivalent to regressing actual unemployment on a series of time trends and then taking the fitted value. The idea is that short-run changes are "filtered" out, and what we are left with is the long-run trend rate of unemployment. This can be thought of as an alternative measure of the NAIRU.

As can be seen from the second panel of Figure 2, the point estimate of the NAIRU has fallen from 6.1 percent in 1994:1 to 5.3 percent in 1997:4. However, the two standard error bands around the point estimate is approximately 1.3 percent. This implies that a 95 percent confidence interval would place the NAIRU anywhere between just over 4 and just under 7 percent during 1997. For example, the point estimate for the third quarter of 1997 was 5.3 percent with a standard error of 0.65 percent. This gives 95 percent confidence interval for the NAIRU of 4.1 percent to 6.6 percent of the labor force. These point and interval estimates are similar to those found in Staiger, Stock, and Watson (1997) and also to those in Gordon (1997). The lack of precision, while disappointing, is typical of estimates of the NAIRU in general. It explains why there is so much uncertainty regarding the level of the NAIRU. Standard statistical tests have almost no power to distinguish between the hypothesis that the NAIRU is 6 percent versus the alternative hypothesis that it is 4 percent. Yet whether the NAIRU is truly 4 percent or 6 percent is of great interest to policymakers.

The point estimate of the NAIRU can be used to recalculate the unemployment gap and then reestimate the Phillips curve. The results are shown in the second column of Table 1. As before, these estimated coefficients can be used to make out-of-sample forecasts of inflation. It is clear that the Phillips curve still consistently overpredicted the level of inflation, but by less that the previous model. The average forecast error is greater than zero, but smaller than for the previous model. This can be seen from the second panel of Figure 1 which shows the actual and predicted inflation for the period 1994–97. As before, it is not so much the size of the forecast errors that gives cause for concern, as the fact that they are systematically positive.[5]

In summary, although the measured NAIRU has fallen since 1994, it has not fallen sufficiently far in order to explain inflation. The NAIRU has still been above actual unemployment in every quarter since 1994:1. This should have caused a sustained acceleration in inflation.

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[5]The results are almost the same if the Holdrick-Prescott measure of the NAIRU is used instead.

Instead inflation was stable or falling over the entire period. Hence, the Phillips curve with the new measure of the NAIRU still overpredicts inflation

IV. Have Costs Fallen?

If changes in the NAIRU do not explain the recent behavior, what does? As mentioned previously, the alternative is that the United States has been fortunate enough to have been on the receiving end of a series of beneficial supply shocks that have helped keep inflation under control. For example, suppose oil prices were to fall unexpectedly. This would reduce the cost of energy to U.S. firms which would enable them to keep their prices relatively low, even if unemployment were so low (i.e., below the NAIRU) that wage costs were rising. If the change in the cost of energy is transitory, then the NAIRU itself would be unaffected. Thus, we would observe inflation falling even as unemployment is below the NAIRU.

In order to account for this possibility, variables representing the potential supply shocks must be included in the Phillips curve. Strictly speaking, a shock should be measured as the difference between the actual value of the variable and value that was anticipated when agents made the economic decisions that determined the NAIRU. In general, reliable data on expectations are not available, so the shocks are approximated by the rate of change of a variable.[6]

The third column of Table 1 shows the results from a Phillips curve regression including supply shock variables. These shock variables measure changes in the real price of oil, changes in the dollar price of imported goods, and changes in the real unit cost of labor. The changes in the price of imports will pick up the effect of a change in the value of the U.S. dollar, as well as changes in foreign currency prices of U.S. imports. The real unit cost of labor will include changes in wages, benefits, and also temporary changes to productivity.

All of the point estimates have the expected sign. For example, a fall in the price of oil of 25 percent would lead to a fall in the inflation rate of one quarter of a percentage point. The p values indicate that the hypothesis that the variable has no impact on inflation cannot not be rejected at conventional significance levels, in the case of all the variables. In the case of the oil price and the import prices, this insignificance is borderline, but in the case of the unit labor cost, the insignificance is overwhelming.

There is some double counting because the price of oil is included in the price of imports and this may lead to multicolinearity. The fourth column of Table 1 shows the results of estimation of the Phillips curve with the oil price variable dropped. As a result, the import price variable becomes highly significant as expected, but unit labor cost variable remains insignificant. These results are similar to those reported by Gordon (1997). He found that import prices had

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[6]This would be exactly right if the variable followed a random walk.

a significant effect on core inflation, but that the deviation of productivity from its trend (which is reflected here in the real unit labor cost variable) did not.

As a forecasting tool, this model performs much better than does the model without supply shocks. The average error of the forecast is close to zero, indicating that this model does not systematically overpredict inflation. This can also be seen from the third panel of Figure 1, which shows actual inflation and the inflation rate predicted by the model in column 4 of Table 1, for the period 1994:1 to 1997:4. Note also that errors are not systematically positive.

Comparing with the first two panels of Figure 1, suggests that the recent U.S. inflation performance has been due to falling import prices and not to fundamental structural change in the economy. Further evidence for this hypothesis can be found by looking at how the price of imports has changed over the last eight years. Figure 3 shows both the level and the rate of change of the relative price of imports (defined as the implicit import price deflator divided by the GDP deflator). This ratio fell, more or less consistently up to 1994:1. It remained approximately constant until 1995:2, then it fell dramatically. This latter fall coincides with the period for which the traditional Phillips curve overpredicts inflation (see Figure 1). On reflection, therefore, it is not surprising that including import price changes in the Phillips curve enables the model to predict inflation more accurately.

It is also worth noting the relative unimportance of the real unit labor cost variable. Some authors[7] have suggested that the reason inflation was falling faster than appeared warranted by unemployment levels was that the structure of labor costs had changed, with productivity rising faster than normal and nonwage labor costs (such as benefits) being cut back. The results shown here suggest that this was not a critical factor in explaining the recent history of U.S. inflation.

V. Conclusions

This paper set out to explain the recent history of U.S. inflation, in particular how inflation could be falling even as unemployment appears to be below the natural rate. Two potential explanations were considered. Firstly, the natural rate of unemployment could have fallen. Secondly, the U.S. could have experienced some temporary disinflationary shocks.

The results presented here suggest that the NAIRU may have fallen slightly, but that this, on its own, is not enough to explain the recent history of inflation. The main explanation for recent inflation in the United States appears to be that there have been unexpected declines in some cost variables. In particular, the cost of imports has fallen in recent years due to the appreciation of the dollar, a decline in commodity prices, and the Asian crisis.

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[7]See, for example, Lown and Rich (1997)

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Table 1. Estimates of the Phillips Curve

(1961 Q1–1993 Q4)

Model	(1) Basic Model	(2) Natural Rate Model	(3) Supply Shocks Model I	(4) Supply Shocks Model II
Lagged inflation	1.016 (0.000)	1.006 (0.000)	0.997 (0.000)	1.002 (0.000)
Unemployment gap	-0.246 (0.007)	-0.361 (0.004)	-0.289 (0.018)	-0.255 (0.033)
Change in real unit labor cost	-	-	0.085 (0.37)	0.079 (0.398)
Change in relative price of imports	-	-	0.045 (0.121)	0.072 (0.001)
Change in the relative price of oil	-	-	0.01 (0.156)	-
Adjusted R^{2} 2/	0.755	0.754	0.804	0.803
Mean forecast error (Standard deviation)	0.38 (0.58)	0.27 (0.52)	0.09 (0.58)	0.002 (0.64)

1/ The table shows the sum of coefficients on four lags of the variables. The statistic in parentheses is the p value from a Wald test of the hypothesis that sum of coefficients on the variable is zero. The lower the p value, the lower the probability that the variable has no effect on inflation. If, for example, the p value is 0.04, the null hypothesis of zero effect cannot be rejected at the 1 percent significance level, but it can be rejected at the 5 percent significance level.

2/ Rate of change variables are scaled to measure annualized percentage rate of change.

Table 2. NAIRU Equation

(1961 Q2–1997 Q3)

Variable	Coefficient	T-Statistic
Constant	2.6	0.27
Trend	0.13	1.10
$Trend^2/1000$	-.69	-1.49
Dependency ratio	10.42	0.99
Minimum wage	-0.09	-0.56
Unionization	-25.66	-2.28
Change in co-incident indicators	5.42	1.84
Capacity utilization	-0.23	-14.86
Recession	-0.03	-0.88
Autoregressive error term	0.95	35.59
Adjusted R^2	0.98	

Table 3. Definitions of Variables 1/

Variable	Definition
Capacity utilization	Capacity utilization of all industry.
Coincident indicators	A composite index of coincident indicators.
Dependency ratio	Population less than 15 years of age , plus the population greater than 65 years of age, all divided by the labor force.
Import prices	Implicit import price deflator from the national accounts, divided by the GDP deflator.
Inflation	Rate of change of CPI for urban consumers excluding the cost of food and energy.
Minimum wage	Minimum wage (dollars per hour) deflated by the CPI for urban consumers.
Unemployment	Civilian unemployment rate.
Unionization	Union membership as a percentage of the civilian labor force.
Recession	Indicator of recession as defined by the National Bureau of Economic Research (NBER).
Real unit labor costs	The unit labor cost of the nonfarm business sector divided by the GDP deflator.

1/ All rates of change are expressed as annual percentage rate of change.

CHART 1

UNITED STATES

ACTUAL AND PREDICTED CORE CPI INFLATION

(In percent)

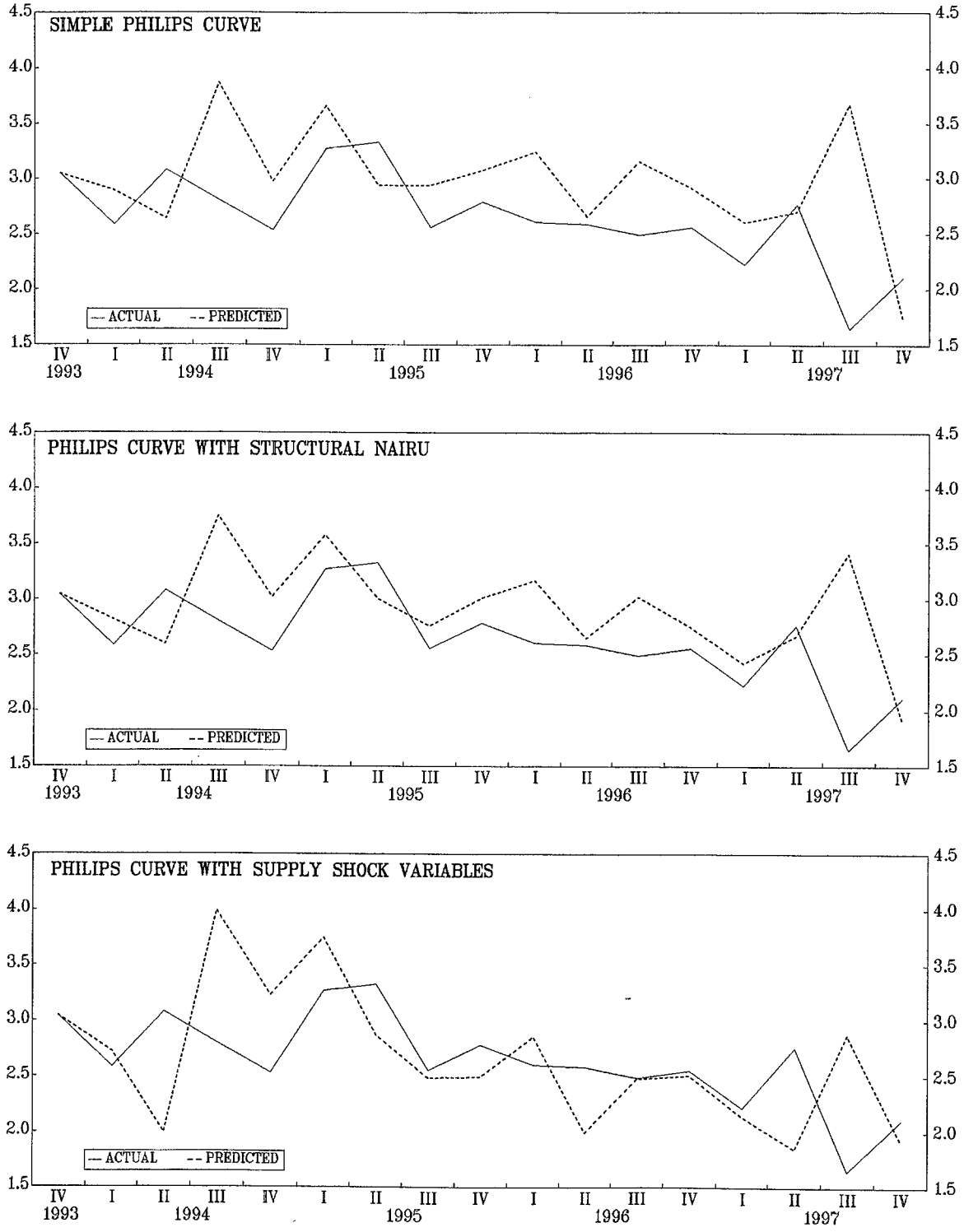


CHART 2

UNITED STATES

ACTUAL UNEMPLOYMENT RATE AND THE NAIRU

(In percent)

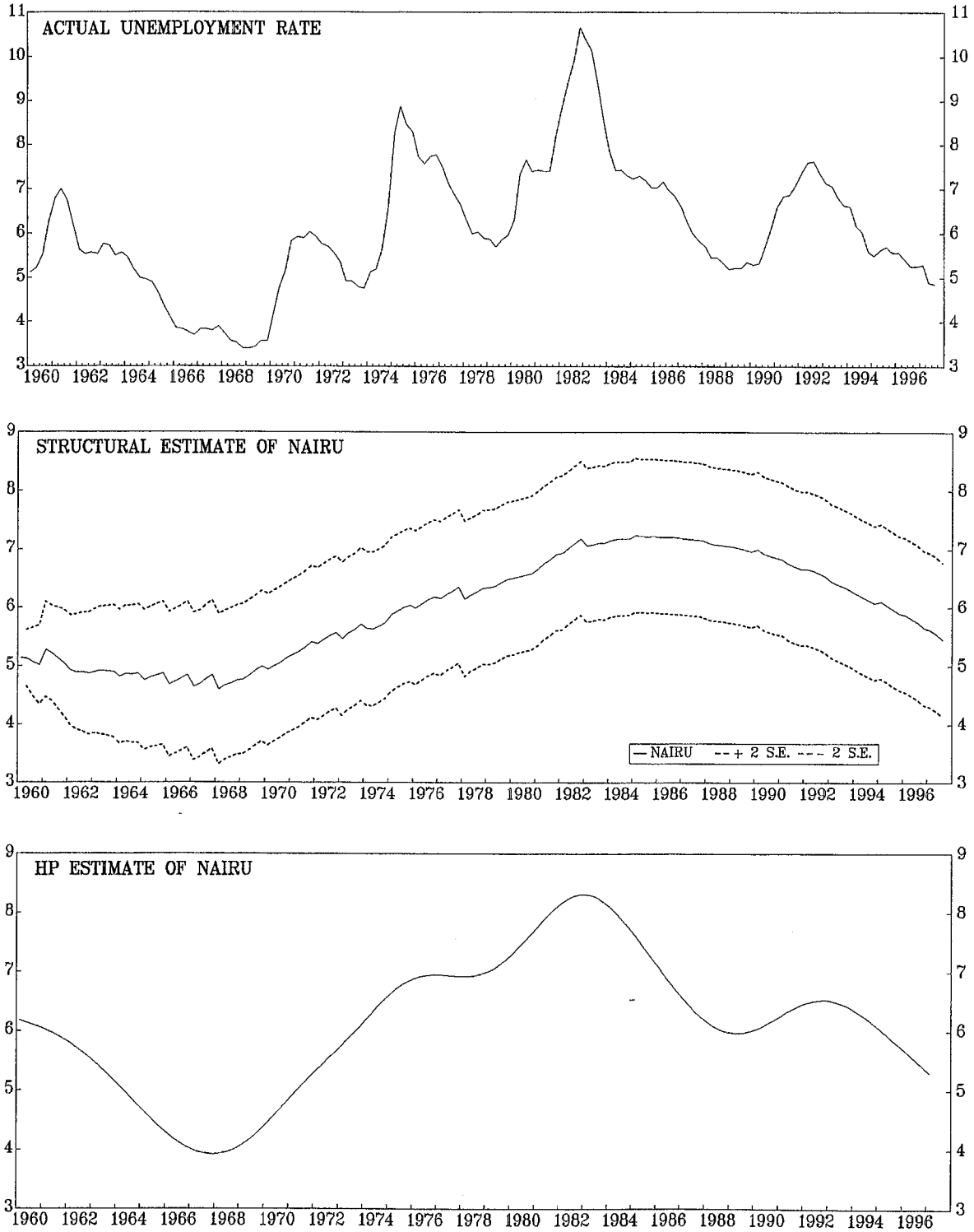
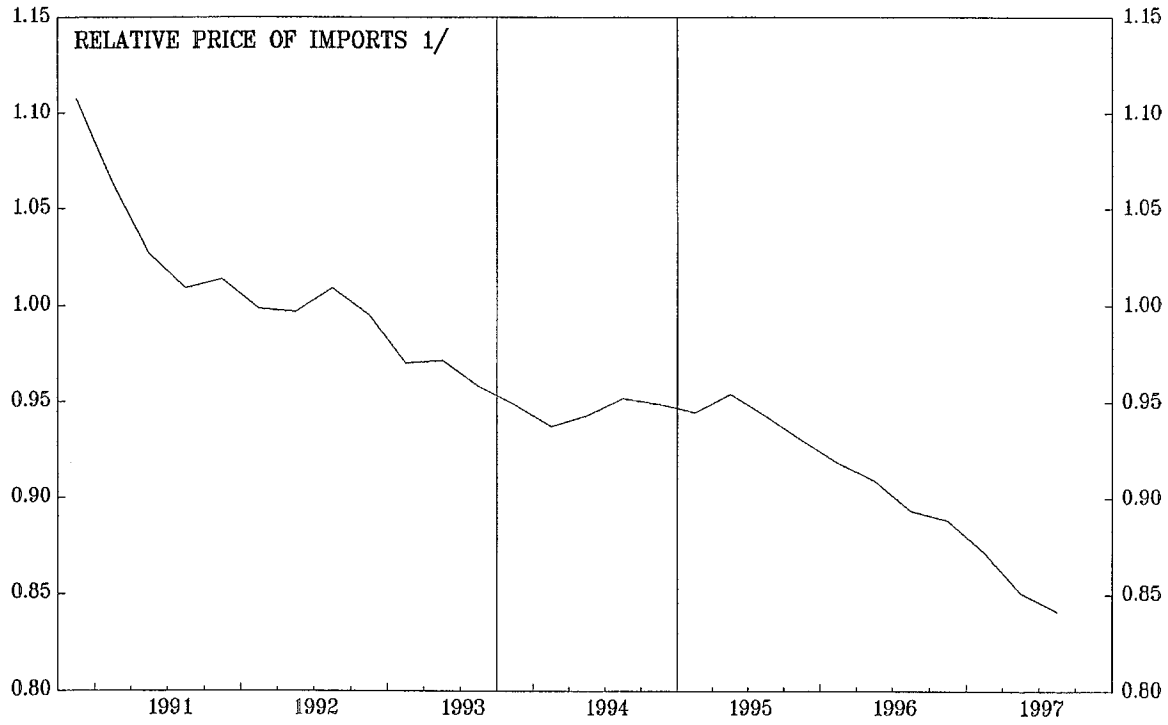


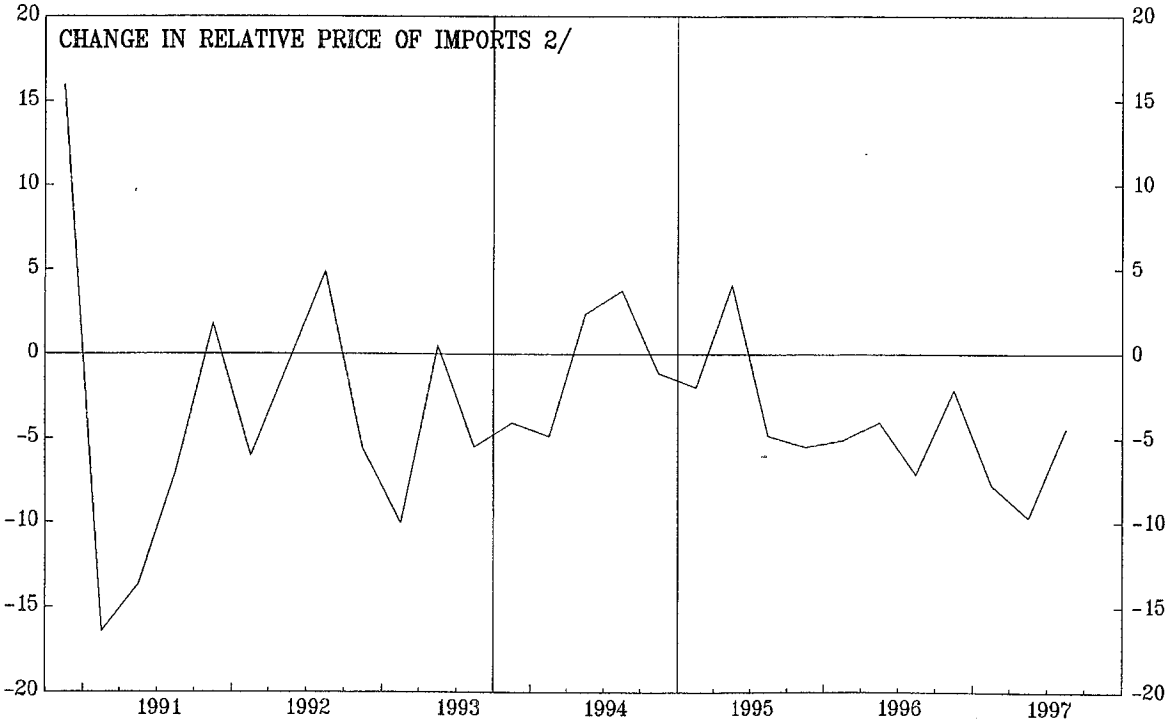
CHART 3

UNITED STATES

THE RELATIVE PRICE OF IMPORTS

(In percent)





1/ Import price deflator divided by GDP deflator.
2/ Annualized percent change.