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Unemployment-Rate Dynamics: Aggregate-Demand and -Supply Interactions

John P. Judd and Bharat Trehan

Vice President and Associate Director of Research, and Senior Economist, Federal Reserve Bank of San Francisco.

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The implications for monetary policy of movements in the unemployment rate depend upon the nature of the underlying disturbances that caused those movements. Positive aggregate-demand shocks cause the unemployment rate to fall as inflationary pressures build, whereas positive aggregate-supply shocks are likely to lead to a fall in both the unemployment rate and inflation. In this paper, we employ a recently developed modeling technique to disentangle the effects of aggregate-demand and -supply shocks on the unemployment rate. The technique is agnostic about alternative macroeconomic theories, deriving identifying restrictions from relatively uncontroversial long-run, or steady state, relationships.

The unemployment rate often plays an important role in monetary-policy deliberations, not only because policy makers are concerned about unemployment itself, but also because it is viewed as an important indicator of future inflation. For example, when the unemployment rate declined rapidly to a relatively low level in recent years, a number of Federal Reserve officials became concerned that the economy was developing dangerous inflationary pressures.[1]

One problem in evaluating the policy implications of movements in the unemployment rate (as well as those of other macroeconomic variables) is that these implications often depend on one's *assumptions* about the structure of the economy. Currently there is little agreement among economists concerning the appropriate paradigm; the Keynesian (both the traditional and "new" versions), real-business-cycle, and monetary-misperceptions paradigms all have significant followings among different groups of macroeconomists.[2]

These paradigms differ in the emphasis they place on aggregate-demand versus aggregate-supply shocks in influencing economic activity and labor-market conditions. Real-business-cycle models ascribe a larger role to aggregate-supply shocks, whereas Keynesian and monetary-misperceptions models place greater weight on aggregate-demand shocks. This distinction between demand and supply factors is important because the appropriate monetary-policy response (or lack thereof) to unemployment rate movements depends on the nature of the underlying disturbance. Positive aggregate-demand shocks cause the unemployment rate to fall as inflationary pressures build, and such developments could make a tightening of monetary policy appropriate. By contrast, positive aggregate-supply shocks are likely to lead to a fall in both the unemployment rate and the rate of inflation. Under these circumstances, a tighter monetary policy most likely would be inappropriate.

In this paper, we employ a recently developed modeling technique to disentangle the effects of aggregate-demand and -supply shocks on the unemployment rate (as well as on other important macroeconomic variables.) The technique is agnostic about alternative theories, deriving identifying restrictions from relatively uncontroversial assumptions about long-run, or steady-state, relationships. Given the current lack of agreement about macroeconomic theory, such models have the advantage that they eschew over-identifying restrictions, and choose not to go beyond the minimum number of restrictions necessary to achieve identification.

Our empirical results suggest that for very short horizons of a few quarters, shocks to aggregate demand account for nearly all of the variance of unemployment rate forecast errors. However, at longer horizons of twelve quarters and more, aggregate-supply shocks play a significant role. Moreover, we find that movements in the unemployment rate that are caused by supply shocks (as defined by our model) are *positively* correlated with inflation, whereas those associated with demand shocks are *negatively* correlated with inflation. Thus, decomposing the sources of unemployment rate movements into demand versus supply shocks can be important in designing effective monetary policy.

The paper is organized as follows. Section I reviews the relevant literature on macroeconomic modeling and discusses the rationale for the approach taken in this paper. Section II sets out the theoretical specification of the model. In Section III, we discuss econometric issues that arise in estimating the model and the results of this estimation, as well as their implications for the sources of variation in important macroeconomic variables, including the unemployment rate. Also in this section we analyze the historical evolution of the unemployment rate and the relationship between inflation and the aggregate-demand and -supply components of the unemployment rate. Policy implications and conclusions are discussed in Section IV.

I. Methodological Considerations and Literature Review

Adherents of the main alternative macroeconomic theories—Keynesian, real-business-cycle, and monetary misperceptions—have very different views about the structure of the economy. A major source of controversy concerns the relative importance of demand and supply shocks. The Keynesian and monetary-misperceptions theories stress the role played by aggregate-demand shocks in inducing short-run movements around long-run trends which are independent of those shocks. In contrast, real-business-cycle theories emphasize the role played by technology and labor-supply shocks in producing short-run fluctuations in output around changing equilibrium values which are themselves determined by factors traditionally emphasized in neo-classical growth models.

These alternative macroeconomic theories have different implications for how monetary policy should be conducted. For example, since Keynesians believe that unemployment rate movements mainly are induced by aggregate-demand factors, inflation will rise (fall) when the measured unemployment rate goes below (above) its natural rate. Assuming the monetary authority knows the natural rate of unemployment, Keynesians suggest that the observed rate of unemployment relative to its natural rate can be a major source of information in setting policies to control inflation.

In contrast, real-business-cycle theorists believe that aggregate-supply shocks are the predominant sources of change in macroeconomic variables. Under these circumstances, policy mistakes would be made if the central bank interpreted the unemployment rate as an indicator of aggregate-demand pressures. Further, existing real-business-cycle models generally have modeled business cycles as Pareto-optimal responses to exogenous shocks. Thus, in these models, there is no role for any type of macroeconomic policy aimed at stabilizing the economy.

Macroeconomists have not been able to agree on which theory (or combination of theories) most accurately describes the economy. Each theory implies a different set of identifying restrictions. Thus, a certain degree of agnosticism is warranted in selecting identifying restrictions. This agnostic approach increasingly has shown up in macroeconomic research in recent years. The use of vector autoregressions appears to reflect this view. No identifying restrictions are needed to obtain macroeconomic forecasts. Of course, if these forecasts are to be interpreted in terms of economic theory, identifying restrictions must be added. In early applications, these took the form of assuming a specific recursive structure for the contemporaneous correlations in the data.[3,4]

The Blanchard-Quah Model

Recently, Blanchard and Quah (1989) specified a small vector autoregression of the macroeconomy that achieves identification by imposing relatively uncontroversial constraints on steady-state conditions, thereby avoiding the restrictions associated with alternative theories of the business cycle. Moreover, their model is *exactly* identified, and thus avoids over-identifying restrictions that may raise theoretical controversy. Blanchard and Quah (BQ) assume that supply shocks (those emphasized in real business cycle models) can have permanent effects on the level of real activity, while demand shocks (those emphasized by the Keynesian and monetary-misperceptions models) can have only temporary effects. These assumptions are consistent with each of the three main macro paradigms. Importantly, they are sufficient to identify certain types of VARs incorporating important macroeconomic time series.

Since the BQ approach is used in this paper, albeit on a larger model, it is useful to see how their method works. (A detailed discussion of their method of identification is provided in Appendix A.) BQ specify a VAR with two variables: the rate of growth of real GNP (y), and the level of the unemployment rate (u). Two types of (unobserved) structural disturbances, v and e, are assumed to affect these variables. (As discussed below, we follow BQ in identifying these disturbances with aggregate-demand and aggregate-supply disturbances.) Equations (1) and (2) are moving average representations of y and u in terms of these two disturbances. For simplicity here, we introduce dynamics into the BQ model by including only one lag of v in each equation, although the full BQ model contains several lags.

$$y_t = a_1 e_t + b_1 v_t + c_1 v_{t-1} \quad (1)$$

$$u_t = a_2 e_t + b_2 v_t + c_2 v_{t-1} \quad (2)$$

In order to study the dynamics of this system, it is first necessary to obtain estimates of the various coefficients in equations (1) and (2). This requires placing certain restrictions on e and v. In traditional fashion, BQ assume that e and v are uncorrelated with each other and have unit variance. In addition, e and v are also serially uncorrelated. Given the representations in (1) and (2), these assumptions imply the following identifying restrictions:

$$\sigma_y^2 = a_1^2 + b_1^2 + c_1^2 \quad (3a)$$

$$\sigma_u^2 = a_2^2 + b_2^2 + c_2^2 \quad (3b)$$

$$\sigma_{y_t,\, u_t} = a_1 a_2 + b_1 b_2 + c_1 c_2 \quad (3c)$$

$$\sigma_{y_t,\, u_{t-1}} = c_1 b_2 \quad (3d)$$

$$\sigma_{y_{t-1},\, u_t} = b_1 c_2 \quad (3e)$$

where σ_y^2 is the (observed) variance of y, σ_u^2 is the variance of u, $\sigma_{y_t,\, u_t}$ is the contemporaneous covariance of u and y, and the other variances are defined similarly.

So far, there are five conditions from which we must obtain six coefficients. One more restriction is needed to identify the model. The traditional approach has been to impose a recursive structure on the contemporaneous correlations in the data (Sims [1980]). For example, one might assume that the coefficient $a_1 = 0$; that is, shocks to the unemployment rate do not have a contemporaneous effect on the rate of growth of output. Such an assumption, however, would be theoretically controversial.

BQ avoid having to assume contemporaneous causal orderings by relying on long-run, or steady-state, restrictions. Specifically, they assume that v has no long-run effect on output; that is,

$$b_1 + c_1 = 0. \quad (3f)$$

This restriction, together with the conventional restrictions on variances and covariances, is sufficient to identify the unobserved shocks from observations on y and u. The restriction also leads to a straightforward interpretation of the underlying structural disturbances: v can be interpreted as an aggregate-demand shock since it can have no long-run effect on y, while e can be interpreted as a supply shock since it is permitted permanently to affect y. In other words, the permanent level of real GNP is determined by real factors. Although aggregate-demand shocks can cause real GNP to deviate from this level, it cannot affect the permanent level itself. By construction, neither demand nor supply shocks have a permanent impact on the unemployment rate.

Using this method, BQ found that demand disturbances had a hump-shaped effect on the time path of output, while supply shocks had an effect that increased gradually over time. They also found that demand disturbances accounted for only 35% of the variance of unpredictable changes in real output in the contemporaneous quarter, leaving 65% for supply disturbances, while demand accounted for 13% at a horizon of eight quarters.[5] In contrast, demand disturbances accounted for 100% of the variance of unpredicted changes in the unemployment rate in the current quarter, and for 50% at an horizon of eight quarters.

The Shapiro-Watson Model

One problem with BQ's analysis is that it allows for only two underlying disturbances to the economy. If, as seems plausible, the economy is affected by more than one kind of supply (or demand) shock, their procedure will tend to confound the effects of these different shocks. Based on this reasoning, Shapiro and Watson (1988) used a system that comprised real GNP, total labor hours, inflation and the real interest rate.[6] This set of variables allowed them to account for four different disturbances: two to aggregate supply, which they identified as shocks to labor supply and technology, and two to aggregate demand, which they referred to as IS and LM shocks, but did not identify separately.

Shapiro and Watson (SW) found that aggregate-demand shocks had a smaller impact on real output than BQ did.[7]

Specifically, aggregate-demand shocks accounted for just 28% of the variance of the output forecast error in the contemporaneous quarter, and 20% at an eight-quarter horizon. In addition, they found that labor supply shocks alone accounted for about 45% of the variance of unpredicted changes in output in the contemporaneous quarter. These findings, as well as those of BQ, sharply contradict the Keynesian and monetary-misperceptions views that trend and cycle are neatly separable, with demand shocks playing the dominant role over the business cycle.

II. Model Specification and Identification

In this section, we present the specification of the model estimated in this paper. We begin with a discussion of the variables included in the model, followed by a discussion of the equations that constitute the model, and how we achieve identification.

The model includes five variables: the unemployment rate, real GNP, a nominal rate of interest, a measure of labor supply, and a variable that measures foreign trade. These variables provide broad coverage of important types of activity in the economy, and thus should capture the economic relationships that are important in determining the behavior of the unemployment rate. Movements in the unemployment rate and the interest rate are likely to be highly correlated with two types of underlying aggregate-demand shocks, which can be thought of as being associated with the IS and LM curves of textbook macroeconomic theory. The interest rate should capture shocks both to inflation expectations and real interest rates, while the unemployment rate should reflect aggregate-demand shocks as they affect the level of economic activity. Following previous research, we assume that movements in real GNP are correlated with technology shocks, once we standardize for aggregate-demand shocks.[8]

We use working-age population as our measure of labor supply. This variable is clearly exogenous, and therefore guards against the possibility of confounding labor demand and supply. However, it has the disadvantage of omitting the effects on labor supply of changes in participation rates and average hours worked. One obvious alternative would be to follow SW and use total labor hours as the labor-supply variable. However, our empirical evidence suggests that using labor hours to measure supply causes a serious bias; we are unable completely to separate the demand-induced changes in labor hours from those induced by labor supply. Specifically, when we include labor hours in our model, we find that a positive labor-supply shock leads to a large, sustained *decline* in the unemployment rate, an outcome that suggests a confusion between labor supply and demand. Such confusion could have a profound effect on conclusions concerning the relative importance of supply and demand disturbances in macroeconomic time series. By contrast, as discussed below, the results obtained when population is used as a measure of labor supply are much more plausible. Thus, given this paper's policy-driven focus on the unemployment rate, we have opted for working-age population.

We also extend the BQ and SW models by explicitly incorporating a foreign variable to identify the effects of shocks originating abroad. Given the growing importance of international trade and capital flows to the U.S. economy, it is desirable to incorporate the independent effects of shocks from abroad. While inclusion of the exchange rate appears to be an obvious choice, the move from fixed- to floating-exchange rates in the early 1970s implies a change in the exchange-rate process that precludes sensible estimation results over our 1954–88 period. Instead, we include as a foreign variable the ratio of real exports to real imports.

The Underlying Model

We begin by assuming that the production technology can be described by a neo-classical growth model, so that the long-run level of output is determined by the capital stock and labor supply.[9] The capital stock term can be eliminated by assuming a Cobb-Douglas production function and a constant steady-state capital-output ratio. Thus, the steady-state level of output can be expressed as a function of the steady-state levels of labor supply and technology.

The levels of labor supply and technology may be permanently affected by labor-supply and technology shocks, respectively. The evolution of these variables is described by

$$s_t^* = \alpha^s + s_{t-1}^* + \beta^s(L)\,\mu_t^s \tag{4}$$

$$e_t^* = \alpha^e + e_{t-1}^* + \beta^e(L)\,\mu_t^e \tag{5}$$

where s^* is the log of the steady-state value of labor supply and e^* represents (unobserved) technology. The labor supply and technology shocks, μ^s and μ^e, are uncorrelated, and the lag polynomials $\beta^s(L)$ and $\beta^e(L)$ describe the transitory movements in s^* and e^* as they move to new permanent levels.

Labor supply is not affected, either in the short or long run, by any of the other variables in the system. This assumption follows from our choice of working-age population to represent the influences of labor supply, and yields four of the ten restrictions we need to identify the model.[10]

Both labor-supply and technology shocks can cause short-run movements in output as the level of output adjusts to a new steady-state value. Short-run movements in output also can be the result of aggregate-demand shocks. However, the two types of aggregate-demand shocks are permitted to have only temporary effects on the level of output. These assumptions yield two more identifying restrictions. Foreign shocks cause output to deviate temporarily from its steady-state value, but are not permitted to have a long-run effect on output.[11] This assumption yields one more identifying restriction.

These considerations suggest the following equations for the relationship between observed and equilibrium values:

$$s_t = s_t^* + \chi^s(L)(\mu_t^s) \quad (6)$$

$$y_t = y_t^* + \chi^y(L)(\mu_t^s, \mu_t^e, \mu_t^f, \mu_t^{d_1}, \mu_t^{d_2}) \quad (7)$$

where $\chi^s(L)$ and $\chi^y(L)$ are vectors of lag polynomials (in the indicated variables) that allow for temporary deviations from steady-state levels. Thus, this specification allows the actual level of output to deviate from the level implied by the Cobb-Douglas production function in the short run. As discussed above, y^* itself is a function of s^* and e^*. μ_t^f denotes shocks originating abroad, while $\mu_t^{d_1}$ and $\mu_t^{d_2}$ are the domestic demand shocks.

Statistical tests suggest that output and labor supply are both nonstationary, and thus we take first differences of equations (6) and (7) (see Appendix B). Substituting equations (4) and (5) into the results yields:

$$s_t - s_{t-1} = \alpha^s + \beta^s(L)(\mu_t^s) + (1-L)\chi^s(L)(\mu_t^s) \quad (8)$$

$$y_t - y_{t-1} = \alpha^y + \beta^y(L)(\mu_t^s, \mu_t^e) + (1-L)\chi^y(L)(\mu_t^s, \mu_t^e, \mu_t^f, \mu_t^{d_1}, \mu_t^{d_2}) \quad (9)$$

Consider now the specification of the foreign variable. In addition to disturbances originating abroad, this variable is affected by all the domestic shocks. However, the two aggregate-demand shocks are permitted to affect the foreign variable only temporarily.[12] These assumptions yield two more identifying restrictions. We assume that the long-run evolution of the foreign variable can be described in the same way as output, so it is included in the model in a form similar to (8) and (9). Thus,

$$f_t - f_{t-1} = \alpha^f + \beta^f(L)(\mu_t^s, \mu_t^e, \mu_t^f) + (1-L)\chi^f(L)(\mu_t^s, \mu_t^e, \mu_t^f, \mu_t^{d_1}, \mu_t^{d_2}) \quad (10)$$

Given that the interest rate appears to be non-stationary (see Appendix B), we specify its equation in differenced form:

$$i_t - i_{t-1} = \chi^i(L)(\mu_t^s, \mu_t^e, \mu_t^f, \mu_t^{d_1}, \mu_t^{d_2}) \quad (11)$$

Thus, all the disturbances in the model can have a permanent effect on the nominal interest rate.

There is some ambiguity about how the unemployment rate should be included in the model. On the one hand, there is a large body of theoretical work in macroeconomics to suggest that the unemployment rate is stationary.[13] Tests carried out over long sample periods tend to confirm this.[14] On the other hand, as shown in Appendix B, unit root tests suggest that the unemployment rate is non-stationary over shorter sample periods.

This inability to reject nonstationarity in the unemployment rate over the post-war period poses a problem. Different researchers have dealt with this problem in different ways. BQ for instance, present results both for the case where the unemployment rate is assumed to be stationary and where it contains a deterministic trend. Unfortunately, removal of a linear trend is not sufficient to make the unemployment rate stationary. Evans (1989) allows for an increase in the mean of the unemployment rate beginning in 1974. As indicated in Appendix B, allowing for this shift in the mean appears to make the unemployment rate stationary.

Acceptance of this "solution" to the nonstationarity problem implicitly assumes the existence of some well-defined, exogenous change in the economy that is associated with a change in the mean unemployment rate. While some economists have pointed to the change in participation rates of women and teenagers in the labor force over this period, the issue is by no means resolved.[15] Accordingly, we estimated two alternative versions of the model, one that allows the mean unemployment rate to change in 1974, and one that holds it fixed over the entire 1954–88 period. The results in the two cases are similar, and so we present only those from the specification that allows for a mean shift. (However, we do point out instances below in which the results from the two specifications differ materially.)

Thus, the complete model comprises equations (8)–(11), plus

$$\mu_t = \alpha^u + \chi^u(L)(\mu_t^s, \mu_t^e, \mu_t^f, \mu_t^{d_1}, \mu_t^{d_2}) \quad (12)$$

where α^u is allowed to shift in 1974Q1. Thus, the unemployment rate is affected by all the disturbances in the model. However, because it is entered as a level, none of these disturbances has a permanent effect on it.

In summary, we have identified the model by restricting certain long-run coefficients to equal zero, and by using working-age population, which is strictly exogenous, for our labor-supply variable. As discussed in Appendix A, we require ten identifying restrictions to separate the influences of each of the five shocks—two domestic demand, two domestic supply, and one foreign—on all the variables in the system. The assumption that population is exogenous yields four identifying restrictions. Four additional restrictions come from the assumption that the two aggregate-demand shocks do not have long-run effects on output and the foreign variable. One more restriction comes from the specification that the foreign shock has no long-run effect on U.S. output. This gives us a total of nine restrictions. Following SW, we choose not to identify the two aggregate-demand shocks separately. In this way, we are able to eliminate the need for a potentially controversial tenth restriction.

III. Estimation and Empirical Results

In this section we describe the estimation technique and present our results. The impulse response functions and the variance decompositions presented below provide information about the structure of the economy as estimated by the model. We use this information to analyze the factors that have contributed to the changes in the unemployment rate that occurred over the period from 1955 to 1988. Finally, at the end of this section, we show correlations between our measures of the aggregate-demand and aggregate-supply components of the unemployment rate and the rate of inflation.

Our model includes the log of the unemployment rate and the first differences of the logs of all other variables. Because population is exogenous, we use ordinary least squares to estimate a regression of population growth on six of its own lags. (A lag-length of six is used in all the equations in the model.)

To illustrate the technique used to estimate the remaining equations, we use the real GNP equation.[16] Real GNP is regressed on lags of all the variables in the system plus contemporaneous values of population, the interest rate, the unemployment rate, and the foreign trade variable. We impose the restriction that neither the aggregate-demand shocks nor the foreign shocks has a permanent impact on the level of GNP by taking the difference of the relevant right-hand-side variables one more time and reducing the lag length by one. Thus the first difference of real GNP is regressed on first differences of population, the second differences of the foreign variable and interest rates, and the first difference of the unemployment rate (in addition to lags of first differences of real GNP). Two-stage least-squares is used to estimate the equation because it contains contemporaneous values of the three endogenous variables (that is, of interest rates, unemployment, and the foreign variable). The contemporaneous value of population and lagged values of all variables in the model are used as instruments.

The remaining equations are estimated in a similar manner. Following our discussion above, domestic aggregate-demand variables are restricted to have only a temporary impact on the foreign variable, while no such restriction is placed on the domestic supply variables. No restrictions are placed on the equations for the interest rate and the unemployment rate. As mentioned above, the inclusion of the level of the unemployment rate in the model implies that no shock to the system has a permanent impact on that rate.

The Estimated Structure of the Model

Exhibit IA shows the impulse response functions from the model. The first two columns of the exhibit show the response of the model's four endogenous variables to domestic shocks, while the third column shows the effects of shocks originating abroad. As discussed above, we identify labor-supply and technology shocks separately, but we do not disentangle the two underlying demand shocks. Thus, the impulse response functions in the second column of the exhibit represent responses to a linear combination of the demand shocks.

Positive aggregate-demand shocks reduce unemployment and raise output and interest rates. By construction, the effects on the unemployment rate and GNP are temporary. The effects of aggregate-demand shocks on the unemployment rate die out in about 12 quarters, while those on output last eight to 10 quarters. At first, the ratio of U.S. exports to imports reacts negatively to domestic demand shocks; that is, higher domestic demand leads to a rise in imports relative to exports. The impulse response function then cycles, becoming positive from five to twelve quarters, at which time the effect dampens out.

Positive shocks to technology reduce the unemployment rate. This effect lasts for about 24 quarters before substantially dying out.[17] Shocks to labor supply have insignificant effects on the unemployment rate, causing it to cycle around its original level. Positive shocks to labor supply

Exhibit IA
Impulse Response Functions

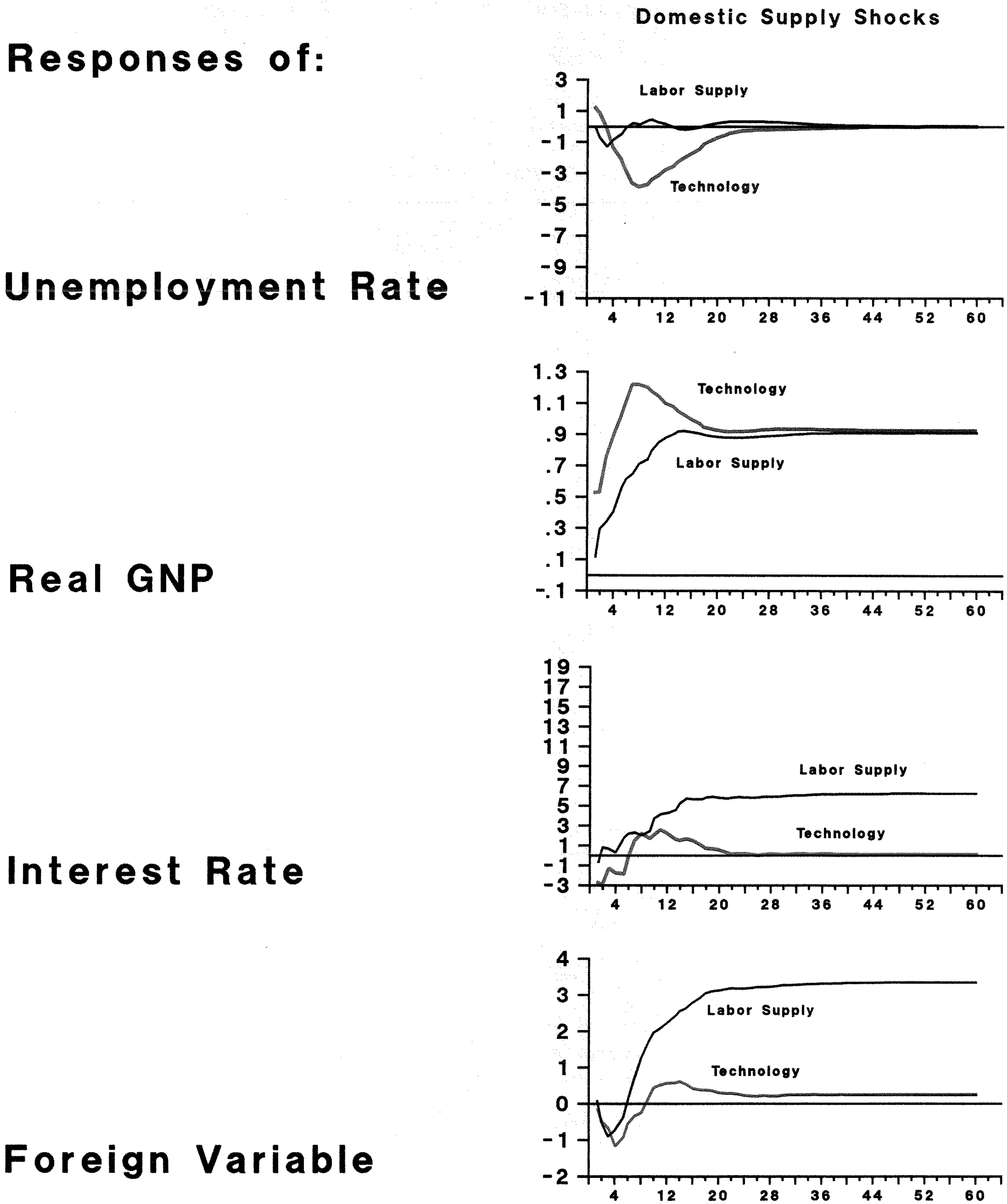
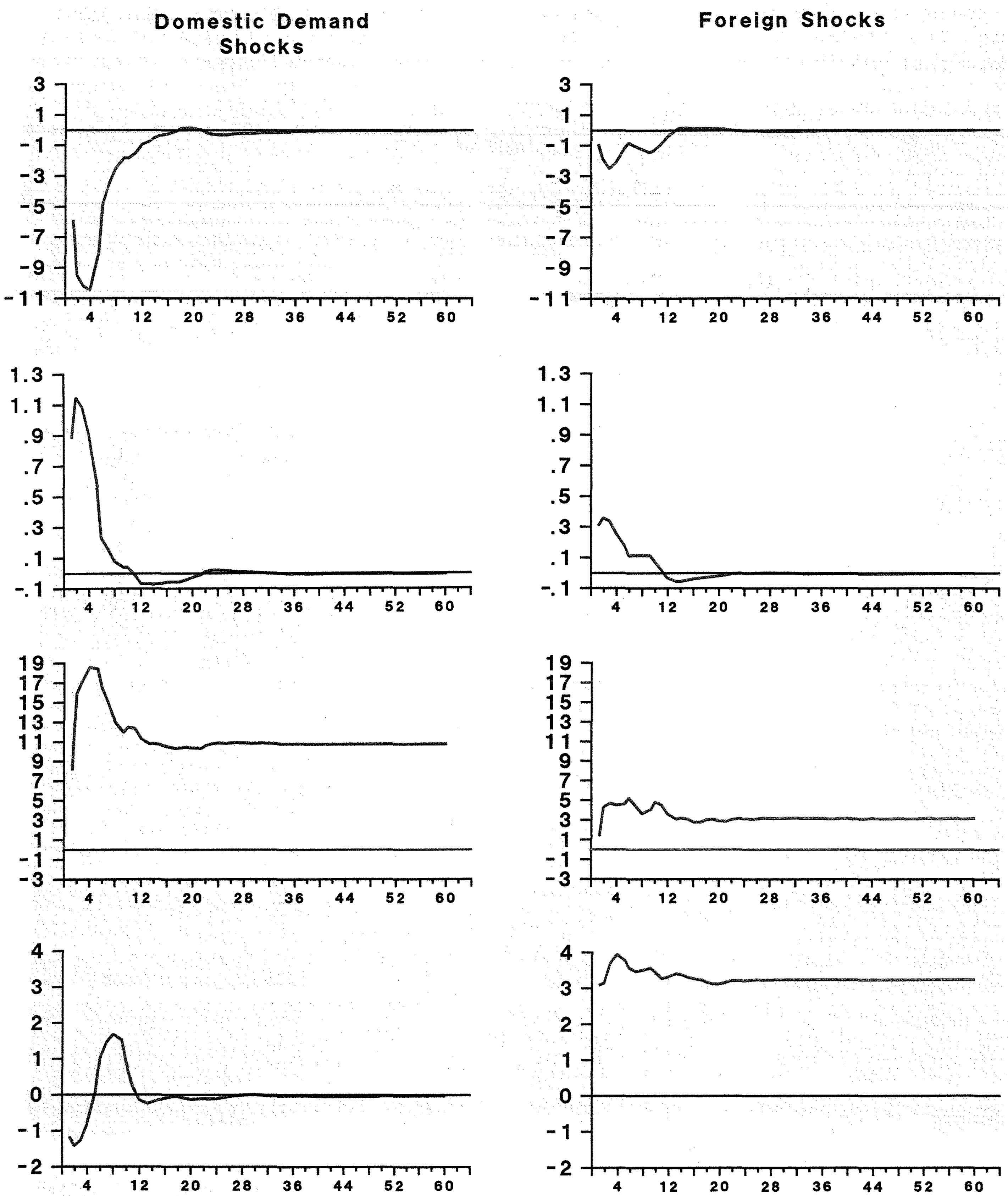


Exhibit IA (continued)



and technology permanently raise output, with the effect of labor-supply shocks building up somewhat more gradually than the effect of technology shocks. Positive shocks to these two variables also permanently raise the level of interest rates, and the ratio of exports to imports.

Positive foreign shocks temporarily raise output and lower the unemployment rate, although the latter effects are relatively small. These shocks also permanently raise the interest rate.

Exhibit IB presents the associated variance decompositions, which show the relative importance of the various kinds of shocks in explaining the errors made in predicting the model's variables. At forecast horizons of up to four quarters, variation in the unemployment rate has been dominated by aggregate-demand shocks. Aggregate-supply shocks begin to play a larger role as the forecast horizon lengthens, reaching 15 percent at eight quarters and 25 percent at 60 quarters. These results suggest that

Exhibit IB
Variance Decompositions

	Shocks				
	Labor Supply (A)	Technology (B)	Domestic Supply (A + B)	Domestic Demand	Foreign
Responses of:					
Unemployment Rate					
Quarters 0	0.0%	6.0%	6.0%	90.0%	3.9%
1	0.7	2.6	3.3	91.4	5.4
2	1.4	1.3	2.7	90.5	6.7
4	1.1	3.5	4.6	90.6	5.7
8	0.9	15.3	16.2	78.2	5.6
12	0.8	21.9	22.7	71.7	5.5
60	1.1	24.7	25.8	68.8	5.3
GNP					
Quarters 0	1.7%	34.7%	36.4%	50.9%	12.7%
1	5.1	28.0	33.1	55.3	11.6
2	6.3	32.7	39.0	50.9	10.1
4	10.7	45.3	56.0	37.1	6.9
8	17.9	60.8	78.7	17.6	3.6
12	24.7	61.7	86.4	11.3	2.3
60	43.0	54.0	97.0	2.5	0.5
Interest Rate					
Quarters 0	0.5%	8.5%	9.0%	87.5%	3.4%
1	0.4	5.4	5.8	85.8	8.3
2	0.3	3.5	3.8	85.8	10.2
4	0.6	2.5	3.1	86.2	10.6
8	1.7	2.3	4.0	84.9	12.0
12	4.9	2.7	7.6	79.9	12.4
60	22.1	0.8	22.9	67.9	9.1
Foreign					
Quarters 0	0.0%	0.1%	0.1%	7.9%	91.9%
1	1.1	1.0	2.1	9.9	88.0
2	2.7	1.7	4.4	8.2	87.4
4	2.4	3.6	6.0	5.2	88.6
8	5.1	2.3	7.4	6.1	86.3
12	12.8	2.2	15.0	4.5	80.5
60	43.2	0.8	44.0	0.7	55.3

unemployment has been substantially affected both by aggregate-demand and -supply shocks during the post-war period.

Aggregate-demand shocks are the most important factor in explaining variation in real GNP in the short run (contemporaneously and at forecast horizons of one and two quarters), accounting for 50 to 55 percent of the variation. Technology shocks also are quite important at these short lags, accounting for from 28 to 35 percent. As the forecast horizon lengthens, technology shocks begin to dominate, as these shocks are permanent, while aggregate-demand shocks are transitory. By the time the lags reach two years, technology shocks dominate demand shocks, with the former factor accounting for 61 percent of the variation and the latter accounting for only 18 percent. Labor-supply shocks begin to become important only after two years. At the frequency of the average business cycle, our results show a larger role for demand shocks relative to supply shocks than does earlier research.

Interest rate variation is dominated at all forecast horizons by domestic demand shocks, although foreign shocks have a noticeable effect in the long run. Domestic supply shocks play only a small role, except at the very long lags. At a lag of 60 quarters, labor supply accounts for 22 percent of the variation in the interest rate, while at shorter lags, the role of this variable is quite small (under five percent).

The foreign variable largely is exogenous with respect to the other four variables in the model—that is, it is determined mainly by its own past behavior—at forecast horizons of up to 12 quarters. At long lags, however, labor supply plays a significant role in the error variance of the foreign variable, reaching 43 percent at 60 quarters. Technology and domestic aggregate demand play only small roles at all forecast horizons.

The effects of the foreign variable on the U.S. economy are relatively modest, as would be expected from the relatively small, albeit growing, role of foreign trade in the U.S. economy. Foreign shocks play a significant role in U.S. real GNP at short lags, accounting for 13 percent of the contemporaneous variation and then declining in importance as the lag lengthens. Foreign shocks also have played a significant role in U.S. interest rate movements, accounting for 10 to 12 percent of the variation in that variable at forecast horizons in the range of two to 12 quarters.

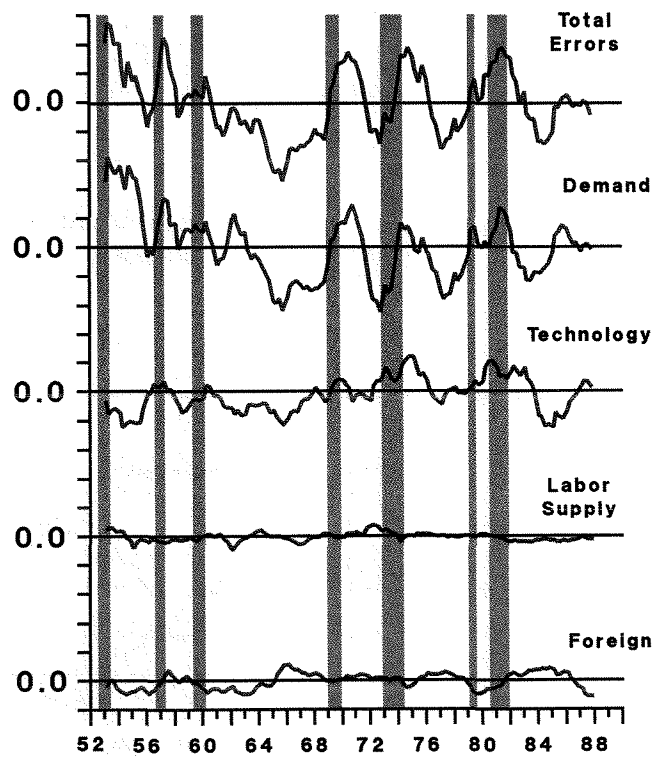
Historical Analysis

We now use our estimated structure to carry out two different exercises that examine the historical evolution of the unemployment rate. First, to understand the factors that have caused movements in the unemployment rate over the course of the business cycle, we look at the sources of our model's forecast errors at a forecast horizon of three years.

The results of this exercise are shown in Exhibit II. By construction, any error in predicting the unemployment rate has to be the result of the unpredicted demand, supply, and/or foreign shocks that took place within the three-year forecast horizon. We obtain the contribution of each kind of disturbance to the forecast error for any particular quarter by multiplying the coefficients in the impulse response functions by the appropriate historical shocks as measured by the model.

The top panel of Exhibit II shows the total error in predicting the unemployment rate twelve quarters ahead over the period from 1955 to 1988. At this forecast horizon, the major errors are closely associated with business cycle swings. The four panels below show the contributions to

Exhibit II
Historical Analysis: Decomposition of 12-Quarter-Ahead Forecast Errors for Unemployment Rate



these forecast errors made by the indicated shocks. Shaded areas represent business cycle downturns.

The most striking feature of this analysis is that aggregate-demand shocks have played by far the largest role in unemployment rate movements over the course of the business cycle in the postwar period. Although technology shocks are important for the average quarterly variability of the unemployment rate over the whole sample, aggregate-demand shocks appear to be more closely related to cyclical swings in the unemployment rate.

Technology shocks do, however, contribute significantly to the longer-run swings in the forecast errors. For example, the well-known productivity surge in the 1960s is picked up in our analysis as a succession of positive technology shocks that led to a lower-than-predicted unemployment rate over most of the decade. Similarly, the slowdown in productivity growth in the early to mid 1970s is picked up as a succession of negative technology shocks.

The 1980s have been marked by large shocks both to aggregate demand and to technology. Not surprisingly, the second panel of Exhibit II shows large, negative aggregate-demand shocks (which pushed up the unemployment rate) during the period from 1980 to 1982, when the Federal Reserve oriented monetary policy around the monetary aggregates to combat the surge in inflation in the late 1970s and early 1980s.

Aggregate-demand shocks then turned positive (thus pushing down the unemployment rate) in 1983 as monetary policy became more accommodative in the face of a continuing recession and falling inflation. In addition, fiscal policy became highly expansionary from 1983 through 1986, with the high-employment deficit jumping sharply in 1983 and reaching a peak in mid 1986. From 1986 through 1988, aggregate demand shocks were relatively small, although on average were slightly negative.

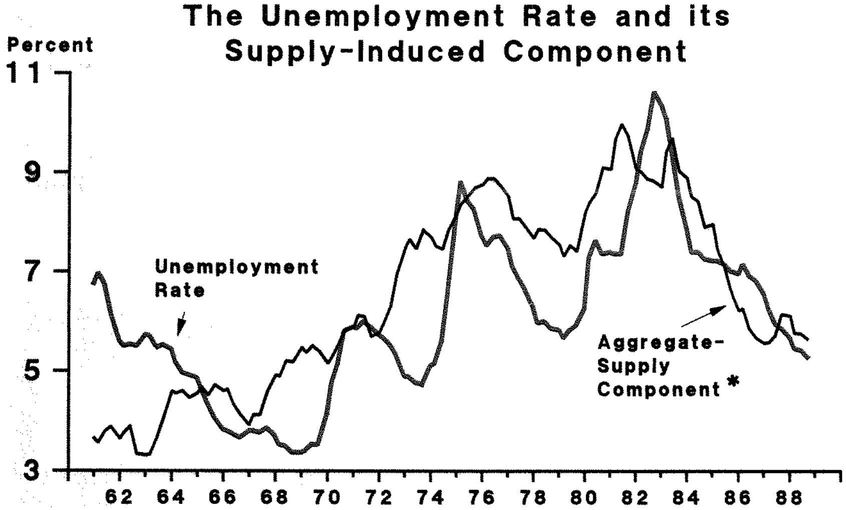
Technology shocks also have been important factors in unemployment rate movements in the 1980s. In fact, they were about as important as aggregate-demand shocks in raising the unemployment rate. This effect was substantial by historical standards and lasted from early 1980 through mid 1984. Technology shocks also accounted for a good part of the unemployment rate decline in 1986 and 1987, when the unemployment rate moved into a range that contributed to the Federal Reserve's concern about future inflation.

What might be responsible for this pattern of technology shocks? Any suggestions would be highly speculative.[18] Several large studies on the sources of productivity change in the U.S., for example, have failed to come up with specific explanations for a substantial portion of that change.[19] Nonetheless, we note that the timing of the negative technology shocks in the early 1970s and the early 1980s is close to the two oil price shocks, suggesting that this factor may have been important. However, as noted elsewhere, inclusion of oil prices causes problems in explaining developments after 1985 (see footnote 6).

Unemployment and Inflation

We turn now to the second exercise of our historical analysis, namely a decomposition of the unemployment rate into its aggregate-demand and -supply components, and a comparison of these components with the inflation

Exhibit III
The Unemployment Rate and its Supply-Induced Component



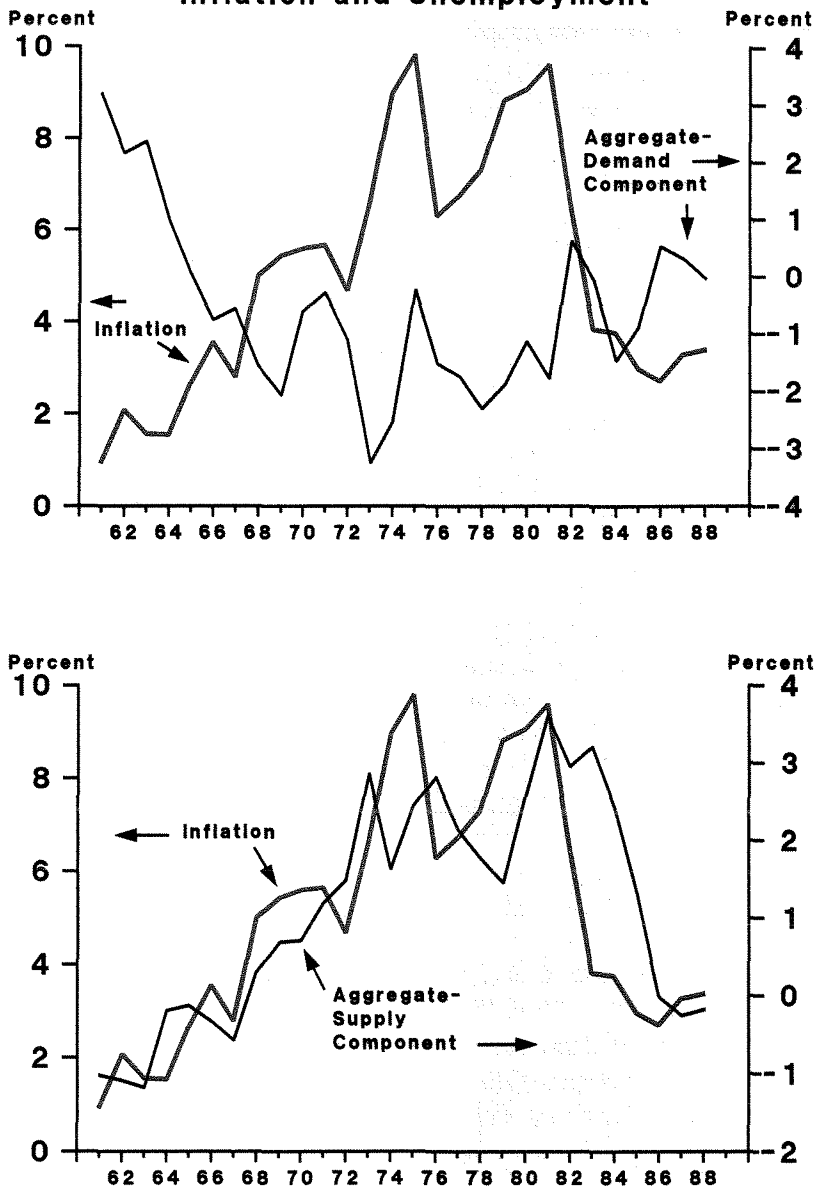
*Includes the estimated mean level of the unemployment rate to allow for comparison with the actual unemployment rate.

rate. In Exhibit III, the actual unemployment rate is plotted against the mean unemployment rate plus the contribution of aggregate-supply factors. To obtain this rate, we subtracted from the unemployment rate both the effects of aggregate-demand-induced changes and the effects of shocks originating abroad.[20] The difference between the two series plotted in Exhibit III represents the effects of aggregate-demand pressures and foreign shocks in the labor market. (Of the two, the latter are not very important.) Demand pressures apparently have reduced the unemployment rate during most of the 1965–1981 period, implying the possibility of an inflationary bias in policy. After 1981, these pressures have been more balanced, sometimes positive and sometimes negative.

According to economic theory, there should be a negative correlation between our measure of the aggregate-demand component of the unemployment rate and the rate of inflation relative to inflation expectations, if our measure is valid. This correlation arises in both the Keynesian Phillips curve and the Lucas-Barro, or monetary-misperceptions, Phillips curve.[21] In the former, an aggregate-demand shock that reduces the unemployment rate leads to higher inflation. In the latter, a positive aggregate-demand shock that raises inflation above inflation expectations (that is, creates an inflation surprise) will lead to a decrease in the unemployment rate.

The expected negative correlation is shown in the top panel of Exhibit IV. (We have used annual averages in

Exhibit IV
Inflation and Unemployment



order to reduce the random fluctuations in the data.) Note that we plot actual inflation rather than the difference between actual and expected inflation. In the following discussion, we implicitly assume a positive correlation between actual and unexpected inflation. The top panel of the exhibit reveals that as the aggregate-demand component of the unemployment rate fell below zero in mid-1960 through 1980, the inflation rate rose, reaching a peak in 1981. Since then, the aggregate-demand component has fluctuated around zero, and inflation has fallen.

The bottom panel of Exhibit IV plots the aggregate-supply component of the unemployment rate and the rate of inflation. As expected, these two series are *positively* correlated. When there is a positive technology shock, for example, inflation falls as prices adjust to a new level, and at the same time the unemployment rate falls as firms' demand for labor rises.

The correlations shown visually in Exhibit IV are presented more rigorously in the first two columns of Exhibit V. The first column presents cross correlations between past, present, and future values of inflation, on the one hand, and the aggregate-demand component of the unemployment rate, on the other. The correlations between the aggregate-demand component of the unemployment rate and inflation are strongly negative, suggesting that our measure of aggregate-demand pressure is functioning as expected.

The second column of the exhibit presents the correlations between our measure of the aggregate-supply component of the unemployment rate and past, present, and future rates of inflation. These correlations are uniformly positive, which appears to validate our concept of the aggregate-supply component of unemployment.

In the third column, we show cross-correlations between the unemployment rate minus its mean rate with past and future values of the inflation rate. The correlations between the aggregate-demand component of the unemployment rate and future inflation are noticeably stronger than those between the (mean-adjusted) unemployment rate and future inflation. Likewise, the positive relationship between past inflation and our measure of the supply-induced changes in the unemployment rate is noticeably stronger than that between past inflation and the unemployment rate.

Notice also that the correlations between past values of inflation and the unemployment rate are positive. Thus, the raw data tend to support the Keynesian Phillips curve, which has causation running from unemployment to future inflation, and refutes the monetary-misperceptions Phillips curve. The latter relationship implies that there should be a *negative* correlation between past inflation surprises and unemployment rates, rather than the positive correlation shown in column three. However, the first column of the table shows that once the aggregate-supply shocks are stripped away, both directions of causation are supported. There is a negative correlation between past inflation and aggregate-demand-induced unemployment (monetary misperceptions) and also between future inflation and unemployment (Keynesian).

Exhibit V

Cross-Correlations Between Inflation and Alternative Measures of Labor Market Pressure

Sample Period: 61:1-88:4

Time[1]	Inflation and Aggregate-Demand Component of Unemployment Rate	Inflation and Aggregate-Supply Component of Unemployment Rate	Inflation and the Unemployment Rate Minus Its Mean
t−12	−.22	.63	.54
t−11	−.22	.67	.57
t−10	−.20	.69	.61
t−9	−.19	.69	.61
t−8	−.20	.71	.61
t−7	−.24	.71	.56
t−6	−.27	.68	.50
t−5	−.31	.67	.43
t−4	−.36	.65	.34
t−3	−.41	.64	.27
t−2	−.50	.62	.17
t−1	−.57	.61	.07
t	−.65	.60	−.03
t+1	−.66	.55	−.10
t+2	−.67	.51	−.16
t+3	−.69	.48	−.20
t+4	−.65	.42	−.21
t+5	−.64	.39	−.22
t+6	−.60	.35	−.22
t+7	−.57	.32	−.21
t+8	−.55	.29	−.21
t+9	−.50	.25	−.21
t+10	−.44	.20	−.19
t+11	−.39	.16	−.17
t+12	−.36	.16	−.14

[1]Exhibit shows correlations between various components of the unemployment rate and past as well as the future values of inflation. For example, the first entry shows the correlation between the current value of the aggregate-demand component of the unemployment rate and the value of inflation 12 quarters earlier.

IV. Policy Implications and Conclusions

The aim of this paper has been to estimate the relative importance of different kinds of disturbances in causing movements in the unemployment rate. Toward that end, we have attempted to keep our model as free as possible of the controversial identifying restrictions that are inherent in the various competing paradigms of the macroeconomy. We find that on average both demand and supply shocks have been important in explaining unemployment rate movements in the postwar period. While demand shocks are relatively more important in causing cyclical swings in the unemployment rate, supply shocks play a significant role in inducing longer-term movements. Our finding that positive supply shocks are correlated with falling unemployment in subsequent periods casts doubt on Phillips-curve analyses, which assume that relative prices and the unemployment rate move independently of each other.

Our historical analysis suggests that supply shocks were important in keeping the unemployment rate low in the 1960s, and relatively high in the early- and mid-1970s. Of particular interest right now is the role played by supply shocks in raising the unemployment rate in the first half of the 1980s, and then lowering it in the second half of the decade. The relatively large role played by supply shocks in the decline in the unemployment rate over the last few years could be one reason the inflation rate has not accelerated as much as past estimates of the unemployment-inflation relationship would have led us to expect.

The analysis is relevant for policy purposes to the extent that policy makers take the unemployment rate into account in determining policy. Policy makers may look at the unemployment rate in order to arrive at an estimate of future inflation. Since movements in the unemployment rate may be the result of either demand or supply factors, looking at the level of the unemployment rate alone (or at the unemployment rate relative to some fixed value) can be misleading in particular episodes; instead, it is necessary first to determine the relative importance of aggregate-demand and -supply forces.

With this in mind, we consider what the model tells us about the conditions that prevailed in 1988 (the last year of our sample period). As Exhibit III indicates, aggregate demand was mildly stimulatory. The unemployment rate averaged 5.5 percent over the year. In the absence of any demand shocks, it would have averaged 5.8 percent. The difference between these two numbers (0.3 percent) provides a measure of aggregate-demand pressures in the economy. A measure of the net impact of supply shocks is obtained as the difference between what the unemployment rate would have been in the absence of demand shocks and what it would have been in the absence of shocks of any kind. Our model implies that in the absence of any shocks to the economy the unemployment rate would have settled at 6.0 percent.[22]

Thus, this difference between the actual 5.5 percent rate in 1988 and the 6.0 percent mean rate is accounted for about equally by demand and supply shocks. Although demand pressures *do* appear to have contributed to labor market tightness in 1988, the degree of pressure probably is not as intense as would be suggested by comparing the prevailing rate with its 6.0 percent mean.

APPENDIX A

Identification

In this appendix we describe the identification problem in terms of the moving average representation of a VAR. Let the vector $X_t = [x_{1t}\ x_{2t} \ldots x_{nt}]$ denote the variables contained in the model, where all the elements are nonstationary, but are not cointegrated. Assume that the structural representation of the model can be written as

$$Z_t = A(L)\,e_t \qquad \text{(A1)}$$

where $Z_t = \Delta X_t$, $A(L) = A_0 + A_1L + A_2L^2 + A_3L^3 \ldots$, and the lag operator L is defined by $Le_t = e_{t-1}$. Further, it is assumed that $\Sigma A_i^2 < \infty$, and that the structural disturbance term e is serially uncorrelated.

Let the estimated VAR representation of the model be given by

$$B(L)\,Z_t = v_t. \qquad \text{(A2)}$$

Multiplying both sides of (A2) by $C(L) = B(L)^{-1}$ leads to the moving average representation

$$Z_t = C(L)\,v_t. \qquad \text{(A3)}$$

where $E(v_t) = 0$, and $E(v_s v_t') = \Omega$ for $t = s$ and is zero otherwise. (A3) is the reduced form representation of (A1), and we have

$$A(L)\,e_t = C(L)\,v_t. \qquad \text{(A4)}$$

This is satisfied for any v_t such that $v_t = S^*e_t$, and $C(L) = A(L)^*S^{-1}$. Thus, to recover the structural representation from the estimated VAR, we need to obtain the matrix S which links the VAR residuals v_t with the structural disturbances e_t.

The exact form of S will depend upon the structure of the model. Under the usual assumption that the structural disturbances are uncorrelated with each other and that they have unit variance (that is, $E(e_t e_t') = I$), the problem of choosing the appropriate S reduces to choosing the elements of S subject to the condition that S is a square root of Ω (the variance-covariance matrix of the VAR residuals). Since Ω has $n(n+1)/2$ unique elements and S is n^*n, we need $n(n-1)/2$ (that is, $n^2 - [n(n+1)/2]$) additional restrictions in order to identify a unique S. If $n = 2$, for example, Ω contains three unique elements while S contains four. Thus, we need one additional restriction to identify S.

Sims (1980) suggested choosing S such that $s_{ij} = 0$, for all $j > i$, which serves to make the system exactly identified. For a two-variable system, this restriction prevents shocks to the second variable from having any contemporaneous effect on the first variable. Sims' restrictions imply that the underlying structural model is a recursive, simultaneous equations model (with independent error terms), a representation that may sometimes be difficult to reconcile with economic theory. Blanchard and Watson (1986) imposed restrictions on contemporaneous correlations that were explicitly derived from economic theory, and variations of this technique have been implemented by Bernanke (1986) and Walsh (1987), among others.

The technique of identification used in this paper has been suggested recently by Blanchard and Quah. In this technique the restrictions used to identify S can be interpreted as restrictions on the long-run effects of the associated shocks on certain variables. To see how this works, assume that the vector Z_t contains only two elements, so that (A3) becomes

$$\begin{bmatrix} z_{1t} \\ z_{2t} \end{bmatrix} = \begin{bmatrix} c_{11}(L) & c_{12}(L) \\ c_{21}(L) & c_{22}(L) \end{bmatrix} \begin{bmatrix} v_{1t} \\ v_{2t} \end{bmatrix}$$

or

$$\begin{bmatrix} z_{1t} \\ z_{2t} \end{bmatrix} = \begin{bmatrix} c_{11}(L) & c_{12}(L) \\ c_{21}(L) & c_{22}(L) \end{bmatrix} \begin{bmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{bmatrix} \begin{bmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{bmatrix}^{-1} \begin{bmatrix} v_{1t} \\ v_{2t} \end{bmatrix}$$

or

$$\begin{bmatrix} z_{1t} \\ z_{2t} \end{bmatrix} = \begin{bmatrix} c_{11}(L)s_{11} + c_{12}(L)s_{21} & c_{11}(L)s_{12} + c_{12}(L)s_{22} \\ c_{21}(L)s_{11} + c_{22}(L)s_{21} & c_{21}(L)s_{12} + c_{22}(L)s_{22} \end{bmatrix} \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix}$$

As discussed above, if e_1 and e_2 are assumed to be independent of each other, only one more restriction is needed to identify S. If it is assumed that e_2 has no long-run effect on x_1 (the first variable in the model), the restriction takes the form

$$c_{11}(1)\, s_{12} + c_{12}(1)\, s_{22} = 0$$

Here, $c_{11}(1)$ is just the sum of the coefficients in the lag polynomial $c_{11}(L)$. Thus, in this case identification is achieved by choosing an S for which a particular weighted sum of the elements of the second column of S is zero. The condition that these weights be the sum of the coefficients of the estimated lag polynomials for the first variable is what ensures that the level of x_1 is independent of e_2.

Shapiro and Watson (1988) show how this restriction can be imposed quite easily in the VAR representation.

APPENDIX B

Data and Preliminary Tests

We use quarterly data over the period 1948Q1–1988Q4 for our estimation.

All data have been obtained from the Citibase data tape. For population, we use noninstitutional population, 16 years and over, after subtracting armed forces. The unemployment rate is the civilian unemployment rate. To make the GNP data comparable, we use real GNP net of federal defense expenditures. The interest rate we use is the six-month commercial paper rate. Data for U.S. exports and imports are from the National Income and Product Accounts.

Tests for Stationarity

We tested for stationarity using the Said-Dickey test, which is recommended by Schwert (1987). The test involves estimating an equation of the form

$$y_t = \alpha + \beta y_{t-1} + \sum_{i=1}^{j} \delta_i \Delta y_{t-i} + e_t.$$

To test whether the y process contains a unit root we have to determine whether $\beta = 1$. However, under the null hypothesis that the process generating y contains a unit root, the ratio of the estimated value of β to its standard error does not have the usual t-distribution. The critical values to be used in this case are tabulated in Fuller (1976).

Schwert (1987) demonstrates that choosing a large value of j (as recommended by Said and Dickey) avoids the problem of falsely rejecting the hypothesis that y contains a unit root. In the table below we present the results for the cases where $j = 8$ and $j = 12$. The table shows that we are unable to reject the null hypothesis of a unit root for population, real GNP, the interest rate, or the foreign variable at the 10% level in either the eight-lag or the 12-lag case.

In the case of the unemployment rate, we present three different sets of results. We are unable to reject the null hypothesis of a unit root in the unemployment rate whether or not we allow for a linear trend. The last column shows the results for the case where we allow for a change in the mean unemployment rate beginning in 1974Q1. For the eight-lag case, the computed test statistic is significant at 5%, while for the 12-lag case the computed value of -2.80 is just below the 5% critical value of -2.89.

Note, however, that these critical values do not allow for a shift in the mean under the alternative hypothesis. It is useful to compare these critical values to those reported in Perron (1988). Perron generalizes the null of a unit root process to allow for a one-time change in the structure of the series, and compares this to the alternative of a stationary series with a discrete change in its mean. (Thus, his null hypothesis is not strictly the same as ours.) It turns out that the critical values vary with the date at which the break occurs. For the case at hand, where the break occurs about two-thirds of the way into the sample, the 5% critical value is -3.33, while the 10% critical value is -3.01.

Table B-1

Unit Root Tests

Sample period 48:1–88:4

					Unemployment Rate		
Variable[1]:	Population[2]	Real GNP[2]	Interest Rate	Foreign	Constant	Trend	Mean Shift
No. of Lags							
8	−2.60	−1.80	−2.09	−2.33	−1.79	−2.68	−3.13
12	−1.85	−1.52	−1.77	−2.54	−1.68	−1.85	−2.80

Notes:
[1]All variables are in logs. Except as otherwise noted, all regressions contain a constant only. The 5% critical value for this case is −2.89, the 10% is −2.58.
[2]Equations contain both a constant and a trend. The 5% critical value is −3.45, the 10% is −3.15.

NOTES

1. See, for example, "Records of Policy Actions of the Federal Open Market Committee," *Federal Reserve Press Release,* for the eight Federal Open Market Committee meetings in 1988.

2. See, for example, Ball, Mankiw, and Romer (1988), Long and Plosser (1983), Lucas (1973), and Greenwald and Stiglitz (1988).

3. Later applications used restrictions derived from economic theory. See Blanchard and Watson (1986), Bernanke (1986), Sims (1986), and Walsh (1987).

4. In another example of theoretical agnosticism, McCallum (1988) has investigated the robustness of nominal-income-targeting rules across different macroeconomic theories.

5. These results refer to the case where no trend is removed from the unemployment rate. Blanchard and Quah also present results for the case where they remove a linear trend from the unemployment rate. Removal of a linear trend tends to increase the relative importance of demand shocks.

6. They also included the price of oil as an exogenous variable, on the grounds that the two recessions during the 1970s were the consequence of the oil price shocks during this period. Inclusion of the oil price variable is problematic, however, since oil prices fell dramatically in 1985 without an obvious effect on real output. Shapiro and Watson estimate their model through the end of 1985 only.

7. SW also present two sets of results: one where there is a deterministic trend in labor hours and one where the trend in hours is stochastic. The results discussed in the text refer to the latter case.

8. See, for example, Blanchard and Quah (1989), Long and Plosser (1983), and Shapiro and Watson (1988).

9. The model outlined here closely follows that in Shapiro and Watson.

10. As described in Appendix A, once we assume that the underlying shocks are uncorrelated and have unit variance, we need $n(n-1)/2$ additional restrictions to identify a model that contains n variables. Since $n = 5$ here, we need a total of 10 restrictions.

11. This assumption implies symmetric treatment of foreign and domestic aggregate-demand shocks; that is, neither have permanent effects on output. However, the foreign shock also is designed to include the effects of foreign supply disturbances. One drawback of our model is that we are treating foreign and domestic supply shocks asymmetrically; that is, domestic supply shocks can have permanent effects, while foreign supply shocks cannot.

12. The assumption that an aggregate-demand shock induced by monetary policy does not have a long-run effect on the foreign variable is uncontroversial. The assumption that a fiscal-policy shock does not have a long-run effect on real exports and imports is less clear cut. See Krugman (1985) and Mussa (1985) for discussions of these issues and other references.

13. See Phelps (1978). For a contrary view, see Summers and Blanchard (1986).

14. See, for instance, Nelson and Plosser (1982).

15. See, for instance, Gordon (1982) and Congressional Budget Office (1987).

16. The reader interested in more detail is referred to Shapiro and Watson (1988).

17. As noted earlier, we also estimated a model with no mean shift in the unemployment rate, even though under this specification unit root tests suggest that the unemployment rate is non-stationary. The impulse response functions and variance decompositions for this model are nearly identical with those presented in the text, with one exception. The model without a mean shift in the unemployment rate ascribes a larger role to technology shocks and a smaller role to demand shocks in determining the error variance of the unemployment rate. Moreover (consistent with our findings in the unit root tests), the effects of different kinds of shocks on unemployment dissipate more slowly in the model without a mean shift than in the model discussed in the text.

18. The list of real shocks considered by Boschen and Mills (1988), for instance, contains changes in the price of oil, marginal tax rates, real government purchases, working-age population, and real exports.

19. See Jorgenson, et al., (1987).

20. More specifically, to obtain the supply component of the unemployment rate for any given quarter, we subtract the effect of all demand and foreign shocks that occurred as long as 40 quarters ago. The impulse response functions in Exhibit 1A show that this is more than long enough for the effects of these shocks to die out.

21. See Gordon (1982), Barro (1977), and Lucas (1973).

22. Prior to 1974, when we assume a mean shift, this rate is estimated to be 4.8 percent. Also, in the model where the mean is not allowed to shift, the mean rate of unemployment is estimated to be 5.0 percent.

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