

Real Wages, Employment, and Inflation

Robert E. Lucas, Jr., and Leonard A. Rapping

Carnegie-Mellon University

Introduction

The aggregate labor-supply function is a cornerstone of both neoclassical growth theory and short-run Keynesian-type employment theory. Yet no empirical estimates of the parameters of this function, comparable to estimated aggregate consumption, investment, or money demand functions, are available.¹ Despite this lack of evidence, economists have found it necessary to proceed on the basis of certain widely accepted assumptions. In the growth literature, it is generally assumed that population growth is

We wish to thank Professors T. McGuire, A. Meltzer, W. Oi, E. Phelps, and A. Rees who commented on an earlier draft of this study. Their willingness to comment on our work should not be interpreted as an endorsement of our views. Indeed, at least one of the readers substantially disagreed with us, but because his disagreement aided us in clarifying our thinking we feel obliged to acknowledge his assistance.

¹ Leaving aside studies of the relative supply of labor to individual industries or firms, most of the empirical work on the supply of labor can be separated into three categories. Studies of hours of work per unit of time per member of the labor force have found a negative relationship between wage rates and hours supplied, especially for male members of the labor force. This result is reported by Lewis (1956), Finegan (1962), Jones (1963), Kosters (1966), and Rosen (1969). A second group of studies has examined the relationship between participation rates and wage rates. These have largely been cross-sectional studies, and they have reported a positive wage-rate effect for women and a small negative effect for men. The reader will find these results in studies by Douglas (1934), Long (1958), Mincer (1962, pp. 63–105), Bowen and Finegan (1965), and Cain (1966). To the best of our knowledge, no attempt has been made to combine all of the existing hours per head and participation-rate studies in such a way as to infer an aggregate supply of labor schedule for a population fixed in terms of its demographic characteristics.

The above-mentioned studies represent attempts to isolate the long-run effect of a permanent change in real wages on labor supply. On the other hand, a third class of labor-supply studies has investigated the short-run cyclical behavior of labor supply as measured by participation rates and their relationship to unemployment rates. These studies suggest a procyclical behavior in the supply of labor. See Mincer's summary of these studies (1966) and recent papers by Black and Russell (1966), Tella (1966), and Cain and Mincer (1969).

exogenous and that the supply of labor from any fixed population is an inelastic function of the real wage rate. In the short-run literature, on the other hand, it is commonly assumed that the labor supply is infinitely elastic at some rigid real or money wage rate. Our purpose in this paper is to construct a model of the labor market which reconciles these apparently divergent views of labor supply and to test the model on annual aggregate, U.S. time series covering the period 1929–65.

Wherever possible, we will motivate our assumptions by reference to the microeconomic labor-market literature. Yet, as with any aggregate study of a single sector of the economy, it will be necessary to gloss over much of the richness of detail provided by the many studies of particular features of labor-market behavior. We will not compensate for this loss by offering a full econometric model of the economy, but in the next section we sketch the structure of our labor-market model and its relation to the other sectors of the economy. There remains, nevertheless, an inevitable arbitrariness in our selection of two functions—the labor-supply function and a marginal productivity condition for labor—to be estimated as a simultaneous equation system.

In addition to our primary aim of understanding the workings of the U.S. labor market, this study has as a secondary purpose the rationalization in supply-and-demand terms of the observed correlation between unemployment rates and the rate of inflation, or Phillips curve. Recent attempts to give a theoretical basis to the Phillips curve have been based largely on a view of the labor market as dominated by collective bargaining, where bargaining outcomes bear no explicit relation to supply-and-demand forces.² While we offer no crucial test of the two views, we shall show that a competitive market theory is rich in implications and is consistent with the U.S. experience.

The remainder of the paper is organized as follows. In section I, a model of the production-employment sector is discussed in general terms and related to the rest of the economy. In section II, an aggregate labor-supply function is developed. The demand side of the market is treated in section III and the role of measured unemployment in section IV. The model is then stated in full in section V, with tests reported in the next section. Section VII is a summary of our conclusions.

I. Structure of the Model

The results reported in section VI, below, are estimates of a two-equation model of the U.S. labor market, where the two equations are the labor-supply function and a marginal productivity condition for labor. The time

² A bargaining interpretation of the Phillips relationship is given by Eckstein and Wilson (1962) and Perry (1964). Others have attempted to motivate the Phillips curve by appealing to an “out-of-equilibrium” adjustment function. This was the original

series on which our tests were conducted are, as are all economic time series, subject to both short- and long-run forces. It is thus impossible, however desirable, to construct and test on these series either a "short-run model" or a "long-run model" of the labor market: an adequate model must contain both a short and a long run. There are, then, three features which we feel a model of the labor market (or, more broadly, the production-employment sector) should possess. First, it should incorporate the neoclassical feature that for fixed capital stock the aggregate supply schedule (relating the price of goods to real output) will become perfectly inelastic over a long period of stable aggregate demand. Second, the model should imply an elastic short-run aggregate supply function consistent with the observed fluctuations in real output and employment in the face of shifting aggregate demand. Finally, the transition from short-run to long-run labor-market equilibrium should be described in full.

The models tested in this paper share these three features. In implementing the models empirically, however, it is necessary to introduce a number of complications which obscure these central features. To aid in interpreting the results, we devote the remainder of this section to a simple prototype of the more complex models actually tested. In doing this, we consider the two functions actually estimated, together with the aggregate production function which was *not* estimated, as a bloc of equations determining the aggregate supply function.

Let m_t be employed persons per household in period t , k_t be capital per household, and y_t be real output per household. Let w_t be the real wage rate, and let Δp_t be the percentage rate of price increase from $t - 1$ to t . We assume an aggregate production function with constant returns to scale, which can be written:

$$y_t/m_t = f(k_t/m_t), \quad f' > 0, f'' < 0. \quad (1)$$

With competitive labor markets and continuous profit maximization on the part of firms, equation (1) implies the marginal productivity condition for labor:

$$w_t = f(k_t/m_t) - (k_t/m_t)f'(k_t/m_t). \quad (2)$$

Equations (1) and (2) can be solved for the short-run (that is, capital fixed) output supply and labor demand functions if one wishes; their content is the same in either form. To (1) and (2) we add a labor-supply function:

$$m_t = S(w_t, w_{t-1}, \Delta p_t, m_{t-1}), \quad (3)$$

where S is an increasing function of w_t , Δp_t , and m_{t-1} , and a decreasing

motivation suggested by Phillips (1958) and later Lipsey (1960), and this view is extended in a recent paper by Phelps (1968). For a discussion of the Phillips relationship and the joint influence of collective bargaining and monetary-fiscal policy, see Bronfenbrenner and Holzman (1963). See also Bronfenbrenner's discussion of government wage-price guidelines (1967).

function of w_{t-1} . In section II we discuss in some detail a Fisherian model motivating this labor-supply function. For the present, our interest is in the properties of the production-employment sector characterized by (1)–(3).

The supply function (3) is *not* homogeneous of degree zero in *current* prices and money wages, p_t and $w_t p_t$. Hence in the short run, the model exhibits a form of the “money illusion” postulated in many modern, Keynesian models. If wages and prices were to remain stable over a long period, however, (3) could be solved for a long-run labor supply (relative to population) which depends only on the *real* wage rate.

Eliminating w_t , m_t and their lagged values from (1)–(3) yields the aggregate supply function:

$$y_t = F(y_{t-1}, k_t, k_{t-1}, \Delta p_t). \quad (4)$$

The derivative of F with respect to p_t is positive, so that the short-run aggregate supply function has an upward slope—although it will not be perfectly elastic with respect to the price level. If prices are stable over a long period, and if the difference equation (4) is stable, the supply function becomes perfectly inelastic. In summary, the model (1)–(3) does possess the features discussed at the beginning of this section.

In discussing (1)–(3), we have regarded the labor market as being in *short-run* equilibrium at each time t . This assumption is not inconsistent with observed fluctuations in employment, nor does it “define away” unemployment.³ The main result of postulating a short-run equilibrium is that measured unemployment, or the measured labor force, will not enter in an important way into the model. We do, however, attempt to account for movements in measured unemployment by using our model to suggest an answer to the question: “What question do respondents to the employment survey think they are answering when asked if they are seeking work?” This is discussed in detail in section IV.

³ Historically, much has been made of the distinction between “voluntary” and “involuntary” unemployment. When formulated carefully, however, this distinction turns out to be purely formal and serves only to obscure the important distinction between models in which labor-market equilibrium implies a particular (full employment) level of output *independent of the level of aggregate demand* and models in which this implication does not hold. Our model is in the latter class. Without attempting a definitive review of the post-Keynesian literature, we wish to point out that many writers appear to treat labor markets as being in equilibrium throughout the cycle. Patinkin (1965, p. 341) interprets Modigliani (1951, pp. 186–239) in this way and attributes to Lange (1945) this interpretation of Keynes. After seeking to differentiate himself from those who insist on labor suppliers being “on their supply curves” at each point in time, he himself attributes “rigidities” to the fact that “individual decisions . . . respond only ‘stickily’ to market changes” (p. 343). Similarly Rees (1951) attributes wage rigidities to the *unwillingness* of employers to cut money wages. Of course, Patinkin is correct in asserting that it is not *necessary* to construct models in which labor markets are continuously cleared, but, as his discussion of the Keynesian literature makes clear, the continuous-equilibrium view is in no sense a radical departure from the views of earlier theorists, nor does it have, in itself, any obvious normative consequences.

A second general remark is necessitated by the presence of the inflation rate Δp_t in the aggregate supply function (4). This would appear to offer the possibility that, by pursuing a systematic policy of inflation, the government can raise real output arbitrarily without limit. We do *not* accept this implication. As we shall see in the next section, if such a policy were followed the model (1)–(3) would cease to hold.

Before turning from the general structure of the labor market to the behavior of individual suppliers and demanders of labor (sections II, III, and IV), we should perhaps raise the broader question of whether a competitive supply-demand mechanism of the sort proposed above, or of *any* kind, can account for labor-market behavior. Posed in such general terms, an a priori discussion of this question is pointless, but two specific non-competitive forces on wages and employment are sufficiently important to warrant special mention: collective bargaining and the military draft.

Clearly, the model sketched above is an inaccurate view of wage and employment determination in a single, unionized industry. In such an industry, the union imposes a higher-than-competitive wage rate, limited by the labor-demand elasticity it faces and the effectiveness of its strikes. Labor supply to the industry is irrelevant, since the excess supply which must exist is not able to bid down wages. A labor-market model for such an industry will thus consist of a demand function for labor and a “wage setting equation.” One is tempted to generalize this view of a unionized industry to the economy as a whole, and, indeed, many economists have yielded to this temptation. Over the period covered by our study, however, at most 25 percent of the labor force was employed under collective bargaining arrangements, so that this generalization makes no sense. Those who cannot find work in the unionized sector will be supplied to the nonunion sector, depressing wages there. As a result, there will be important distortions in the *relative* wage structure, but we have found neither theoretical presumption nor empirical evidence to indicate that the effect of unionism on *aggregate* wage rates is sizable (or even of predictable direction).⁴

⁴ While the effect of collective bargaining on *relative* union/nonunion wage rates has been established (at various points in time) by Lewis (1963), the bargaining effect on the aggregate wage rate (weighted average of union and nonunion rates) remains uncertain and, indeed, largely unexplored. Since successful union activity will reduce employment in the unionized sector, releasing workers to the rest of the economy, there is not even a presumption that the union effect on the aggregate wage rate is positive. For example, if the demand elasticity for labor is unity in both sectors (union and nonunion) and if labor is inelastically supplied, unions will have *no* effect on either aggregate employment or the average wage rate. Even if one assumes an inelastic labor demand in the unionized sector, the union effect on wages at the peak of union power (the 1950s, when 25 percent of the work force was unionized and the relative union/nonunion wage was, according to Lewis, 1.15) is estimated at less than 4 percent. Since the percentage of the labor force covered by collective bargaining agreements has varied from 9 percent in 1929 to a high of about 25 percent in 1953, time-series analyses of the impact of bargaining on real wages has been possible. The few

Since the military is included in our wages and employment data, with the government treated exactly as a private employer, it is also important to consider the impact of the military draft. Ideally, one should deduct those coerced into the military (a figure which would differ from total draftees) from employment and from "population," deduct their pay from compensation of employees, and deduct their product from GNP—in short, redo the national accounts. We have not attempted this but have instead introduced a wartime dummy variable to control for the effects of the draft during World War II—the only period in our sample where draftees form a substantial fraction of total employment. This is discussed further in section II.

II. Aggregate Supply of Labor

By the supply of labor, we mean the quantity of man-hours supplied to the *market* economy per year.⁵ There are several ways in which this quantity can vary in response to changes in the real wage rate. The wage rate may influence the size of the population through its effect on the child-bearing decision, it may affect the fraction of a given population supplied to the labor force (that is, the participation rate), or it may alter the number of hours supplied per year per labor-force member. We will examine only the last two responses—hours and participation rates—and attempt to explain changes in total labor supply for a population of fixed size and with a fixed age and sex composition.⁶

The relationship of labor supplied to the real wage, referred to in the preceding paragraph, is implied by the familiar utility analysis of the

empirical studies we have examined suggest that collective bargaining may have a modest upward impact on aggregate real wages, but most of the observed secular and cyclical variation in this series is explained by competitive market forces. This conclusion is suggested by Rees (1959) in his study of real wages in manufacturing for the period 1889–1957, and by Cagan (1968) who also examined the manufacturing wage data for the period 1890–1961.

⁵ Our analysis will be restricted to the household decision problem involving the choice between market work and leisure. This is admittedly an oversimplification of a more complex decision problem involving choices among market work, leisure, homework, and schoolwork. Our approach obviates the need for discussion of an implicit homework wage rate, and it also permits us to suppress the formal introduction of an explicit schoolwork wage rate. For a fuller statement of these issues, see Mincer (1962), Cain (1966), and Kosters (1966). It should also be stressed that since we are defining *leisure* to include *all* uses of time except remunerative labor, this term covers a variety of activities: for example, schooling, job seeking, retirement, and housework.

⁶ We are aware that in treating the population as exogenous we are failing to explain the single most important factor accounting for the secular growth in the U.S. labor force (on this point see Easterling 1965). Yet this assumption does not in any way lessen the usefulness of our model in understanding the dynamics of labor supply and in separating short- from long-run labor supply responses to once-and-for-all real wage rate changes.

goods-leisure choice facing a single household in a competitive market. For a household facing fluctuating money wages and goods prices, this trade-off at *current* prices captures only one facet of the labor-supply decision. Equally important will be choices involving substitution between *future* goods and leisure and *current* goods and leisure. Consider, for example, the decision facing a worker who has been laid off (or who, in our terms, is confronted with a fall in the wage at which he can find work). Since accepting work at a lower wage may involve, say, an investment in search or in moving to another community, the decision on current labor supply will differ depending on the wage he anticipates in the near future. If the current fall in wages is regarded as temporary, he may accept leisure now (be unemployed). If it is regarded as permanent, he may accept work elsewhere.

To examine these features of the labor-supply choice more systematically, we shall utilize an extended version of the utility analysis of a representative household, involving four commodities: current goods consumption (\bar{C}) and labor supply (\bar{N}), and "future" consumption and labor supply (\bar{C}^* and \bar{N}^*). The household is assumed to maximize utility:⁷

$$U(\bar{C}, \bar{C}^*, \bar{N}, \bar{N}^*), \quad U_1, U_2 > 0, U_3, U_4 < 0, \quad (5)$$

subject to the constraint that the present value of consumption cannot exceed the present value of income. Present values are computed using a nominal interest rate r , at which the household may lend any amount up to its current assets or borrow any amount up to that which may be secured by future income. The initial nonhuman assets, fixed in money terms, are \bar{A} , and present and future goods, prices, and money wage rates are P, P^*, W , and W^* . Thus, U is maximized subject to:

$$P\bar{C} + \frac{P^*}{1+r} \bar{C}^* \leq \bar{A} + W\bar{N} + \frac{W^*}{1+r} \bar{N}^*. \quad (6)$$

We assume that for all positive prices a unique maximum is attained at which $\bar{C}, \bar{C}^*, \bar{N}, \bar{N}^* > 0$. Then the solution to the maximum problem gives each of these decision variables as a function of the four "prices" in (6) and \bar{A} . In particular, we have the current labor-supply function:

$$\bar{N} = F\left(W, \frac{W^*}{1+r}, P, \frac{P^*}{1+r}, \bar{A}\right). \quad (7)$$

⁷ Liviatan has shown (1966) that the common procedure of collapsing an n -period decision problem into a two-dimensional problem raises the usual index number problems. These problems are neither more nor less severe than those which arise when, say, the price level is measured by an index, a procedure quite common in economics.

The function F is homogeneous of degree zero in its five arguments, so that if the current price level P is chosen as a deflator, (7) is equivalent to:

$$\bar{N} = F\left[\frac{W}{P}, \frac{W^*}{P(1+r)}, 1, \frac{P^*}{P(1+r)}, \frac{\bar{A}}{P}\right], \quad (8)$$

The theory's implications for the signs of the derivatives of F are, in general, ambiguous, as one would expect, but on the presumption that future goods and leisure are substitutes for current leisure, that leisure is not inferior, and on the presumption that the asset effect is small, there is a presumption that:⁸

$$\begin{aligned} \partial F/\partial(W/P) > 0, \quad \partial F/\partial\left(\frac{W^*}{P(1+r)}\right) < 0, \\ \partial F/\partial\left(\frac{P^*}{P(1+r)}\right) < 0, \quad \partial F/\partial(\bar{A}/P) < 0. \end{aligned} \quad (9)$$

This simple theory of a single household suggests an aggregate labor-supply function relating total man-hours supplied annually, N_t , deflated by an index of the number of households, M_t , to the empirical counterparts of the arguments of F . Let W_t be an index of money wages, P_t the GNP deflator, r_t a nominal interest rate, and A_t the market value of assets held by the household sector. Let W_t^* and P_t^* be (unobservable) indexes of the anticipated prices of the composite goods "future labor" and "future con-

⁸ To obtain information on the signs of the partial derivatives of the labor-supply function F given in (7) from the hypothesis that the household maximizes (5) subject to (6), we follow the standard procedure of expressing each derivative as the sum of two terms: a Slutsky, or substitution, term and a term representing the asset (income) effect of a price change. Let $K(N, W)$ denote the substitution effect of a wage change on current labor supply, and so forth. Then:

$$\begin{aligned} \partial F/\partial W &= K(N, W) + N \frac{\partial F}{\partial A}, \\ \partial F/\partial\left(\frac{W^*}{1+r}\right) &= K\left(N, \frac{W^*}{1+r}\right) + N^* \frac{\partial F}{\partial A}, \\ \partial F/\partial P &= K(N, P) - C \frac{\partial F}{\partial A}, \\ \partial F/\partial\left(\frac{P^*}{1+r}\right) &= K\left(N, \frac{P^*}{1+r}\right) - C^* \frac{\partial F}{\partial A}. \end{aligned}$$

The only implication of the utility maximization hypothesis for the signs of the individual terms is: $K(N, W) > 0$. The additional hypothesis that consumption in both periods and future leisure are each substitutes for current leisure implies that the other three substitution terms are negative. Finally, we suppose that $\partial F/\partial A$ is negative but negligible. Combining these hypotheses yields (9).

sumption" based on information available at t . Then, based on (8), we postulate the log-linear relationship:

$$\ln(N_t/M_t) = \beta_0 + \beta_1 \ln(W_t/P_t) - \beta_2 \ln \left[\frac{W_t^*}{P_t(1+r_t)} \right] - \beta_3' \ln \left[\frac{P_t^*}{P_t(1+r_t)} \right] - \beta_4 \ln \left(\frac{A_t}{P_t M_t} \right), \quad (10)$$

where (cf. [9]) β_1 , β_2 , β_3' , and β_4 are positive, and β_0 may have either sign.⁹ Letting $w_t = W_t/P_t$, $w_t^* = W_t^*/P_t^*$, $a_t = A_t/P_t$, and $\beta_3 = \beta_2 + \beta_3' > 0$, and observing that $\ln(1+r_t) \sim r_t$, (10) may be rearranged to give the more easily interpreted:

$$\ln(N_t/M_t) = \beta_0 + \beta_1 \ln(w_t) - \beta_2 \ln(w_t^*) + \beta_3[r_t - \ln(P_t^*/P_t)] - \beta_4 \ln(a_t/M_t). \quad (11)$$

Thus labor supply is assumed to depend on current and expected real wages, on the expected real interest rate, $r_t - \ln(P_t^*/P_t)$, and on asset holdings. The presence of both current and anticipated future wage rates in this function is very much in the spirit of modern labor economics in which the laborer is viewed as a capitalist and the decision to transfer one's supply from one market to another (which is how one typically accepts a wage cut or obtains a higher than normal increase in our economy) is recognized as an investment decision. The presence of the real interest rate (which was suggested earlier by Patinkin [1965, p. 129]) reflects the ability to transfer consumption from one period to another.

An alternative way to view the wage response indicated by (11) is in terms of a current real wage consisting of "permanent" and "transitory" components.¹⁰ Thus the terms involving wages on the right of (11) may be written $\beta_1 \ln(w_t/w_t^*) + (\beta_1 - \beta_2) \ln(w_t^*)$. The variable w_t^* has the natural

⁹ The implication of our theory is that a change in the wage rate will elicit a particular labor-supply response from the household. As a practical matter, of course, there is no single wage rate. Instead, wages vary according to occupation, education, sex, race, geography, and religion. When labor-supply responses vary with these characteristics, relative as well as absolute real wages will influence the aggregate supply of labor. It is assumed that over our sample period, changes in the relative wage structure are such that equation (10) remains a good approximation of the true relation among the included variables.

¹⁰ The distinction between the labor-supply effect of a permanent as opposed to a transitory real wage-rate change serves as the basis of Friedman's (1962) explanation of the unusually large increase in the supply of labor during World War II. To the best of our knowledge, Friedman was the first to suggest the empirical usefulness of the permanent-transitory wage-rate distinction when studying the supply of labor. In studying the labor supply of married women, Mincer (1962), Cain (1966), and Cain and Mincer (1969) have distinguished between the effect of permanent and transitory variables on the supply of married women. But their model and objectives are different from ours. We do not address ourselves to the problems of the intrahousehold allocation of leisure and work, and it is difficult to compare directly our model with models primarily designed to explain the labor-supply behavior of the female member of the household. Nonetheless, we should stress that they have distinguished between the effect of permanent and transitory variables on the supply of female labor.

interpretation as a permanent or normal real wage rate; the elasticity of labor supply with respect to this wage may have either sign, admitting the possibility of a backward-bending supply curve. The variable $\ln(w_t/w_t^*)$ is then the ratio of current to permanent wages. If $w_t > w_t^*$, or if current wages are abnormally high, more labor is supplied than would be implied by the long-run labor-supply function. If $w_t < w_t^*$, workers are off the long-run supply curve to the left.¹¹

As indicated above, there is some reason to believe that the asset effect on labor supply is minor (that β_4 is near 0), and for this reason this variable was originally excluded from our tests. Later we introduced some rather unsatisfactory "proxies," with generally poor results.¹² These results are reported in Appendix I, but for the present a_t/M_t will be dropped from the discussion. Similarly, while results with a nominal interest rate, r_t , are reported in Appendix I, our most satisfactory models exclude this variable, and it will be dropped from the discussion which follows.¹³ Finally, it is

¹¹ Like Friedman's original permanent income hypothesis (1957), this view of labor supply has life-cycle as well as business-cycle implications. For example, the theory "predicts" that workers will concentrate their labor supply in years of peak earnings, consuming leisure in larger than average amounts in childhood and old age. A systematic development and testing of such implications is beyond the scope of this paper.

¹² Our assumption that the nonhuman asset effect is small is consistent with some but not all of the available literature. Using a nonemployment income variable which includes reported income from owned assets, transfer payments, and other items, Bowen and Finegan (1965) obtained a negative and significant coefficient when regressing participation rates on this variable. They obtained this result for the years 1940, 1950, and 1960 and for several different age-sex groups. But another cross-sectional study by Kosters (1966) who used the 1960 0.1 percent sample was considerably less successful in identifying a nonemployment income effect on male hours of work. Kosters discusses the measurement problems occasioned by the use of census nonemployment income data as a proxy for income from nonhuman assets.

¹³ In the model reported in section VI and in many of those reported in Appendix I, either the asset variable or the nominal interest rate or both has been excluded from the regression equation for labor supply. In these cases the link between (9) and the version of (11) with r_t and $\ln(a_t/M_t)$ omitted needs clarification. A household's nonhuman wealth will consist of claims to future income, partly fixed in money terms and partly in real terms. (For the representative household, A is, of course, positive.) An increase in future prices P^* will then induce an increase, less than proportional, in the current market value of assets. In regressions which include an asset variable which measures market value, this capital gain or loss effect of price changes will be controlled for. Since the gain in assets is positively related to P^* , and assets are negatively related to current labor supply, the negative effect of P^* on current labor supply will be *accentuated* in regressions omitting $\ln(a_t/M_t)$. Hence β_3 is positive, whether or not an asset variable appears in (11). When the interest rate r_t is omitted, a similar issue is raised. The nominal rate may vary with P^*/P_t , so that β_3 is biased toward zero in regressions with r_t excluded. There is some theoretical ground for believing this effect to be present, but there is little evidence that nominal interest rates adjust to expected inflation with sufficient speed to maintain a constant real rate. Indeed, the evidence indicates a very slow adjustment. Fisher (1930, p. 418), who empirically investigated the relationship between interest rates and the change in prices for the United States and Great Britain, concluded: "The results suggest no direct and consistent connection of any real significance exists between P' [the actual rate of price change] and i [the rate of interest]." (The definitions in brackets were supplied by us.) A more recent study by Sargent (1969) corroborates Fisher's findings.

often alleged that during World War II appeals to patriotism increased the supply of labor to both the military and nonmilitary sectors. To account for this, some of our tests in Appendix I introduce a zero-one dummy variable, D_t , equal to one for 1941–45 and zero otherwise.¹⁴ Each of these variables, r_t , $\ln(a_t/M_t)$, and D_t , figures in (11) in a similar way, so that the reader should have no difficulty in determining the effect on the model of adding any, or any combination, of them.

To complete the construction of an operational supply hypothesis, it is necessary to postulate a mechanism by which the real wage and price anticipations, w_t^* and P_t^* , are formed. A full analysis of this problem involves two elements: the formulation in t of forecasts for periods $t + 1$, $t + 2$, . . . , and the construction of an index number based on these forecasts. Since we know in advance that this problem has no neat or illuminating solution, there is little incentive to conduct this analysis. Instead, we simply postulate the adaptive scheme:

$$\frac{w_t^*}{w_{t-1}^*} = \left(\frac{w_t}{w_{t-1}^*} \right)^\lambda e^{\lambda'}, \quad (12)$$

where $0 < \lambda < 1$, and where $e^{\lambda'}$ is added to permit an anticipated trend in real wages.

In logs, (12) becomes:

$$\ln(w_t^*) = \lambda \ln(w_t) + (1 - \lambda) \ln(w_{t-1}^*) + \lambda'. \quad (13)$$

Similarly, we assume that price anticipations are formed adaptively, with the *same* reaction parameter λ :

$$\ln(P_t^*) = \lambda \ln(P_t) + (1 - \lambda) \ln(P_{t-1}^*) + \lambda''. \quad (14)$$

Since we will allude to the trend term λ' at several points when interpreting our theoretical model and when evaluating our empirical results, we might mention that this term depends on major political and military events as well as the past development of prices. Its determination will not be examined in our study.

¹⁴ Insofar as D_t indexes patriotism, it reflects a rightward shift in the supply function, resulting in increased employment and lower average wages (other things equal). We will also regard D_t as an admittedly imperfect control for the effect of the draft. As a measure of the effect of the draft, it has a positive effect on employment and an uncertain effect on the wage rate. If all of the reluctant military personnel are from the nonmarket sector, the draft is simply a leftward shift in market demand with a depressing effect on wages. On the other extreme, if all of the coerced military personnel are from the nonmilitary market sector, the effect on average wages will depend on both the elasticity of labor demand in the nonmilitary sector and the difference between military pay rates and market rates. The effect of D_t will thus depend in an unknown way on patriotism and draft forces. It is our judgment that the net effect on wages will be negative; the effect on employment is positive.

Using a Koyck transformation to eliminate w_t^* and P_t^* between (11), (13), and (14) (with r_t and a_t/M_t deleted from [11] as discussed above), we obtain:

$$\begin{aligned} \ln(N_t/M_t) = & (\beta_0\lambda - \lambda'\beta_2 - \lambda''\beta_3) + (\beta_1 - \lambda\beta_2) \ln(w_t) \\ & - (1 - \lambda)\beta_1 \ln(w_{t-1}) + (1 - \lambda)\beta_3 \ln(P_t/P_{t-1}) \\ & + (1 - \lambda) \ln(N_{t-1}/M_{t-1}). \end{aligned} \quad (15)$$

Estimates of the parameters of (15) and its variants are reported in section VI.¹⁵

Since the labor-supply equation (15) is not homogeneous in current money wages and current prices, we might say that there is "money-illusion" in the supply of labor. We should stress, however, that this behavior is not "irrational," nor does it stem from ignorance concerning the course of prices. In (15), "money-illusion" results not from a myopic concentration on money values but from our assumption that the suppliers of labor are adaptive on the level of prices, expecting a return to normal price levels regardless of current prices, and from the empirical fact that the nominal interest rate does not change in proportion to the actual rate of inflation. With these expectations, it is to a supplier's advantage to increase his current supply of labor and his current money savings when prices rise.¹⁶

¹⁵ One need not view (12) and (13) as exact equations. We will subsequently introduce an error term in (15) and assume that the errors are serially independent. Under this assumption, error terms in (12) and (13) are necessarily serially dependent, and this dependence is broken by the Koyck transformation.

¹⁶ The assumption that price expectations are formed on the (trend corrected) level of prices as opposed to their rate of change is crucial to the predictions of our model, since it accounts for the "switch" in sign on the coefficients of the inflation term in passing from (11) to (14). The appropriateness of this assumption is, of course, an empirical question, but we wish to point out that the route we have taken has a long history. To illustrate, we quote first from Hicks (1946, pp. 270-71): "In order to explain the rigidity of wages, we have to assume in the parties to the wage bargain some sense of normal prices, hardly distinguished (perhaps) from 'just' prices. The rigidity of wages extends over precisely that time—it may be quite a long time—during which the parties concerned persuade themselves that changes in related prices (whether prices of the products of labour, or of the things labour buys) are temporary changes. Once they become convinced that these changes are permanent changes, there is a tendency for wages to change; in situations of extreme instability, when they have lost their sense of normal prices, negotiators have recourse to automatic sliding scales and the rigidity of money wages ceases altogether." Our treatment differs from Hicks' in its asymmetrical handling of suppliers and demanders. A still closer forerunner of our model is provided by Tobin (1952, p. 581): "Labor may have inelastic price expectations; a certain 'normal' price level, or range of price levels, may be expected to prevail in the future, regardless of the level of current prices. With such expectations, it is clearly to the advantage of wage earners to have, with the same current real income, the highest possible money income. For the higher their money incomes the greater will be their money savings and, therefore, their expected command over future goods."

In his celebrated study of hyperinflation, Cagan (1956) assumed that the expected

Since (15) rests on the expectations hypotheses (13) and (14) fully as much as on the utility theory underlying (11), it is evident that one can expect (15) to obtain *only* in an economy where wages and prices might plausibly be forecast as (13) and (14) assume. In particular, a marked and sustained change in the trend rate of inflation (from one value of λ'' to another) will lead households using (14) to consistently over- or under-forecast prices, in which case some other forecasting scheme would presumably be adopted. We think (13) and (14) are plausible for the period 1929–65 in the United States, although the average inflation rate is somewhat higher in the latter part of the period than in the former. But we wish to emphasize that the theory underlying (15) shows that it is altogether illegitimate to insert an arbitrary, fixed value of $\ln(P_t/P_{t-1})$ into (15) to obtain estimated long-run effects of inflation on labor supply.

III. Aggregate Marginal Productivity Condition for Labor

We assume an aggregate production function with constant elasticity of substitution, with constant returns to scale and labor-augmenting technological change. Let y_t be the real gross national product, N_t the employment variable used in the preceding section, K_t the economy's real capital stock, and Q_t an index of labor quality (in practice, a years-of-school-completed index).¹⁷ Then:

$$y_t = [a(Q_t N_t)^{-b} + c(K_t)^{-b}]^{-1/b}, \quad (16)$$

where a and c are positive, and $b > -1$. Then $\sigma = 1/(1 + b)$ is the elasticity of substitution. The marginal productivity condition for labor implied by (16) and profit maximization under competition can be written in the form:¹⁸

$$w_t = a Q_t \left(\frac{y_t}{Q_t N_t} \right)^{1+b}. \quad (17)$$

rate of price change was an exponentially weighted average of past inflation rates. Since his application involved monthly inflation rates comparable to the rate of price change per decade in our sample, there is no inconsistency between his practice and ours. Previous studies which used expectations adaptive on price *levels* include Nerlove's study of the supply of farm products (1958), and Lewis's study of union/nonunion wage determination (1963). More recent studies, such as Sargent (1969), have used hypotheses permitting both "extrapolative" (like Cagan's) and "regressive" (like ours) components in the expected inflation rate. In short, there is no empirical consensus on the formation of price expectations, nor indeed should there be, since inflation policies of governments vary over countries and over time and households are obliged to vary the way they form expectations accordingly.

¹⁷ While our basic model includes only labor-embodied technical change, we do not rule out other sources of technical change. In Appendix I we present results based on a constant elasticity of substitution production function which contains not only labor-embodied technical change but a neutral source of technical advance introduced by multiplying equation (16) by e^{at} .

¹⁸ See Arrow *et al.* (1961).

Taking logs and rearranging, (17) implies:

$$\ln(N_t) + \ln(Q_t) - \ln(y_t) = \sigma \ln(a) + \sigma[\ln(w_t) - \ln(Q_t)]. \quad (18)$$

Equation (17) is not a specialization of the marginal productivity condition (2); rather, it is obtained from (2) using the equality $k_t/m_t = f^{-1}(y_t/m_t)$ given by (1). The content of (16) and (17) is, of course, the same as the content of (16) and the form of (2) obtained from (16). The main virtue of (17) (or [18]) from our point of view is that it enables us to have some control over simultaneous equations problems in estimating the supply function without requiring time series on K_t .

Equation (18) is operational, and estimates of its parameters have been obtained. The use of (18), however, rests on the hypothesis that labor is a freely variable input. To the contrary, there is a good deal of evidence that varying labor entails adjustment costs and that this leads firms to adjust gradually to the level implied by (18) rather than attempting to maintain it continually through time.¹⁹ We shall not pursue the analysis of the maximum problem suggested by this remark but rather simply observe that it suggests a relation involving current *and* lagged output and employment, and the current real wage, which reduces to (18) under stationary levels of output and employment. Retaining the assumption of log linearity, this may be written:

$$\ln(Q_t N_t) = c_0 - c_1 \ln\left(\frac{w_t}{Q_t}\right) + c_2 \ln(y_t) + c_3 \ln(y_{t-1}) + c_4 \ln(Q_{t-1} N_{t-1}), \quad (19)$$

where c_0, \dots, c_4 satisfy:

$$c_0 = (1 - c_4)\sigma \ln(a), \quad c_1 = (1 - c_4)\sigma, \quad c_2 + c_3 = 1 - c_4. \quad (20)$$

Monotonic convergence at fixed wage rates implies:

$$0 < c_4 < 1, \quad (21)$$

¹⁹ The investment in firm specific on-the-job training is perhaps the single most important factor making it costly for firms to continuously adjust their work forces. Both Oi (1962) and Becker (1964) develop this argument to explain the quasi-fixity of labor inputs. Schramm (1967) treats labor and capital inputs symmetrically as partially fixed factors and finds that in the manufacturing sector lagged values of *both* variables affect current input decisions. There is also considerable evidence to suggest that the employment/output ratio rises during downturns and falls during upturns, an observation implying labor adjustment costs. However, there are wide differences among studies in the estimates of the short-run elasticity of labor inputs with respect to output. Using post-World War II quarterly data, estimates between 0.30 and 0.55 have been obtained by Wilson and Eckstein (1964) and Kuh (1965, 1966), but the estimated elasticity is quite sensitive to what is held constant in the regressions. McGuire (1968) has carefully documented this fact and has obtained estimates in the range 0.8 and 0.9 on quarterly data.

which implies that c_1 is positive. Using the last equality of (20) to eliminate c_3 puts (19) into the form:

$$\ln \left(\frac{Q_t N_t}{y_t} \right) = c_0 - c_1 \ln \left(\frac{W_t}{Q_t} \right) + c_4 \ln \left(\frac{Q_{t-1} N_{t-1}}{y_{t-1}} \right) + (c_2 - 1) \ln \left(\frac{y_t}{y_{t-1}} \right). \quad (22)$$

Estimates of the parameters of (22) are reported in section VI.

It is natural to interpret the presence of real output, y_t , in (22) as a measure of the impact of aggregate demand on the labor market. This interpretation is, however, fallacious, as should be clear from the discussion in section I. A fall (for example) in aggregate demand will involve a shift to the left in the *schedule* relating real output, y_t , and the price level, P_t . This event will appear to individual firms as a price decline or demand shift, and in response firms will vary output and labor input *simultaneously*. Our hypothesis states that, as this adjustment takes place, (22) will remain valid; it does *not* state that labor demand will respond to exogenous shifts in output.

In our empirical work, however, output is treated as an exogenous variable, which gives rise to a simultaneous equations problem. This difficulty cannot be resolved by obtaining labor demand as a function of capital stock, wages, and the price level. It is true that such an equation is entitled to be called a demand function for labor, as (22) is not, but since the price level is no more exogenous than is the level of real output a simultaneity problem would persist. In short, there is, in our view, no way to set up an aggregate labor-market model in which employment and wages are affected by other variables in the economy but do not in turn affect them.

IV. Measured Unemployment

The government generates an unemployment series based on the number of persons who answer "yes" to the question: "Are you actively seeking work?"²⁰ There is a strong temptation to assume that respondents to this survey take the question to mean, "Are you seeking work at the current wage rate?"—but it is important to recognize that this assumption is

²⁰ The unemployment series most often used is based on a census survey. Presently, unemployment is defined as follows: "Unemployed persons comprise all persons who did not work during the survey week, who made specific efforts to find a job within the past four weeks, and who were available for work during the survey week (except for temporary illness). Also included as unemployed are those who did not work at all, were available for work, and (a) were waiting to be called back to a job from which they had been laid off; or (b) were waiting to report to a new wage or salary job within 30 days" (quoted from U.S. Department of Labor 1968, p. 48).

simply a hypothesis the truth of which is far from obvious. In our model, it has been implicitly assumed that this interpretation is *not* correct, since the current wage is assumed to equate quantity demanded and quantity supplied exactly each period. In this section, we offer an alternative hypothesis about what it is people mean when they classify themselves as unemployed.

Our theory of the *market* behavior of suppliers of labor is developed in section II. We now return to this theory to see if it can also suggest a hypothesis about responses to the employment survey, but before doing so we make some general observations about wage rates and unemployment. First, an unemployed worker does not generally know what *his* current wage rate is. To find out, he must engage in a search over a variety of employment possibilities (and there are always *some*), always balancing the gains from further search against the gains from accepting a job at the best wage his search has turned up to date. As a guide in this search process, he must use some notion of his "normal" wage rate, based on wages in occupations in which he has formerly worked, wages of comparably skilled and aged workers, and so forth. The normal wage rate serves as a guide to job search. Once the searcher becomes convinced that his normal wage rate is lower than he originally thought, he may "bid" his money wage rate down by changing occupations or moving to a new location. Indeed, it is occupational or locational change which is the principal means whereby individuals can, in fact, cut their money wages. The search process may extend over a wide geographic area and may include search among many different potential occupations. It is not only a search for information concerning current job availabilities but concerning the future course of job development as well. Because information is limited and costly to acquire, and because action on the basis of acquired information sometimes requires large resource investments in moving and retraining, the suppliers of labor will adjust slowly.²¹

In the above discussion we speak as though everyone has a reasonably firm view of his "normal" wage rate. This of course is an oversimplification. However, those unemployed persons who can speak with the least ambiguity about *their* normal wage rates are those workers, primarily industrial, who have been *laid off*, as opposed to dismissed, from jobs formerly held. The term lay off has an explicit connotation of a temporary deviation from a normal or "permanent" situation.

²¹ Perhaps the clearest statement of the view that unemployment is essentially employment at job search can be found in Alchian and Allen (1967, pp. 494-524) and Mortensen (in press). While Alchian and Allen emphasize information lacunae and search costs as the source of lagged wage adjustments, another paper by Holt and David (1966) stresses a kind of psychological resistance to wage cuts in the form of an aspiration-level model which is combined with a search process to generate unemployment. The Alchian-Allen model is closely related to an earlier paper on information by Stigler (1961), while the Holt-David view is very much in the spirit of Simon's work (1957).

These observations, none of which is original with us, suggest strongly that the labor force as measured by the employment survey consists of those who are employed *plus* those who are unemployed but would accept work at what they regard as their normal wage rates (or, equivalently, in their normal occupation). In section II, we pointed out that the index w_t^* of anticipated future wages can be interpreted as a (trend corrected) measure of normal or permanent wages. According to (13), suppliers will regard the current real wage as normal (that is, will not revise their estimates of the height of the trend line of wages) provided $w_t = w_{t-1}^*$. Similarly, a normal price level may, using (14), be defined as P_t^* such that $P_t = P_{t-1}^*$. Using these definitions of normal wages and prices, we may evaluate the right side of (11) at these prices to define *normal labor supply* N_t^* :

$$\ln(N_t^*/M_t) = \beta_0 + \beta_1 \ln(w_{t-1}^*) - \beta_2 \ln(w_t^*) + \beta_3[r_t - \ln(P_t^*/P_{t-1}^*)] - \beta_4 \ln(a_t/M_t). \quad (23)$$

Then from (11) and (23):

$$\ln\left(\frac{N_t^*}{N_t}\right) = \beta_1 \ln\left(\frac{w_{t-1}^*}{w_t}\right) + \beta_3 \ln\left(\frac{P_{t-1}^*}{P_t}\right). \quad (24)$$

Since $\ln(N_t^*/N_t) \sim (N_t^* - N_t)/N_t^*$, the left side of (24) is a kind of unemployment rate. There are two reasons, however, why it might differ from the measured unemployment rates, U_t . First, many persons in the normal work force, N_t^* , may not report themselves as actively seeking work, especially teen-agers and women. Second, there is a frictional component of measured unemployment which cannot be captured by a variable which, like our N_t^* , is defined in terms of a representative household. Since there is good reason to believe that frictional unemployment varies positively with the nonfrictional component, it will not simply appear in (24) as an additive constant.²² To summarize these two forces, we assume that U_t and $\ln(N_t^*/N_t)$ are linearly related:

$$U_t = g_0 + g_1 \ln(N_t^*/N_t), \quad g_0, g_1 > 0, \quad (25)$$

then combining (24) and (25):

$$U_t = g_0 + g_1 \beta_1 \ln\left(\frac{w_{t-1}^*}{w_t}\right) + g_1 \beta_3 \ln\left(\frac{P_{t-1}^*}{P_t}\right). \quad (26)$$

²² The argument that frictional unemployment and nonfrictional unemployment do not additively determine aggregate unemployment is developed by Gaver and Rapping (1966) in terms of a stochastic job-search model with jobs being simultaneously created and destroyed.

Finally, using the Koyck transformation to eliminate w_t^* and P_t^* between (26), (13), and (14), we obtain:

$$U_t = (\lambda g_0 + \lambda' g_1 \beta_1 + \lambda'' g_1 \beta_3) - g_1 \beta_1 \ln \left(\frac{w_t}{w_{t-1}} \right) - g_1 \beta_3 \ln \left(\frac{P_t}{P_{t-1}} \right) + (1 - \lambda) U_{t-1}. \quad (27)$$

Equation (27) will be added to (15) and (22) to form the three-equation system which is discussed further below. In our view, it adds nothing to the theory of labor-market behavior contained in (15) and (22), but it has independent interest because of its resemblance to the now famous Phillips curve. (Indeed, defining a Phillips curve as any equality linking an inflation rate and unemployment with a negative correlation, (27) is a Phillips curve.) The derivation of (27) from the labor-supply theory of section II, together with a behavioral hypothesis introduced in this section, leads to some strong warnings as to the empirical performance one should expect from this Phillips curve and the policy implications one should draw from it.

First, the trend rates of change in real wages and prices (λ' and λ'') appear in the constant term of (27). Hence, there is no reason to expect stability of the Phillips curve across countries with different inflation rates or rates of productivity change, or in time series on a single country where these trends change sharply. Similarly, changes in the trend rate of inflation will induce a counteracting shift in the Phillips curve, so that (27) in no sense exhibits a "trade-off" offering arbitrarily low unemployment rates to a country which will tolerate sufficiently high rates of inflation. (It should be emphasized, of course, that these assertions about the way in which households perceive and adjust to changes in trend rates of inflation are not supported empirically by this study. We *test* [13] and [14], which refer to reactions to deviations from trend rates of change, and *assume* that expected trends would be revised, given sufficient cause.)

If we are correct in assuming that the expected trend rate of inflation, λ'' , would eventually adjust to a sustained actual rate of inflation, then there is an important sense in which there is a relevant trade-off between unemployment today and unemployment tomorrow, a proposition suggested by Friedman (1968). To illustrate the point, consider figure 1. Assume that there has been a *sustained* rate of inflation of 2 percent so that the expected trend rate of inflation, λ'' , equals 0.02. Let U_t^* be the steady state value of U_t from (27). This value is g_0 when $\lambda' = \Delta \ln w_t$. Now let $\Delta \ln P_t$ rise to 0.03, and let it be maintained at this new level. From figure 1 we see that unemployment will fall to U_t^* , but now the suppliers of labor are consistently underestimating the price level (recall, $P_{t-1}^* < P_t$ when $\Delta \ln P_t > 0$). Consequently, λ'' will eventually rise to 0.03, and then unemployment will return to U^* (see [27]). If, on the other hand, a sustained

Rate of
Inflation

$$\Delta \ln P_t$$

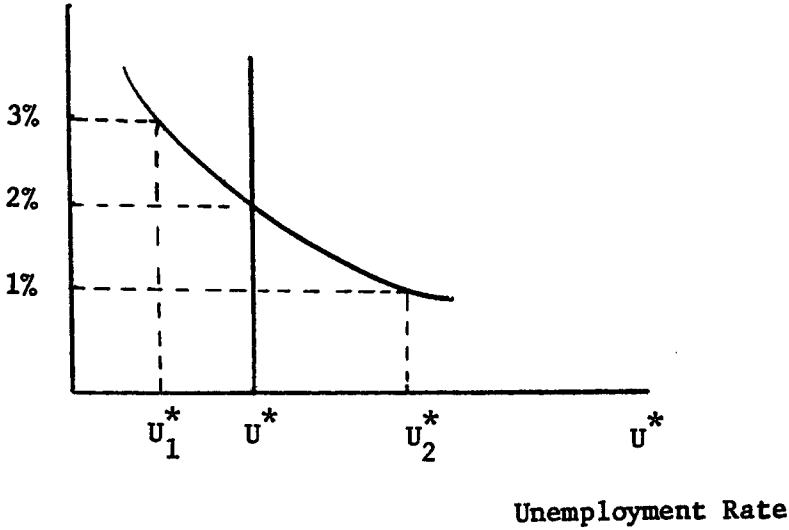


Fig. 1

2 percent inflation is followed by a *sustained* 1 percent inflation, unemployment will *increase* to U_2^* , but eventually it will return to U^* . It appears that a policy designed to sustain an inflation can temporarily reduce unemployment, but unless the higher rate of increase in prices can be permanently maintained a subsequent attempt to return to the original rate of inflation will result in an offset to the initial employment gains.²³

V. Summary Statement of the Model

In this section, the model developed in sections II–IV is restated in econometric form with a uniform notation. The restrictions on the regression coefficients implied by the theory are summarized, and estimation is discussed.

²³ Our argument that there is no *long-run* employment-inflation trade off is based on theoretical considerations. In another study (Lucas and Rapping, in press), we attempt to empirically verify this position within the framework of a more general price expectations model than equation (14).

The marginal productivity condition for labor, corresponding to (22), is:

$$\ln \left(\frac{Q_t N_t}{y_t} \right) = \beta_{10} - \beta_{11} \ln \left(\frac{w_t}{Q_t} \right) + \beta_{12} \ln \left(\frac{Q_{t-1} N_{t-1}}{y_{t-1}} \right) + \beta_{13} \ln \left(\frac{y_t}{y_{t-1}} \right) + u_{1t}, \quad (28)$$

where:

$$\beta_{11} > 0, \quad 0 < \beta_{12} < 1, \quad (29)$$

and where u_{1t} is a random error.

The labor supply function corresponding to (15) is:

$$\ln \left(\frac{N_t}{M_t} \right) = \beta_{20} + \beta_{21} \ln (w_t) - \beta_{22} \ln (w_{t-1}) + \beta_{23} \ln \left(\frac{P_t}{P_{t-1}} \right) + \beta_{24} \ln \left(\frac{N_{t-1}}{M_{t-1}} \right) + u_{2t}, \quad (30)$$

where:²⁴

$$0 < \beta_{21} < \frac{\beta_{22}}{\beta_{24}}, \quad \beta_{22} > 0, \quad \beta_{23} > 0, \quad 0 < \beta_{24} < 1, \quad (31)$$

and where u_{2t} is a random error.

The unemployment-rate function, corresponding to (27), is:

$$U_t = \beta_{30} - \beta_{31} \ln \left(\frac{w_t}{w_{t-1}} \right) - \beta_{32} \ln \left(\frac{P_t}{P_{t-1}} \right) + \beta_{33} U_{t-1} + u_{3t}, \quad (32)$$

where:

$$\beta_{31} > 0, \quad \beta_{32} > 0, \quad 0 < \beta_{33} < 1, \quad (33)$$

$$\beta_{31}/\beta_{32} = \beta_{21}/\beta_{23}, \quad \beta_{33} = \beta_{24}, \quad (34)$$

and where u_{3t} is a random error.

The error vectors (u_{1t}, u_{2t}, u_{3t}) , $t = 1, \dots, T$, are assumed to be independent and identically distributed, with a finite covariance matrix, and a mean vector $(0, 0, 0)$. The variables Q_t , y_t , M_t , and P_t are taken to be exogenous;²⁵ the endogenous variables are N_t , w_t , and U_t . All three equations are overidentified.

²⁴ The prediction that $\beta_{21} > 0$ follows from considerations raised in section I rather than in section II: since β_{21} is the short-run labor-supply elasticity, it must be positive for the aggregate supply function of goods to have the upward slope assumed in section I. The inequality $\beta_{21} < \beta_{22}/\beta_{24}$ follows from $\beta_{22} > 0$, which is implied by the argument of section II. Also note that since $\beta_{22} > 0$ follows from other predictions in (31), (31) contains five (not six) independent restrictions.

²⁵ We have already discussed the assumption that y_t and P_t are exogenous. On the other hand, we think of M_t and Q_t as predetermined variables. The current population and its quality are the result of past decisions which, of course, depend in part on past real wage rates.

The reduced-form equations for w_t and N_t/M_t implied by (28) and (30) are:

$$\ln(w_t) \left. \vphantom{\ln(w_t)} \right\} = \pi_{i0} + \pi_{i1} \ln(w_{t-1}) + \pi_{i2} \ln\left(\frac{P_t}{P_{t-1}}\right) \quad (35)$$

$$\ln\left(\frac{N_t}{M_t}\right) \left. \vphantom{\ln\left(\frac{N_t}{M_t}\right)} \right\} = \pi_{i0} + \pi_{i1} \ln(w_{t-1}) + \pi_{i2} \ln\left(\frac{P_t}{P_{t-1}}\right) \quad (36)$$

$$+ \pi_{i3} \ln\left(\frac{y_t}{M_t}\right) + \pi_{i4} \ln(Q_t) + \pi_{i5} \ln\left(\frac{Q_{t-1}N_{t-1}}{y_{t-1}}\right)$$

$$+ \pi_{i6} \ln\left(\frac{y_t}{y_{t-1}}\right) + \pi_{i7} \ln\left(\frac{N_{t-1}}{M_{t-1}}\right) + \epsilon_{it},$$

where $i = 1$ for (35) and $i = 2$ for (36). The restrictions on $\pi_{i0}, \dots, \pi_{i7}, \pi_{20}, \dots, \pi_{27}$ implied by (29) and (31) are:

$$\pi_{11} > 0, \quad \pi_{12} < 0, \quad \pi_{13} > 0, \quad \pi_{16} > 0, \quad \pi_{17} > 0, \quad (37)$$

and:

$$\pi_{21} < 0, \quad \pi_{22} > 0, \quad \pi_{23} > 0, \quad \pi_{25} > 0, \quad \pi_{27} > 0. \quad (38)$$

In addition, the hypothesis that the difference equations (35) and (36) are stable, which was first introduced in the discussion of section I, requires that the real parts of the roots of

$$x^2 - (\pi_{11} + \pi_{27})x + (\pi_{11}\pi_{27} - \pi_{17}\pi_{21}) = 0 \quad (39)$$

be less than one in absolute value. (If all the information in the structure were imposed on the reduced form, this quadratic would have one zero root and one nonzero real root.)

The estimated reduced-form coefficients will, under our assumptions, be consistent estimators of the true coefficients and asymptotically normally distributed when estimated by ordinary least squares. We have estimated the coefficients of (28), (30), and (32) using two-stage least squares, which involves using only (35) of the reduced form. The estimated structural coefficients will also be asymptotically normal. In addition to the coefficients and their standard errors, we report the multiple correlation coefficient and the Durbin-Watson statistic. The latter is included as a rough measure of serial correlation, although nothing is known about its distribution in models such as ours.

VI. Results

In this section, we report estimates of the parameters of equations (28), (30), (32), (35), and (36), and tests of the hypotheses (29), (31), (33), (34),

(37), and (38).²⁶ These estimates were obtained from aggregate, U.S. time series covering the years 1930–65. Employment is man-hours engaged in production per year in the civilian and government sectors. The money wage rate is compensation per man-hour, a measure which includes wages and salaries, and public and private fringes. The price level is the GNP implicit price deflator. Real output is GNP in constant dollars. Labor quality is an index of years of school completed. Population is an index of the number of households, corrected for changes in age-sex composition.²⁷

²⁶ Formally, we regard (28), (30), and (32), together with the assumptions on the error vectors, as a maintained hypothesis, and we wish to test the hypothesis that the parameters β_{11} , β_{12} , β_{21} , β_{22} , β_{23} , β_{24} , β_{31} , β_{32} , and β_{33} lie in that subset of nine-dimensional space satisfying (29), (31), (33), and (34). (The matter is further complicated if we test rather than assume the serial independence of the errors.) In lieu of a generally accepted test of hypotheses of this sort, we shall summarize and evaluate our results from several points of view using the customary “*t*-statistics” as measures of precision. Hence our conclusion that our model is “consistent with the 1929–65 data . . . and with several related empirical studies” (p. 747 below) should be regarded as a careful but informal conclusion on our part, *not* as a consequence of any single, formal, statistical test.

²⁷ The data used in this study are available upon request. The series on measured unemployment is from Lebergott (1964) and the Manpower Report (U.S. Department of Labor 1967, p. 201). The Moody’s Aaa rate (used later) is from the President’s Economic Report (Council of Economic Advisers 1967, p. 272). Gross national product, the implicit GNP deflator, compensation per full-time equivalent employee, and persons engaged were all taken from Survey of Current Business sources (U.S. Department of Commerce 1966, pp. 2, 90, 102, 110, 158). The man-hour series is the product of the number of persons engaged in production reported by the Department of Commerce times annual hours worked per year by full-time employees for the whole economy as reported by Denison (1962, p. 85). Denison’s series was extended beyond 1958 by regressing his series on the Bureau of Labor Statistics (BLS) weekly manufacturing hours series (U.S. Department of Labor Statistics 1966, p. 44) for the years 1929–58. Then, this regression equation was used in conjunction with known BLS manufacturing hours data to predict hours for the whole economy for 1959–65. Compensation per man-hour was obtained by dividing annual compensation per full-time equivalent employee by annual man-hours worked by full-time employees. The index of labor quality is taken from Denison (1962, p. 85). His data were available from 1929–58 and were extended by a simple linear extrapolation. The aggregate supply of labor, N_t , was deflated by a variable which accounts for changes in the total supply of labor due solely to changes in the total number of households *as well as* the joint age-sex distribution of the population. The nominal nonhuman asset variable, A_t (used later), should be deflated by an index of the number of households only. However, because our age-sex corrected population series was roughly proportional to the population over fourteen years of age, we deflated both N_t and A_t by the same index, M_t . In constructing M_t , let L_{0i} = the labor force in the zero period of the i th age-sex group, and let P_{0i} = the population of the i th group again in the zero period. Then we define our population index as

$$M_t = \sum_{i=1}^n \left(\frac{L_{0i}}{L_0} \right) \left(\frac{P_{1i}}{P_{0i}} \right)$$

where

$$L_0 = \sum_{i=1}^n L_{0i}.$$

This index has two simple and equivalent interpretations. First, it is a weighted average of the percentage increase in the population of each age-sex cohort, the weights

The estimated reduced-form coefficients (equations [35] and [36]) appear in lines 4 and 5 of table 1. The five hypotheses (37) on the coefficients of the equation for $\ln(w_t)$, (35), are *all* confirmed at the .005 level using the relevant one-tail test of significance. Of the five hypotheses (38) on the coefficients of the equation for $\ln(N_t/M_t)$, (36), only one is confirmed at the .05 level: $\hat{\pi}_{17} > 0$ as predicted. The other four are neither confirmed nor contradicted, the estimated coefficients being insignificantly different from zero. Good fits were obtained on both equations; serial correlation appears to be absent. The two roots of the quadratic (39) are complex conjugates with real parts equal to 0.68, confirming (but with no statistical significance) the predicted stability of these difference equations. In summary, of the ten sign implications placed by the theory on the reduced form, six are confirmed at the .05 level; four are neither confirmed nor contradicted. Equation (35) strikingly out performs (36).

The estimated structural coefficients (equations [28] and [30]) appear on lines 1 and 2 of table 1. Tests on these coefficients are not, of course, independent of the reduced form tests just discussed, since the predictions on the structure imply those on the reduced form. But the converse of this statement is *not* true, so that a comparison of the estimates with (29) and (31) does provide additional information as to the validity of the model.

The three predictions (29) on the marginal productivity condition (28) are confirmed at the .005 level. The fit on this equation is good, and there appears to be no evidence of serial correlation. The coefficient on $\Delta \ln y_t$ is also different from zero, indicating that one cannot add an additional (to [20]) restriction on the coefficients in this equation without a significant loss in explanatory power.

The five predictions (31) on the labor-supply function (30) are also all confirmed at the .005 level. The fit on this equation is reasonably good. There is some slight indication of positive serial correlation.

Estimates of the employment-rate function (32) are reported on line 3 of Table 1. Three of the four predictions (33), which are independent of

being the percentage of the base year labor force who are members of the particular age-sex group. Second, writing the index as

$$M_t = \frac{1}{L_0} \sum_{i=1}^n \left(\frac{L_{0i}}{P_{0i}} \right) P_{1i},$$

we interpret it as the relative increase in the labor force that would have occurred because of the change in population if the base period participation rates had remained unchanged. The index i covers six age-sex groups—males and females separately for age groups 14–20, 20–65, and 65 and over. We used the 1947–49 arithmetic average of reported participation rates taken from the Manpower Report (U.S. Department of Labor 1965, p. 202). The figures include the armed forces and institutional population. The population data are taken from Current Population Reports (U.S. Department of Commerce), and these data include estimates of overseas military personnel. Prior to 1940 it was assumed that there were 150,000 overseas personnel; subsequent to that date the above sources included overseas personnel.

TABLE 1
LABOR MARKET MODEL I REDUCED FORM, SUPPLY, DEMAND, AND
UNEMPLOYMENT RATE ESTIMATES USING TWO-STAGE LEAST-SQUARES PROCEDURES
(TIME SERIES 1930-65)

EQUATION AND DEPENDENT VARIABLE	INDEPENDENT VARIABLES											R^2 and d^a
	Constant	$\ln w_t$	$\ln w_{t-1}$	$\Delta \ln P_t$	$\ln(N/M)_{t-1}$	$\ln(\psi_t/Q_t)$	$\ln(NQ/P)_{t-1}$	$\ln(\psi_t/w_t-1)$	$\Delta \ln \gamma_t$	U_{t-1}	$\ln Q_t$		$\ln(y/M)$
Supply: $\ln(N/M)_t$	3.81 (.93)**	1.40 (.51)**	-1.39 (.51)**	0.74 (.17)**	0.64 (.09)**	...	...	...	...	...	...	0.798 1.56
First order condition on labor: $\ln(NQ/P)_t$	-2.21 (.70)**	...	...	...	...	0.58 (.11)**	...	-0.21 (.04)**	...	...	...	0.993 1.84
Unemployment rate function: U_t	0.042 (.010)**	...	...	-0.59 (.08)**	...	...	...	...	0.80 (.05)**	...	...	0.925 1.50
Reduced form wage: $\ln w_t$	-15.65 (3.50)**	...	0.44 (.17)**	-0.22 (.07)**	-1.15 (.45)**	1.24 (.44)**	-0.41 (.24)*	...	...	0.27 (.55)	1.25 (.44)**	0.997 2.26
Reduced form employ- ment: $\ln(N/M)_t$	11.60 (3.50)**	...	0.08 (.17)	0.06 (.07)	0.91 (.45)*	-0.39 (.44)	...	0.80 (.45)	...	-1.02 (.55)*	0.02 (.44)	0.976 1.73

NOTE.— N = man-hours per year, M = population over fourteen years of age with constant age-sex distribution, Q = index of labor quality as measured by years of school completed, U = fraction of the labor force unemployed, w = real compensation per man-hour, P = implicit GNP deflator, y = real GNP.
^a All R^2 are adjusted for degrees of freedom.
 * One-tail significance at .05 test level (except for intercepts $\Delta \ln \gamma_t$ and $\ln Q_t$ which are two-tail tests).
 ** One-tail significance at .005 test level (except for intercepts $\Delta \ln \gamma_t$ and $\ln Q_t$ which are two-tail tests).

any implications tested elsewhere, are confirmed at the .005 level; the fourth is confirmed at the .05 level. The estimated ratios $\hat{\beta}_{31}/\hat{\beta}_{32}$ and $\hat{\beta}_{21}/\hat{\beta}_{23}$, which are predicted to be equal in (34), are, respectively, 0.70 and 1.89. To get a rough idea of the significance of this difference, one may use the approximation

$$SE\left(\frac{\hat{\beta}_{31}}{\hat{\beta}_{32}}\right) \sim \frac{SE(\hat{\beta}_{31})}{\hat{\beta}_{32}},$$

where $SE(\)$ denotes standard error, which is valid for large samples and similarly for the standard error of $\hat{\beta}_{21}/\hat{\beta}_{23}$. This gives standard error estimates of 0.41 and 0.69, respectively. Hence it seems unlikely that the observed difference is significant at the .05 level. Finally, $\hat{\beta}_{33}$ and $\hat{\beta}_{24}$, whose equality is also predicted in (34), are, respectively, 0.80 and 0.64 with standard errors of .05 and .09, respectively. In summary, (32) is a satisfactory Phillips curve, and, further, the predicted link between (32) and the rest of the model appears to be consistent with the data.

In reviewing these results, the reader should be aware, as we are, that the absence of small sample tests and the arbitrary nature of the choice of significance levels makes the test results less easy to interpret than our rather formal summary might suggest. Further, as discussed below, many variants of the basic model were also tested. Finally, many predictions of "our" theory are also predictions of virtually any plausible theory (for example, the prediction that unemployment rates are positively correlated with their own lagged values). But we wish to emphasize that the configuration of signs predicted by (29), (31), and (33) is only one of $(2)^6(3)^3 = 1728$ possible outcomes. The theory has thus provided us with an extremely sharp prediction on the way the variables examined are related, and these predicted relationships have been confirmed by the 1930–65 data.

As a second, informal, way of evaluating our results as well as an aid in interpreting them, it will be useful to compare them with results of previous studies with which ours overlap. First, from the estimated supply-function parameters, one may compute long- and short-run elasticities with respect to the real (or money) wage rate. The estimated long-run elasticity is $(1 - \hat{\beta}_{24})^{-1}(\hat{\beta}_{21} - \hat{\beta}_{22}) = (1.40 - 1.39)/0.36 = 0.03$, or essentially zero. This finding indicates that the neoclassical growth model assumption of a zero labor-supply elasticity is approximately correct. Further, the Keynesian-type assumption of a relatively elastic short-run supply schedule is also confirmed, using the estimate $\hat{\beta}_{21} = 1.40$.

From the marginal productivity condition for labor, the statistic $(1 - \hat{\beta}_{12})^{-1}\hat{\beta}_{11} = 0.46/0.42 = 1.09$ is an estimate of the aggregate elasticity of substitution. This estimate is broadly consistent with the variety of cross-sectional estimates which are available and generally higher than other

time-series estimates.²⁸ Since aggregation introduces increased possibilities for substitution in consumption between goods of different factor intensities as well as substitution in production of each good, this latter result is perhaps not surprising. The long-run elasticity of employment with respect to output has been constrained in (28) to be unity. The short-run elasticity has been left free to vary, however, and is estimated to be $1 - \hat{\beta}_{13} = 0.79$. In the sense that labor inputs appear to be quasi-fixed with respect to short-run output changes, this finding is consistent with those of Wilson and Eckstein (1964), Kuh (1966), and McGuire (1968), although since different variables are controlled for in each case this fact provides little information.

The estimated reduced-form equation for the real wage rate provides a third point of contact with earlier studies.²⁹ The effect of inflation on real wages has been a subject of concern to economists for some time. This concern has been motivated by interest in the wage-lag doctrine according to which real wages fall during inflationary periods. Hamilton (1952), Hansen (1925), and Mitchell (1903), each studying a different historical period, all argued for the wage-lag hypothesis, and all of these writers suggest that the wage lag results from some form of "money-illusion" or contract fixity.

Mitchell (1903), and later Lerner (1956), both argued that the decline in real wages during the Civil War was a result of monetary inflation. Later Kessel and Alchian (1959) reinterpreted the northern experience in the Civil War, arguing that real, not monetary factors, account for the decline in real wages between 1860 and 1865 (without, however, controlling simultaneously for real and monetary variables). Examining a different historical period, these writers (Kessel and Alchian 1960) were again unable to uncover any evidence in support of the wage-lag hypothesis. For the post-World War II inflation, they examined profit rates in high labor cost industries relative to profit rates in low labor cost industries, and they could not find a systematic difference in the behavior of profits in the two groups of industries. Our empirical results are not consistent with these findings. For the period 1930-65, we find that the partial effect of inflation on real wages is negative and quantitatively significant. A 10 percent

²⁸ Both the time-series and cross-section CES production function studies are summarized and discussed by Nerlove (1965). Additional CES time-series production-function estimates can be found in a study by Lucas (1964).

²⁹ One should be cautious in interpreting this equation. In particular, although the coefficient of $\ln Q_t$ is apparently near zero, this should *not* be interpreted to mean that changes in labor quality do not affect real wages, since our real income variable already includes the secular wage effect of improvements in labor quality as well as other sources of technical change. For this reason there is an important sense in which our model does not "explain" the secular growth in real wages. Similarly, note that the population variable like the income variable also affects real wage movements but is left unexplained in our model.

increase in prices will result in a 2.2 percent decline in real wages, and this result is based on a model which controls for real factors in the form of the variable output per capita, (y_i/M_i) .³⁰

To this point, we have been concerned exclusively with a single model, which has been found to be consistent with the 1929–65 data we used, and, in a general way, consistent with several previous related empirical studies. As remarked at several points above, this model is but one variant of the class of models suggested by our theory. Other variants are obtained by adding different combinations of asset variables, nominal interest rates, and a dummy variable to control for wartime phenomena. In addition, models based on a different price-and-wage expectations hypothesis were tested. These results are tabulated and discussed briefly in Appendix I.

There are three important reasons for including these additional results. First, since our discussion of the tests in this section emphasizes the small probability that our predictions could have been confirmed “by chance,” we are anxious to make clear that the predicted configuration of coefficient signs is confirmed in all the variants estimated. Second, our selection of the model reported in this section as the “best” of those estimates was made on informal and tenuous grounds. Finally, many coefficient estimates vary rather widely depending on which other variables are included, so that the standard errors reported in table 1 overstate considerably the accuracy of these estimates.

VII. Summary and Conclusions

The aim of this study has been to construct and test an aggregative model of the U.S. labor market. On the demand side of this market, we employed a variant of the widely used marginal productivity condition based on a constant elasticity of substitution production function. The aggregate supply function tested was suggested by a Fisherian two-period model of a representative household. This theory views suppliers of labor as reacting primarily to three variables: an anticipated “normal” or “permanent” real wage rate, which corresponds to the wage rate in the usual one-period analysis of the labor-leisure choice and has a negligible effect on labor supply; the deviation of the current real wage from this normal rate, which has a strong, positive effect on labor supply; and the deviation of the price level from its perceived “normal” trend, which also has a strong positive effect on labor supply.

This labor-supply theory has been shown to resolve two apparent contradictions in the economic theory of labor markets. First, as stressed in

³⁰ Kessel and Alchian (1962) have argued that even when inflation is fully anticipated, real wages may still decline, *ceteris paribus*, because firms will shift to more capital-intensive processes which reduces the demand for labor.

the introduction and in section I, it is consistent both with the observed wage inelasticity of labor supply in the long run and with short-run fluctuations in employment, which require an elastic labor supply. Second, by regarding the labor-supply choice as depending on a multiperiod decision problem, "money illusion," in the sense of a supply function which is *not* homogeneous of zero degree in *current* money wages and prices, is reconciled with rational behavior on the part of households.

As a corollary to the supply theory utilized in this paper, the survey-measured labor force (as used to compute unemployment rates) is viewed *not* as an effective market supply, part of which cannot find employment, but rather as the supply of labor which *would be forthcoming* at perceived normal wages and prices. Measured unemployment (more exactly, its non-frictional component) is then viewed as consisting of persons who regard the wage rates at which they could currently be employed as temporarily low and who therefore choose to wait or search for improved conditions rather than to invest in moving or occupational change. The view that non-frictional unemployment is, in this sense, "voluntary" does not of course imply that high measured-unemployment rates are socially costless. Rather, it implies that economic fluctuations are costly, not simply because they induce idleness but because they lead workers as well as capitalists to make investments (in moving, training, and so forth) on the basis of perceived rates of return which cannot in fact be sustained.

We conclude with a brief mention of two problems which we regard as central to an understanding of labor markets and which our study *cannot* be used to answer. One is tempted to use our estimated structural equations to study the dynamics of the labor-market response to changes in prices and output. As we have stressed at several points above, however, this question is illegitimate: movements over time in labor-market variables will be determined simultaneously with changes in other sectors. Thus, while we know that our model is consistent with a gradual approach to full employment equilibrium, we cannot say whether or not the speed of approach is consistent with the observed business cycle. Second, our model emphasizes the crucial role of expectations formation, while testing only the very crudest expectations model. We have used an adaptive scheme which will clearly hold only under reasonably stable rates of price increase. To define what is meant by reasonable stability, and to discover how expectations are revised when such stability ceases to obtain, seem to us to be a crucial, unresolved problem.

Appendix I

Additional Results

As indicated in section VI, several versions of the basic model have been tested. We refer to the model reported in section VI as model 1; models 2 through 9 are described below.

Our basic model omits interest rates, real nonhuman assets per family, and the wartime zero-one dummy variable from the supply equation. Given our expectations assumption, each variable must be introduced by using both the current and one-period lagged value. In models (2) through (4), each variable is introduced separately.

We have also experimented with an alternative expectations hypothesis. Models (5) through (8) are the same as models (1) through (4) except that anticipated real wages and prices are formed in the following simple ways:

$$\ln w_t^* = \lambda \ln w_t + (1 - \lambda) \ln w_{t-1} + \lambda', \quad (\text{A1})$$

and

$$\ln P_t^* = \mu \ln P_t + (1 - \mu) \ln P_{t-1} + \mu', \quad (\text{A2})$$

where $0 \leq \lambda \leq 1$, and $0 \leq \mu \leq 1$, and λ' and μ' are the expected trend rates of growth. Substituting (A1) and (A2) into the labor-supply equation (11), we obtain a different equation from (15). In particular, except for w_{t-1} and P_{t-1} , there are no other lagged independent variables nor does the lagged dependent variable appear. With this formulation there remains considerable statistical evidence as indexed by the d statistic of serial correlation in the residuals.

Model (9) is the same as model (1) except that a time variable is added to the first-order condition and both reduced forms. We interpret this variable as an index of technical change.

Space limitations prevent us from discussing each estimated model in as complete a detail as we have done for model (1). However, tables similar to table 1 are contained in the Lucas-Rapping chapter in Phelps *et al.* (in press), and each reader is free to tabulate or summarize those aspects of our results which he thinks are most relevant. We have chosen to summarize our statistical results by stressing the estimated short- and long-run elasticity of labor supply and the effect of inflation on the supply of labor. The relevant supply elasticities for all of the models—(1) through (9)—are summarized in table A1. We will also summarize the overall “goodness-of-fit” of our models by tabulating the number (and proportion) of statistically significant reduced-form estimates as well as a separate tabulation for the structural estimates. This is done in table A2.

TABLE A1

SOME HIGHLIGHTS OF SUPPLY EQUATION ESTIMATES FOR MODELS (1) THROUGH (9)

MODEL	SHORT-RUN LABOR SUPPLY ELASTICITY	LONG-RUN LABOR SUPPLY ELASTICITY	EFFECT OF INFLATION ON LABOR SUPPLY	VARIABLES HELD CONSTANT
1 . . .	1.40**	0.03	0.74**	$(N/M)_{t-1}$
2 . . .	1.35**	0.03	0.70**	$(N/M)_{t-1}, r_t, r_{t-1}$
3 . . .	0.78**	0.12	0.49**	$(N/M)_{t-1}, D_t, D_{t-1}$
4 . . .	1.12*	0.58	0.68**	$(N/M)_{t-1}, a_t/M_t, a_{t-1}/M_{t-1}$
5 . . .	3.93**	0.03	1.14**	...
6 . . .	3.59**	0.04	1.03**	r_t
7 . . .	2.11**	0.10	0.55*	D_t
8 . . .	2.93**	-0.07	1.04**	a_t/M_t
9 . . .	1.13*	0.01	0.72**	$(N/M)_{t-1}$

* One-tail significance at .05 level.

** One-tail significance at .005 level.

TABLE A2
SUMMARY OF ESTIMATES FOR MODELS (1) THROUGH (9)

MODEL	NO. OF SIGNIFICANT REDUCED FORM ESTIMATES COMPARED TO TOTAL	NO. OF SIGNIFICANT STRUCTURAL ESTIMATES COMPARED TO TOTAL
1	6/10	9/9
2	5/14	9/11
3	5/14	10/11
4	1/14	8/11
5	5/8	7/7
6	7/10	7/8
7	6/10	8/8
8	3/10	7/8
9	6/10	9/9

When the Moody's Aaa interest rate and its lagged value are added to the supply equation (model [2]), the short- and long-run supply elasticity is practically unchanged as compared to that obtained in model (1). And since the estimated effect of inflation is also unchanged, it would appear that omitting the interest rate variable does not seriously bias the remaining coefficient estimates. However, we do not attach special importance to this result because we have serious reservations concerning the meaning of the Aaa rate as an index of the rate relevant to households.

When the current and lagged interest rate variables are replaced by the current and lagged wartime dummy variable (model [3]), the results are broadly consistent with our supply theory. But there is an important difference between model (3) and model (1) in that the estimated short-run real wage elasticity and the inflation-elasticity estimates are smaller in model (3) than in model (1). While the point estimates are significantly different in an economic sense, they are not significantly different from each other at the 5 percent *t*-test level. The point estimates on the dummy coefficient indicate a quantitatively important wartime effect—the supply of labor rose by 12 percent because of the war. This may reflect a patriotism effect.

We have made no attempt to construct our own nonhuman household-wealth series. Instead we have used three different readily available series on nominal, nonhuman wealth—and deflated these series by the implicit GNP deflator and by our population index to obtain (a_i/M_i) in (11). Model (4) is based on the Meltzer wealth series.³¹ The Meltzer wealth series was obtained directly from Professor Meltzer (1963). This series is for reproducible wealth less government reproducible wealth plus government debt. It covers the period 1930–58, and, therefore, models (4) and (8) are based on only twenty-nine observations. In model (4) the addition of nonhuman wealth per capita increases the estimated long-run supply elasticity. However, this finding is based on a model in which the estimated asset coefficients are insignificantly different from zero in both the structural equations and the reduced forms.

Estimates of the real wage and inflation coefficients for models (5)–(8) are summarized in table A1. On the whole, the assumption that only the present

³¹ Similar results were obtained with the Ando–Brown (1964, p. 20) and Chow (1966) series. Upon request, results using these series are available.

and the recent past influence the formation of expectations generates larger estimates of short-run supply elasticities than were previously obtained.

Model (9) yields supply elasticities similar to model (1). An examination of the estimated first-order condition indicates that all of the production-function conclusions are practically unchanged when a time variable is added.

In table A2 we show the ratio of the number of significant reduced-form and structural coefficients to the total number estimated. In this summary, we omit all of the coefficients for which our theory does not predict the signs. This includes the estimated coefficients for the intercept, the change-in-income variable, the labor-quality variable, and the time variable.

The summary results in table A2 suggest to us that among a broad class of models using the same general body of time-series data, "significant" results are almost always obtained. And, broadly speaking, conclusions concerning the effect of transitory and permanent wage changes as well as inflation on the supply of labor remain intact regardless of which model we use.

References

- Alchian, A., and Allen, W. *University Economics*. Belmont, Calif.: Wadsworth, 1967.
- Ando, A., and Brown, E. C. "Lags in Fiscal Policy." *Stabilization Policies*. Englewood Cliffs, N.J.: Prentice-Hall, 1964.
- Arrow, K. J.; Chenery, H. B.; Minhas, B. S.; and Solow, R. M. "Capital-Labor Substitution and Economic Efficiency." *Rev. Econ. and Statis.* 43 (August 1961): 225-50.
- Becker, G. S. *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education*. New York: Nat. Bur. Econ. Res., 1964.
- Black, S. W., and Russell, R. R. "The Estimation of Potential Labor Force and GNP." Paper presented at the Econometric Society meetings, Winter 1966, at New York.
- Bowen, W. G., and Finegan, T. A. "Labor Force Participation and Unemployment." In *Employment Policy and the Labor Market*, edited by A. M. Ross. Berkeley: Univ. Calif., 1965.
- Bronfenbrenner, M. "A Guidepost-Mortem." *Indus. Labor Relations Rev.* 20 (July 1967): 637-50.
- Bronfenbrenner, M., and Holzman, F. D. "Survey of Inflation Theory." *A.E.R.* 53 (September 1963): 593-661.
- Cagan, P. "The Monetary Dynamics of Hyperinflation," in *Studies in the Quantity Theory of Money*, edited by M. Friedman. Chicago: Univ. of Chicago Press, 1956.
- . "Theories of Mild, Continuing Inflation: A Critique and Extension," in *Inflation: Its Causes, Consequences, and Control*, edited by S. W. Rousseas. New York, 1968.
- Cain, G. *Married Women in the Labor Force: An Economic Analysis*. Chicago: Univ. of Chicago Press, 1966.
- Cain, G., and Mincer, J. "Urban Poverty and Labor Force Participation: Comment." *A.E.R.* 59 (March 1969): 185-94.
- Chow, G. C. "On the Long-Run and Short-Run Demand for Money." *J.P.E.* 74 (April 1966): 111-32.
- Council of Economic Advisers. *Economic Report of the President, January 1967*. Washington: Government Printing Office, 1967.

- Denison, E. F. *The Sources of Economic Growth in the United States and the Alternatives before Us*, Supplementary Paper no. 13, published by Committee for Economic Development, 1962.
- Douglas, P. H. *The Theory of Wages*. New York: Macmillan, 1934.
- Easterling, R. A. Comments on paper by J. Mincer. In *Prosperity and Unemployment*, edited by R. A. Gordon and M. S. Gordon. New York: Wiley, 1966.
- Eckstein, O., and Wilson, T. "Determination of Wages in American Industry." *Q.J.E.* 76 (August 1962):379-414.
- Finegan, T. A. "Hours of Work in the United States." *J.P.E.* 70 (October 1962):452-70.
- Fisher, I. *Theory of Interest*. New York: Macmillan, 1930.
- Friedman, M. *A Theory of the Consumption Function*. Chicago: Aldine, 1957.
- . *Price Theory: A Provisional Text*. Chicago: Aldine, 1962.
- . "The Role of Monetary Policy." *A.E.R.* 58 (March 1968):1-18.
- Gaver, D., and Rapping, L. A. "A Stochastic Process Model of the United States Labor Market." Unpublished paper, Carnegie-Mellon Univ., 1966.
- Hamilton, E. J. "Prices and Progress." *J. Econ. Hist.* 12 (Fall 1952):325-49.
- Hansen, A. "Factors Affecting the Trend of Real Wages." *A.E.R.* 15 (March 1925):27-42.
- Hicks, J. R. *Value and Capital*. Oxford: Clarendon Press, 1946.
- Holt, C., and David, M. "The Concept of Job Vacancies in a Dynamic Theory of the Labor Market." In *The Measurement and Interpretation of Job Vacancies*, edited by R. Ferber. New York: Nat. Bur. Econ. Res., 1966.
- Jones, E. B. "New Estimates of House of Work per Week and Hourly Earnings, 1900-1957." *Rev. Econ. and Statis.* 45 (November 1963):374-86.
- Kessel, R. A., and Alchian, A. A. "Real Wages in the North During the Civil War: Mitchell's Data Reconsidered." *J. Law and Econ.* 20 (October 1959):95-114.
- . "The Meaning and Validity of the Inflation-Induced Lag of Wages Behind Prices." *A.E.R.* 50 (March 1960):43-66.
- . "Effects of Inflation." *J.P.E.* 70 (December 1962):521-37.
- Kosters, M. *Income and Substitution Effects in a Family Labor Supply Model*. RAND no. P-3339. Santa Monica, Calif.: RAND Corp., 1966.
- Kuh, E. "Cyclical and Secular Labor Productivity in United States Manufacturing." *Rev. Econ. and Statis.* 47 (February 1965):11-30.
- . "Measurement of Potential Output." *A.E.R.* 56 (September 1966):762.
- Lange, O. *Price Flexibility and Employment*. Bloomington, Ind.: Principia, 1945.
- Lebergott, S. *Manpower in Economic Growth: The American Record Since 1800*. New York: McGraw-Hill, 1964.
- Lerner, E. M. "Inflation in the Confederacy, 1961-65." In *Studies in the Quantity Theory of Money*, edited by M. Friedman. Chicago: Univ. of Chicago Press, 1956.
- Lewis, H. G. "Hours of Work and Hours of Leisure." *Proceedings of the Indus. Relations Res. Assoc.*, 1956:196-207.
- . *Unionism and Relative Wages in the United States: An Empirical Inquiry*. Chicago: Univ. of Chicago Press, 1963.
- Lipsey, R. G. "The Relationship between Unemployment and the Rate of Change of Money Wage Rates in the U.K., 1862-1957." *Economica* 27 (February 1960):1-31.

- Liviatan, N. "Multiperiod Future Consumption as an Aggregate." *A.E.R.* 56 (September 1966): 828-40.
- Long, C. D. *The Labor Force Under Changing Income and Employment*. Princeton, N.J.: Princeton Univ. Press, 1958.
- Lucas, R. E., Jr. "Substitution between Labor and Capital in U.S. Manufacturing, 1929-1958." Ph.D. dissertation, University of Chicago, 1964.
- Lucas, R. E., Jr., and Rapping, L. A. "Price Expectations and the Phillips Curve." *A.E.R.*, in press.
- McGuire, T. W. "An Empirical Investigation of the U.S. Manufacturing Production Function in the Post-War Period." Ph.D. dissertation, Stanford University, 1968.
- Meltzer, A. H. "The Demand for Money: The Evidence from the Time Series." *J.P.E.* 71 (June 1963): 219-47.
- Mincer, J. "Labor Force Participation of Married Women." In *Aspects of Labor Economics*, edited by H. G. Lewis. A conference of the Universities-National Bureau Committee for Economic Research. Princeton, N.J.: Princeton Univ. Press, 1962.
- . "Labor Force Participation and Unemployment: A Review of Recent Evidence." In *Prosperity and Unemployment*, edited by R. A. Gordon and M. S. Gordon. New York: Wiley, 1966.
- Mitchell, W. C. *A History of the Greenbacks*. Chicago: Univ. of Chicago Press, 1903.
- Modigliani, F. "Liquidity Preference and the Theory of Interest and Money." In *Readings in Monetary Theory*, edited by F. A. Lutz and L. W. Mints. New York: Blakistan, 1951.
- Mortensen, D. T. "A Theory of Wage and Employment Dynamics." In *The New Microeconomics in Employment and Inflation Theory*, E. Phelps et al. New York: Norton, in press.
- Nerlove, M. *Dynamics of Supply: Estimation of Farmers' Response to Price*. Baltimore: Johns Hopkins Press, 1958.
- . "Notes on Recent Empirical Studies of the CES and Related Production Functions." Technical report no. 13, Institute for Mathematical Studies in the Social Sciences, July 1965, at Stanford University.
- Oi, W. "Labor as a Quasi-fixed Factor of Production." *J.P.E.* 70 (December 1962): 538-55.
- Patinkin, D. *Money, Interest, and Prices*. New York: Harper & Row, 1965.
- Perry, G. "The Determinants of Wage Rate Changes." *Rev. Econ. Studies* 31 (October 1964): 287-308.
- Phelps, E. "Money Wage Dynamics and Labor Market Equilibrium." *J.P.E.* 76, pt. 2 (August 1968): 687-711.
- Phelps, E., et al. *The New Microeconomics in Employment and Inflation Theory*. New York: Norton, in press.
- Phillips, A. W. "The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957." *Economica* 25 (November 1958): 283-99.
- Rees, A. "Wage Determination and Involuntary Unemployment." *J.P.E.* 59 (April 1951): 143-53.
- . "Patterns of Wages, Price and Productivity." In *Wages, Prices, Profits and Productivity*, edited by C. Myers. New York: American Assembly, Columbia Univ., 1959.
- Rosen, S. "On the Interindustry Wage and Hours Structure." *J.P.E.* 77, no. 2 (March/April 1969): 249-273.

- Sargent, T. "Price Expectations and the Interest Rate." *Q.J.E.* 83 (February 1969):127-41.
- Schramm, Richard. "Optimal Adjustment of Factors of Production and the Study of Investment Behavior." Ph.D. dissertation, Carnegie-Mellon Univ., 1967.
- Simon, H. A. *Models of Man*. New York: Wiley, 1957.
- Stigler, G. "The Economics of Information." *J.P.E.* 69 (June 1961):213-25.
- Tella, A. "Hidden Unemployment 1953-62: Comment." *A.E.R.* 56 (December 1966):1235-41.
- Tobin, J. "Money Wage Rates and Employment." In *The New Economics*, edited by S. E. Harris. New York:Knopf, 1952.
- U.S., Department of Commerce, Bureau of the Census. *Current Population Reports*, C.3, no. 186, and P.25, nos. 98, 114, 310, 311, and 321.
- U.S., Department of Commerce, Office of Business Economics. *The National Income and Product Accounts of the United States, 1929-1965: Statistical Tables: A Supplement to the Survey of Current Business*. Washington: Government Printing Office, 1966.
- U.S., Department of Labor. *Manpower Report of the President*. Washington: Government Printing Office, 1965 and 1967.
- U.S., Department of Labor, Bureau of Labor Statistics. *Employment and Earnings*. Vol. 14, no. 7. Washington: Government Printing Office, 1968.
- U.S., Department of Labor Statistics. *Employment and Earnings Statistics for the United States, 1909-66*. Bulletin no. 1312-4. Washington: Government Printing Office, 1966.
- Wilson, T. A., and Eckstein, O. "Short-Run Productivity Behavior in U.S. Manufacturing." *Rev. Econ. and Statis.* 46 (February 1964):53-64.