The Effect of Market Expectations on Employment, Wages, and Prices

Working Paper No. 17

The Effect of Market Expectations on Employment, Wages, and Prices

Denis S. Karnosky

August 1973

Dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Economics in the Graduate School of Duke University

ABSTRACT OF THE DISSERTATION

The Effect of Market Expectations
on Employment, Wages, and Prices

Denis S. Karnosky

Doctor of Philosophy in Economics
Duke University, 1973

This dissertation presents statistical evidence bearing on the factors which determine behavior in the aggregate markets for commodities and labor services. A model of this market is developed and tested by means of regression analysis on quarterly data generated by the private sector of the United States economy. The model consists of aggregate supply and demand relationships for labor services, an implicit commodity supply function in the form of a price-setting equation, and an adjustment mechanism which explains the dynamic response of labor market behavior to external shocks.

The model is constructed on two basic premises. First, the aggregate markets for commodities and labor services are interdependent in a simultaneous system; and, thus, behavior in each market is determined by relative prices between the markets. Secondly, market participants have only imperfect information about market conditions and incur costs in adjusting behavior to new information. Thus, the relative prices which affect behavior are postulated to be expected prices rather than actual prices. The model explains disequilibria in the aggregate markets as temporary phenomena which result from the lack of accurate information in the markets. Aggregate employment, wage rates, and prices are treated as jointly determined variables in the system. Directly observed measures of

price and aggregate demand expectations are used to test the relationships implied by the model.

The empirical evidence is found to be consistent with the implied relationships between the measures of market expectations and both aggregate employment and prices. These results support the postulated effect of expectations on labor demand and commodity supply behavior. The test results suggest that the wage adjustment mechanism which is incorporated in the model is not accurate. This function reflects the premise that unemployment is the only source of information available to households concerning current demand conditions in the labor market. The empirical evidence suggests that a more general specification of the wage adjustment mechanism is required.

The test results support the contention that in the absence of direct government control of prices or resource movements, the aggregate markets for commodities and labor services interact as a free market system. The only impediments to market-clearing behavior are temporary in effect and reflect the costs of adjustment and lack of accurate market information.

ACKNOWLEDGEMENTS

I am indebted to a substantial group of people who contributed in various ways to the completion of this project. Special mention must be made of Professor William P. Yohe, whose counsel has been invaluable for much more than the completion of this study.

I am grateful to the Federal Reserve Bank of St. Louis for the provision of facilities and time from other duties. The programming ability of Mike McCoy was a great help, as was the analytical aid provided by Donna Jenny and Jill Von Gruben. I am indebted to Mary Fava for her careful typing and patience through the chaos of many drafts. Hillary Debenport kept the whole thing together.

My parents Stanley C. and Mary T. Karnosky provided the environment which led to the completion of my graduate program. To them I will be eternally grateful.

My wife Mary provided the necessary encouragement, but my greatest debt I owe to her faith and patience. Angie and Eric have been the source of inspiration, but unfortunately, they have suffered the most.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The purpose of this dissertation is to test an economic model which purports to explain observed relationships between aggregate employment, wages, and prices. The model is based on the premise that in the absence of direct government controls, the markets for labor and commodity services operate jointly as a free market system. An explanatory economic model is derived from the theory of individual utility maximization and is evaluated in a situation where economic units have imperfect market information and face positive costs of adjustment. The only impediments to instantaneous market clearing are those reflecting the temporary effects of imperfect information pertaining to current market conditions. The model is tested by means of regression analysis on time series observations generated by the private sector of the United States economy. The sample consists of quarterly observations for the period from the first quarter of 1955 to the second quarter of 1971.

The motivation for this study stems from the continuing debate about the sources of inflation and the government action appropriate to combat a persistent or accelerating rate of general price increase. The conduct of monetary and fiscal policy in the United States since the period of the Korean War predominantly has been intended to secure desired patterns of economic activity by means of affecting the aggregate demand for goods and services. By affecting demand, the stabilization authorities seek to induce

changes in output, employment, and prices consonant with their interpretation of national economic goals. While it is widely agreed that the stabilization authorities are able to affect aggregate demand, given the existing institutions, there is substantial disagreement on the manner in which changes in aggregate demand are manifested in output, employment, and prices.

There have been empirically based allegations which question the ability of stabilization authorities to induce behavior consistent with a reduction in the rate of increase of prices through demand policies. For example:

> The hard fact is that market forces no longer can be counted on to check the upward course of wages and prices even when the aggregate demand for goods and services declines in the course of a business recession. [1]

> The failure of prices and wages to decelerate in 1970-71 cannot be reconciled with any notion that competitive market forces prevail in determining the price level. [2]

These allegations are based on the premise that there exist forces within the commodity and labor markets which impede or prevent market-clearing price movements. This position has been developed to explain aggregate price increases during periods of apparent excess capacity or aggregate supply. This explanation, commonly identified as cost-push, concerns an autonomous reduction of the aggregate supply, which, given a rate of aggregate demand, results in increasing prices and falling output. The argument, in very simple terms, holds that attempts to restrain this type of inflation by restriction of aggregate demand can be successful only at the cost of a permanent and often substantial decrease in output and

---

[1] Arthur F. Burns, "The Problem of Inflation" (address before the Joint Luncheon Meeting of the American Economic Association and the American Finance Association, Toronto, Ontario, Canada, December 29, 1972), pp. 2-3.

[2] Arthur M. Okun, "The Mirage of Steady Inflation," Brookings Papers on Economic Activity, (No. 2, 1971), p. 498.

employment.[1] At worst, such actions are thought by some to have only a minimal effect on prices, having their fullest effect instead on output and employment. The appropriate actions suggested by this latter analysis involve not attempts to influence demand, but operations directed at restricting the shift in aggregate supply.

Background: Prices and Unit-Labor Costs

A convenient relationship for the analysis of price behavior is the ratio of unit-labor costs to prices. This ratio has theoretical content, includes most of the variables pertinent to this study, and has played no small role in the investigation of the nature and cause of inflation.[2]

The theory of profit-maximizing firm behavior in a static framework predicts a functional relationship between the market-clearing price of a commodity and the average variable cost incurred in production. In the case of a profit-maximizing firm which faces a known demand function, $Q^d = f(P)$,

---

[1] Discussions of cost-push inflation are numerous in the literature. See for example, Gardner Ackley, Macroeconomic Theory, pp. 439-45; Michael K. Evans, Macroeconomic Activity: Theory, Forecasting, and Control; An Econometric Approach, pp. 290-305; and Martin Bronfenbrenner and Franklyn D. Holzman, "Survey of Inflation Theory," American Economic Review, LIII (September, 1963), 613-28.

[2] "Inflation" is probably not the proper description of the phenomenon to be investigated in this study. The model developed here is designed to explain movements in the reported price deflator for the private sector. This price measure includes only the prices of current consumption services. However, inter-temporal utility maximization, as considered in this study, requires a price index for wealth and thus should include other asset prices. In terms of such an index, an inflation is an increase in the money cost of a given level of utility. The price of current services is not an accurate measure of this cost in that movements in current prices may be offset by declines in futures prices, the current price of claims on future services. For a discussion of the constant utility price index see Armen A. Alchian and Benjamin Klein, "On a Correct Measure of Inflation," Journal of Money, Credit and Banking, V (February, 1973, Part I), 173-91.

Inflation, as used in the present study, refers to increases in the price of claims to current services. The real rate of interest will be considered, however, in its effect on household consumption decisions.

and operates on a joint production function in two factor inputs, a variable factor (X_1) and a fixed factor (X_2), optimal operation requires

$$(1.1)\quad P = [\frac{\varepsilon}{1+\varepsilon}]P_{x_1}(\frac{\partial Q}{\partial X_1})^{-1}.$$

In equation (1.1), ε = price elasticity of demand for Q, P_{x_1} = unit price of input X_1, and $\partial Q/\partial X_1$ = marginal product of X_1.[1] For a general Cobb-Douglas production function, $Q = AX_1^{\alpha_1}X_2^{\alpha_2}$, this becomes

$$(1.2)\quad P = \frac{1}{\alpha_1}[\frac{\varepsilon}{1+\varepsilon}]\frac{P_{x_1}\cdot X_1}{Q}.$$

The term, $P_{x_1}\cdot X_1/Q$, is the unit cost in the variable factor of producing the quantity Q in the current period. Thus, if X_1 measures units of labor services, equation (1.2) defines the profit-maximizing price to be a function of unit-labor costs, at a given wage P_{x_1}. This relationship has a strong tradition in the econometrics of price determination and is incorporated in various forms in most of the major econometric models.[2]

As evidenced by the popularity of unit costs in statistical investigations of price determination, a fairly high correlation has been observed between commodity prices and associated unit costs--especially labor

---

[1]Also, this relation is often interpreted as determining the optimal level of employment of the variable factor, given the level of prices P. Profit-maximization in this case requires hiring X_1 up to the point where the marginal revenue product of X_1, $[P\cdot\partial Q/\partial X_1\cdot(1+\varepsilon)/\varepsilon]$, is equal to the unit price of X_1.

[2]For a survey of the price equations incorporated in several of the prominent models of the U.S. economy see, William D. Nordhaus, "Recent Developments in Price Dynamics," in The Econometrics of Price Determination: Conference, October 30-31, 1970, ed. by Otto Eckstein, pp. 34-46. In that same volume see L. R. Klein, "Price Determination in the Wharton Model;" Albert A. Hirsch, "Price Simulations with the OBE Econometric Model;" George de Menil and Jared J. Enzler, "Prices and Wages in the FR-MIT Penn Econometric Model;" and Saul H. Hymans, "Prices and Price Behavior in Three U.S. Econometric Models," pp. 221-324.

costs. This correlation has been found across foreign countries with developed economies and across various industrial categories in the United States.[1]

A cursory review of the data reveals several interesting phenomena in the relationship of prices to unit-labor costs. Over extended periods of time the ratio of unit-labor costs to prices has been observed to be fairly constant but has varied significantly within sample periods, especially on a quarterly basis. As shown in Chart 1, the variance has been cyclical in nature--generally rising from mid-expansion to late-recession and thereafter falling. Several explanations for this behavior have been offered. Hotson looked not at the chronological movement but at the frequency distribution of changes in the ratio of unit-labor costs to prices. He concluded that the variance was random and normally distributed.[2]

On the surface, at least, this variation in the ratio appears to reflect primarily variation in unit-labor costs, as prices moved much more smoothly. Several writers attribute the movement to changes in the elasticity of demand, from equation (1.2). The hypothesis is that as the economy approaches full capacity utilization, the monopoly power of individual firms increases as customer alternatives decrease. Thus, firms are able to increase price without fear of losing customers to competitors. This view is derived from the presumption that, on average, prices are determined in oligopolistic markets where price is <u>set</u> as a mark-up over unit costs. The

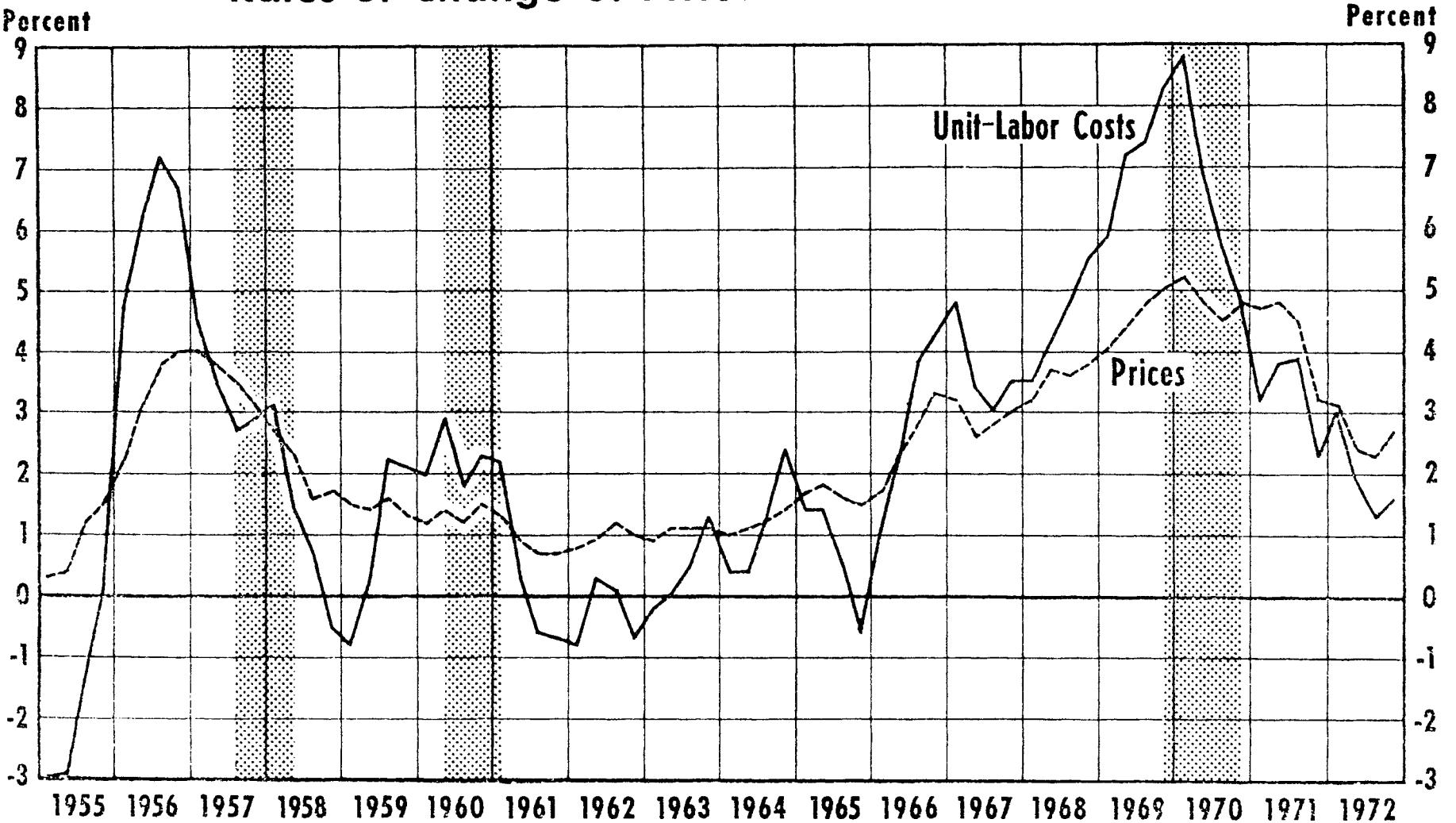
---

[1]John H. Hotson, <u>International Comparisons of Money Velocity and Wage Mark-ups</u>.

[2]Hotson, <u>International Comparisons</u>, pp. 127-51.

Chart 1

Rates of Change of Prices and Unit-Labor Costs *



* The rates of change are presented as four-quarter moving averages in order to reduce the quarter-to-quarter variation. The variables are from the private sector. Source: U.S. Department of Labor.

The shaded areas represent periods of economic recession as defined by the National Bureau of Economic Research.

mark-up is determined so as to maximize profit subject to the discouragement of other firms from entering the industry.[1]

An alternative explanation is offered by Schultze and Tryon.[2] They explain prices as a mark-up over standard or "normal" costs--those costs which are expected to be lasting in nature. The hypothesis is that changes in unit costs result in price changes to the extent that they represent permanent changes to the firm. Thus on a quarter-to-quarter basis, variance in the ratio of observed unit-labor costs to prices is expected.[3] The importance of "normal" unit costs has also been noted by Eckstein and Fromm who took the evidence as indicative of a degree of oligopolistic price behavior in the manufacturing sector of the United States.[4] Similar results, without interpretation, are reported by Ball and Duffy in their study of price determination in the United States and eleven other countries.[5]

Wages, Employment and Output

Although unit-labor costs do serve as a reliable predictor of price movements, the relation does not provide enough information by itself to be

---

[1]Paolo Sylos-Labini, Oligopoly and Technical Progress, trans. by Elizabeth Henderson, Harvard Economic Study, Vol. CXIX. See also Franco Modigliani, "New Developments on the Oligopoly Front," Journal of Political Economy, LXVI (June, 1958), 215-32.

[2]Charles L. Schultze and Joseph L. Tryon, "Prices and Wages," in The Brookings Quarterly Econometric Model of the United States. ed. by James S. Duesenberry, et al., pp. 281-333.

[3]Schultze and Tryon postulated that normal costs are computed as a 12-quarter moving average of actual unit costs. In commenting on their study Evans rejects their analysis on the basis that it is unreasonable to expect only one-twelfth of a change in unit costs to be passed on to prices. Evans, Macroeconomic Activity, p. 298.

[4]Otto Eckstein and Gary Fromm, "The Price Equation," American Economic Review, LVIII (December, 1968), 1159-83.

[5]R. J. Ball and Martyn Duffy, "Price Formation in European Countries," in Price Determination, pp. 347-68.

useful for economic policy purposes. Equation (1.2) defines the profit-maximizing triad of price-output-employment for the firm, given the current wage, the demand schedule facing the firm, and the technical production coefficients. The numerator of the ratio, the wage bill of the firm, contains the prevailing wage in the labor market and the amount of labor services the firm employs, but not necessarily utilizes in production, at that wage. The determinants of these variables must be ascertained, in particular the degree to which the variables are influenced by conditions in the market for labor services. The extent to which labor supply reacts to policy induced changes in aggregate demand can have a bearing on the profit-maximizing behavior of the firm and thus on the price-output combination.[1]

Even though one is successful in explaining the variance of the ratio of unit-labor costs to prices and is able to predict prices on the basis of the relationship to unit-labor costs, the important question of the source of variance in unit-labor costs remains. This variance reflects relative changes in wage rates, employment, and output. The factors which determine the observed mix of these variables must be considered.

The variables which compose unit-labor costs would not be expected to be independent of each other. For example, the ratio of employment to output is the inverse of what is commonly taken as a measure of labor productivity, a variable which is not unrelated to the wage. From the standpoint of a firm, the rate at which it rewards labor would be considered relative to the expected return. However, measures of output per man-hour have shown periods of substantial variation relative to wage rates. Thus, the demand for labor services relative to the wage rate and the planned rate

---

[1]This point is strongly emphasized in Sidney Weintraub, An Approach to the Theory of Income Distribution, pp. 17-19.

of output is a consideration. The factors which determine the observed wage-employment-output plans of firms are an important element to be considered.

On the supply side of the labor market, the theory of individual choice predicts that a utility maximizing person who derives satisfaction from leisure in addition to consumption will attempt to adjust his employment so as to equate the marginal disutility of leisure time sacrificed, evaluated at the prevailing wage, with the marginal utility of consumption, evaluated at prevailing commodity prices.[1] This postulate says that the amount of labor services supplied to the market responds not only to changes in wages but also to changes in commodity prices. The real wage rate serves as a measure of the opportunity cost of a unit of leisure time; and the relative prices of consumption and leisure, given the subjective valuation of each by the individual, determines the amount of each demanded by that individual. However, statements which allege to refute this postulate can be found in the literature.

> Now ordinary experience tells us, beyond doubt, that a situation where labour stipulates (within limits) for a money-wage rather than a real wage, so far from being a mere possibility, is the normal case. Whilst workers will usually resist a reduction of money-wages, it is not their practice to withdraw their labour whenever there is a rise in the price of wage-goods.[2]

Keynes based this refutation on two arguments, one derived from empirical observation and the other based on his interpretation of the implications of the postulate. This first argument is presented in the

---

[1]This statement is recognized as being what Keynes termed the second Classical Postulate: "The utility of the wage when a given volume of labour is employed is equal to the marginal disutility of that amount of employment." John Maynard Keynes, The General Theory of Employment, Interest, and Money, p. 5.

[2]Ibid., p. 9.

quote above. The second argument is based on the conclusion drawn by Keynes that:

> The postulate that there is a tendency for the real wage to come to equality with the marginal disutility of labour clearly presumes that labour itself is in a position to decide the real wage for which it works, though not the quantity of employment forthcoming at this wage. [1]

Keynes contended, and rightly so, that in a non-barter economy an individual is not in a position to bargain with a potential employer for a real wage rate. Prices of commodity services are determined in another market, and the wage-price mix which results from a given level of employment may not be consistent with general equilibrium. For example, attempts by labor to increase the real wage might generate pressures in the commodity market which would cause prices to rise proportionately.

A question to be considered here is whether the evidence cited by Keynes and others refutes the theory of individual choice. An implication drawn from the postulate that relative prices and relative subjective valuation determine the demand for consumption and leisure is that the supply of labor is determined by the real wage in a positive functional relationship. This implication was drawn from the conjunction of the postulate, which is a universal statement, and a set of initial conditions, which are singular statements. These singular statements define the particular situation to which the postulate is applied. The refutation of the postulate requires not only that the prediction statement be shown to be inconsistent with empirical observation but also requires that the set of initial conditions be shown to be in agreement with the observations.[2]

---

[1] Ibid., p. 11.

[2] See R[obert] L. Basmann, On Predictive Testing of a Simultaneous Equations Model: The Retail Market for Food in the U.S., Paper for the Institute for Quantitative Research in Economics and Management, Institute Paper No. 78.

It is the purpose of this study to provide evidence on the effects of relative prices on behavior in the markets for labor and commodity services. Labor supply and demand functions which are derived from the theory of individual utility maximization are presented in the next section. The set of initial conditions includes non-zero costs of information and adjustment. The implications for the behavior of prices, wages, and employment are derived and compared with the empirical evidence.

CHAPTER II

THE GENERAL FRAMEWORK FOR ANALYSIS

This chapter is concerned with developing a model of the aggregate markets for labor and commodity services. The model, while describing aggregate behavior, is based on premises which are presented with reference to microeconomic analysis.[1] The analysis concentrates on the interaction of two economic groups. The first consists of households and has the characteristic of ownership of human capital. The second group consists of firms who own non-human capital and organize human and non-human resources to produce commodities.[2] The system of two markets is in equilibrium when the prices prevailing in each market are consistent with the plans of households and firms.

The Supply of Labor Services

The economic theory which states that individuals attempt to maximize utility purports to explain behavior as reflecting the interaction of each

---

[1]The problems associated with aggregation are recognized, and the validity of the manner in which it is handled in the derivation of the model is crucial to the evaluation of the empirical tests of the model.

[2]This artificial distinction obviously ignores the important question of the form in which wealth is held by individuals. The existence of an organization directed toward the production of commodities reflects a prior decision by some number of individuals to forgo current consumption. Households would be expected to share in the ownership of this firm. However, this study is not concerned with the manner in which wealth, not held in the form of current consumables, is allocated among other assets. For a discussion of the firm-household relationship see Armen A. Alchian and Harold Demsetz, "Production, Information Costs, and Economic Organization," American Economic Review, LXII (December, 1972), 777-95.

person's subjective valuation of alternative consumption patterns and his ability to secure each alternative. The behavior of each person is presumed to be governed by his desire to maximize his individual well-being. The effective constraint on individual behavior is composed of the legal and institutional framework of the system and individual real wealth, i.e., claims on current and future commodity services.[1] Wealth consists of the value of human capital and the current stock of long-lived assets inherited from the past. The latter represents prior decisions not to consume commodity services. In a static framework, the human wealth of the household consists of current income, in terms of command over current commodity services, that the household can earn through the sale of its human capital. In an inter-temporal setting, human wealth consists of claims on current commodity services that can be secured against current and future labor services which are expected to flow from the household. Thus, the current period demand for commodity services is constrained by the ability of the individual to market his labor services, both currently and in the future, and by the manner in which the market evaluates claims on future labor services. This constraint plays a central role in the analysis.[2]

---

[1]This constraint does not preclude "illegal" activity in violation of the accepted set of property rights. A judicial system which levies heavier penalties for premeditated crimes might be analyzed in this context as cognizant of the opportunity costs which were presumed to be considered prior to the commission of the crime.

[2]The constraint is emphasized by several writers as forming the crux of Keynes' analysis of secular unemployment. See Robert W. Clower, "The Keynesian Counterrevolution: A Theoretical Appraisal," in The Theory of Interest Rates; Proceedings of a Conference Held by the International Economic Association, ed. by F. H. Hahn and F. P. R. Brechling, pp. 103-25, and Axel Leijonhufvud, On Keynesian Economics and the Economics of Keynes: A Study in Monetary Theory.

The decision of a household to demand commodities and supply labor services in the market is presumed to reflect the unit's preference pattern for commodity services and leisure. Consider a typical household whose composite utility function is defined in terms of current and future leisure and consumption of commodity services. A function which reflects these inter-temporal considerations is

$$(2.1)\quad U = \sum_{0}^{n}[U_i(C_{t+i},N_{t+i})(\frac{1}{1+\delta})^i];U'_{i_C}>0,\ U'_{i_N}<0.$$

Total utility over the planning horizon (U) is a positive function of commodity services consumed in each period (C_{t+i}) and a negative function of the proportion of each time period used in employment (N_{t+i}).[1] The rate of inter-temporal substitution within the utility function is determined by the rate of time preference (δ).

The attainable utility set is bounded from above by the real wealth of the household. This wealth consists of the integral of past income not consumed (the non-human assets of the group) and, with perfect capital markets, the present value of income which can be earned over the planning horizon by the sale of human resources. The rate of discount, assumed here to be exogenous, is that rate at which future income can be converted to claims on current commodity services in the market. The budget constraint is of the form[2]:

---

[1]The substitution of employment for leisure in the household utility function reflects the assumption that leisure and employment are the only ways in which individuals can utilize time. Obviously consumption involves the use of time, as does trading in the markets. For the purposes of this analysis, the assumption is made that consumption requires a fixed proportion of each period, independent of the volume of consumption.

[2]The equality in the relation precludes the possibility that the household may wish to hold non-human wealth at the end of the current planning period. In this form the household acts so as to have zero non-human wealth at the end of the planning period.

$$(2.2)\quad \sum_{0}^{n}[P_{t+i}C_{t+i}-w_{t+i}N_{t+i}][\frac{1}{1+r}]^{i} = A$$

where (P_{t+i}) is the market price of commodity services in each period, (w_{t+i}) is the wage rate at which a unit of labor services may be sold in each period, and (r) is the rate of discount in the market. The beginning-of-period stock of non-human wealth is designated as A. Maximizing equation (2.1) subject to equation (2.2) yields the demand functions for commodity services in each time period in the planning span and the supply of labor services flowing from the household in each period.

These two functions, in current period consumption and employment, are of the general form:

$$(2.3a)\quad C_0 = C[w_0,w_1(\frac{1+\delta}{1+r}),\ldots,w_n(\frac{1+\delta}{1+r})^n,P_0,P_1(\frac{1+\delta}{1+r}),\ldots,P_n(\frac{1+\delta}{1+r})^n,A]$$

$$(2.3b)\quad N_0 = N[w_0,w_1(\frac{1+\delta}{1+r}),\ldots,w_n(\frac{1+\delta}{1+r})^n,P_0,P_1(\frac{1+\delta}{1+r}),\ldots,P_n(\frac{1+\delta}{1+r})^n,A].$$

These functions are homogenous of degree zero in the (2n+3) arguments. Equation (2.3b) defines the supply of labor services in the current period as a function of the prices of labor services and commodity services in each period, evaluated by the rate of time preference relative to the rate at which the household is able to borrow against future income. Following the procedure utilized by Lucas-Rapping, these relationships can be simplified by considering a two period planning horizon.[1] Setting n=1 and dividing through on the right by the current period price of commodity services gives

---

[1]Robert E. Lucas, Jr. and Leonard A. Rapping, "Real Wages, Employment, and Inflation," Journal of Political Economy, LXXVII (September-October, 1969), 721-54.

$$(2.4a)\quad C_0 = C[\frac{w_0}{P_0}, \frac{w_1}{P_0}\ (\frac{1+\delta}{1+r}),\ 1,\ \frac{P_1}{P_0}\ (\frac{1+\delta}{1+r}),\ \frac{A}{P_0}]$$

$$(2.4b)\quad N_0 = N[\frac{w_0}{P_0}, \frac{w_1}{P_0}\ (\frac{1+\delta}{1+r}),\ 1,\ \frac{P_1}{P_0}\ (\frac{1+\delta}{1+r}),\ \frac{A}{P_0}]\ .$$

The only implication of the utility-maximization hypothesis for the specific form of these relationships is that the signs of the partial derivatives with respect to the current wage rate are positive. Thus, in order to state either relationship in a testable form, postulates defining the specific form of the functions and specifying the signs of each of the other partial derivatives are required. Postulating that these functions are linear in the logarithms and that the rate of time preference is constant, the current period supply of labor services becomes

$$(2.5)\quad \ln N_0 = \alpha_0+\alpha_1\ln(\frac{w_0}{P_0})+\alpha_2\ln(\frac{w_1}{P_0})+\alpha_3\ln(\frac{P_1}{P_0})-(\alpha_2+\alpha_3)\ln(1+r)+\alpha_4\ln(\frac{A}{P_0})$$

where $\alpha_0 = (\alpha_2+\alpha_3)\ln(1+\delta)$. Rearranging terms gives

$$(2.6)\quad \ln N_0 = \alpha_0+\alpha_1\ln(\frac{w_0}{P_0})+\alpha_2\ln(\frac{w_1}{P_1})+(\alpha_2+\alpha_3)\ln(\frac{P_1}{P_0})-(\alpha_2+\alpha_3)\ln(1+r)+\alpha_4\ln(\frac{A}{P_0})$$

which shows the supply of labor services in the current period to be a function of the current real wage rate, the future real wage rate, the future price of commodity services relative to current price, the nominal rate of interest, and the stock of non-human wealth evaluated at current commodity prices. The theory of utility-maximization predicts $\partial N_0/\partial w_0 > 0$ and thus $\alpha_1 > 0$. Determination of the signs of the other coefficients requires additional premises. Again, following Lucas-Rapping, current leisure is presumed to be a substitute for future leisure and for current and future consumption. Thus, the signs of the partial derivatives of the labor supply

function are[1]

$$\alpha_1 > 0; \quad \alpha_2 < 0; \quad \alpha_3 < 0; \quad \alpha_4 < 0.$$

The function (2.6) predicts that a ceteris paribus increase in the price of current commodity services will decrease the supply of labor services if and only if $\alpha_1 > |\alpha_2+\alpha_3+\alpha_4|$. Thus, an increase in the current price of commodity services does not necessarily result in a decrease in the opportunity cost of leisure and, consequently, does not necessarily imply a reduction in the current supply of labor services.[2] A temporary increase in prices in which the future price of commodity services is unchanged would be expected to elicit a smaller depressive effect on the current labor supply than would a permanent increase which moves P_0 and P_1 upward proportionately. In addition, the real wealth decrease resulting from a rise in current prices would stimulate the labor supply.

Thus far the analysis has been conducted with the implicit assumptions that market information is readily and costlessly available to the household and that activity can be adjusted at zero cost.[3] The introduction of non-trivial information and adjustment costs changes substantially the predictions of equation (2.6). The wages and prices appearing in the function are no longer those prevailing in the respective markets but, instead, are those perceived by the household. These estimates are not

---

[1] Ibid., p. 728.

[2] Keynes based his rejection of the second Classical Postulate, in part, on his observation that workers did not withdraw their services from the labor market whenever there was a rise in the price of commodity services. Keynes, General Theory, p. 9. Thus, utility analysis, extended into a Fisherian inter-temporal setting, seeks to explain, at least in part, Keynes' observation.

[3] Such assumptions constitute a portion of the set of initial conditions. These conditions are singular statements which define the circumstances to which a theory is applied. See Morris R. Cohen and Ernest Nagel, An Introduction to Logic and Scientific Method, pp. 211.

necessarily accurate nor consistent with market-clearing in the entire system.

The wage information available to an individual at any point in time consists of the wage at which his current employer, if any, has been willing to utilize his labor services until that time, the wage his employer has offered for continued employment, and some notion of the best alternative wage that had been sacrificed by accepting the past offers of the current employer. The information about the best wage available for future use of the services, either with the current employer or elsewhere, is not readily available and can be acquired only at a cost. Thus, the wage variables in the supply function are interpreted as the households' estimate of the best wage available in each period, given their expectations of labor demand. The effect of this change in initial conditions is illustrated in Figure 2.1 below which relates labor supply to actual wage rates.

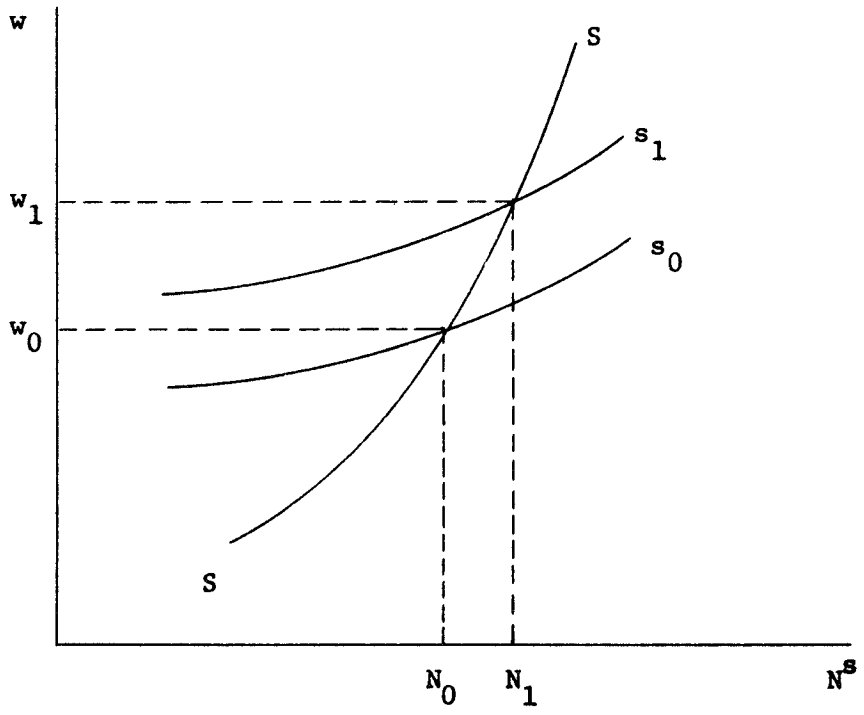


Fig. 2.1

The curve SS traces the amount of labor services offered at each current wage rate when, given the other arguments in the labor supply function, the household correctly perceives the best wage available. Thus, in the current period, if the household recognizes w_0 as the best wage it can secure, then N_0 units of labor services are offered in the market. If w_1 is the best wage offer then N_1 units of labor services are offered. The curve s_0 defines the supply of labor services forthcoming at each wage for any shift in demand away from the point w_0-N_0. This is the short-run labor supply when the perceived wage is w_0. Given the curve SS, there exists a short-run function such as s_0 for each expected wage, relative to the actual wage in the market. The curve s_1, for example, is the short-run labor supply function associated with the expected wage w_1.

Figure 2.1 illustrates the effect of costly and imperfect information on the individual's supply of labor services. Due to non-zero information costs, a shift in the aggregate demand for labor services is not instantaneously detected by each individual in the labor market. Thus, the new market-clearing wage is not immediately determined. Instead, the perceived wage level remains relatively unchanged since the individual worker is not immediately able to determine if the decline in demand is confined only to his current employer or if it represents a general decline in the current demand for labor services. In the former case, the wage alternatives available to the individual would be higher than in the case of a general decline in the demand; such a decline would lower all wage offers. It is postulated here that the individual's first reaction is to evaluate a decrease in the demand for labor services as specific to his current employer. That is, general declines in demand take time to be detected. Thus the response of labor supply to a shift in demand for labor services is traced

along s_0 instead of SS. A firm-by-firm reduction in wage offers, reflecting a general downward shift in demand for current period labor services, encounters substantial resistence from employees who are not as yet aware that their alternative wages have also declined.

A discrepancy between the expected, or perceived, wage and that wage which is consistent with the intersection of the labor demand schedule and the function SS can arise and be maintained if market information is not readily available. A change in the demand for labor from a situation where the household has accurately adjusted its wage expectations will elicit attempts by the household to determine whether or not its current wage expectations are still accurate.[1] One element of this search will be a period of voluntary unemployment of the household's labor services reflecting the decision to engage in a time-intensive survey of alternative wages. The manner in which the household reacts to increased uncertainty about its estimates of the best available wage provides the adjustment mechanism in the explanatory economic model to be tested here. Consideration of this problem is delayed until later in the chapter.

The price of current commodity services, as it appears in the labor supply function, is an element which is considered in the determination of the opportunity cost of leisure. This price is the household's best estimate of the price which will prevail, on the average, in the commodity market during the current period. Even though an individual is able to secure the wage to which he aspires in the labor market, he has no guarantee that, once

---

[1] A significant portion of the recent literature deals with the effect of uncertainty on labor market behavior. Comprehensive analyses are to be found in Edmund S. Phelps, et al. Microeconomic Foundations of Employment and Inflation Theory.

employed, the prices he will be confronted with in the commodity market are consistent with utility-maximization at that wage.[1] The function (2.6) is not interpreted as suggesting that an individual is able to bargain for a real wage with a potential employer. That employer is probably not able to deliver on a promised average commodity price which is actually determined by the joint action of numerous firms and households in the market. However, individuals are presumed to recognize that changes in commodity prices can alter their attainable level of utility.

The variable P_0 in the labor supply function is not the actual price which prevails in the commodity market in the current period. Instead this variable is the household's estimate of that price at the time when employment-consumption plans are being made. As with the expected wage, there is no guarantee that the expected price will be realized. For each wage, the effect of an incorrect estimate of the prevailing commodity prices is to cause the household to offer a sub-optimal level of labor services in the market. An under-estimate of commodity prices results in an over-estimate of the opportunity costs of leisure and, thus, a larger supply of labor at current wages than would be forthcoming with better price information.

With imperfect information about commodity prices, the household must engage in a second form of search behavior in addition to the pursuit of wage

---

[1]This result is a consequence of imperfect information in a money economy. In the classical system where payment was typically assumed to be made in kind, there was no dichotomy between the labor and commodity markets in that workers produced their own wage income. The employment decision was indistinguishable from the consumption decision. In the order of things, the labor market clears first and the commodity market then clears, in that period, as a consequence. See David Laidler, "On Wicksell's Theory of Price Level Dynamics," Manchester School, XL (June, 1972), 125-44.

information. When the average price in the commodity market is different from that which had been expected, the household is faced with a complicated problem. The household may have actually mis-estimated prices, in which case its employment-consumption plans prove to be sub-optimal. However, the prices sampled may not represent the true distribution of prices prevailing in the market and more search could yield a price for a given basket of commodity services which is more consistent with expectations. The response of labor supply to changes in commodity prices is then dependent upon the degree to which the change had been expected and, if the change is unexpected, the degree to which household price anticipations are altered.

The effect on labor supply of introducing information considerations is summarized in the amended function below. The actual price and wage variables in equation (2.6) are replaced by estimates as held by households.

$$(2.7)\quad \ln N_0 = \alpha_0 + \alpha_1 \ln\left(\frac{w_0^{\varepsilon}}{p_0^{\varepsilon}}\right) + \alpha_2 \ln\left(\frac{w_1^{\varepsilon}}{p_1^{\varepsilon}}\right) + (\alpha_2+\alpha_3)\ln\left(\frac{p_1^{\varepsilon}}{p_0^{\varepsilon}}\right) - (\alpha_2+\alpha_3)\ln(1+r) + \alpha_4 \ln\left(\frac{A}{p_0^{\varepsilon}}\right).$$

The Demand for Labor Services

The demand by an individual firm for factors of production is a derived demand which is related to the output and sales plans of the firm. The firm hires and owns factors of production for the purpose of organizing them into a process which is expected to yield a flow of income to the owners of the firm.[1] Thus, the objective of the firm is to maximize the stream of profit over time. Profit-maximization in a system where costs of adjustment

---

[1]The owners are treated as individuals whose behavior is governed by utility-maximizing considerations. Having made a prior decision to hold wealth in the form of non-human capital, these individuals expect the maximum possible flow of income from their venture. In this context they hire managerial talent consistent with this aim.

are inconsequential requires the firm to employ factors of production in relative and absolute magnitudes such that the increment in revenue realized from the last unit of each factor utilized is equal to the incremental cost of that factor.

Consider a firm, which in the market for a given commodity Q, faces a demand function of the form $Q = f(P)$, $f'<0$. The production of the commodity requires the joint effort of human and non-human capital, as defined by the production function $Q = F(K,N)$, where K and N are units of non-human and human capital, respectively. The current user costs of human and non-human capital are denoted as w and R, respectively. In the absence of any adjustment costs, this firm would attempt to maximize:

$$(2.8)\quad \theta = Q[f^{-1}(Q)] - wN - RK + \gamma[Q-F(K,N)].$$

The necessary conditions for this maximization are

$$(2.9a)\quad \frac{\partial\theta}{\partial Q} = P[\frac{1+\eta}{\eta}] + \gamma = 0,\ \eta = \frac{P}{Q}\frac{dQ}{dP}$$

$$(2.9b)\quad \frac{\partial\theta}{\partial N} = w + \gamma F_N = 0$$

$$(2.9c)\quad \frac{\partial\theta}{\partial K} = R + \gamma F_K = 0$$

Combining (2.9b) and (2.9c) yields the optimal factor proportions according to

$$(2.10)\quad \frac{w}{F_N} = \frac{R}{F_K}$$

where F_N and F_K represent the partial derivatives of the production function with respect to the subscripted variables. Assuming that the production process can be represented by a generalized Cobb-Douglas production function [$Q=AK^{\beta}N^{\alpha}$], condition (2.10) becomes

$$(2.10a)\quad N = \frac{\alpha}{\beta}[\frac{R}{w}]K.$$

Solving the production function for K and substituting into (2.10a) yields

$$(2.10b)\quad N = \{\frac{\alpha}{\beta}[\frac{R}{w}]\}^{\frac{\beta}{\rho}}[\frac{Q}{A}]^{\frac{1}{\rho}}; \qquad \rho = \alpha + \beta.$$

Equation (2.10b) defines the profit-maximizing demand for labor services in the current period for a firm which faces zero adjustment costs and knows the demand schedule for its product. In each period, the demand for labor services is a function of the current relative user costs of factors, the technological coefficients, and the scale of production in that period.

As in the derivation of the labor supply function, the utility-maximizing procedure used to arrive at equation (2.10b) is undertaken with the presumption that economic units have perfect market information. In the case above, the demand function was known with certainty by the firm. Thus, given the current rental prices of factors of production and relative productivity, the profit-maximizing price-output-employment mix arrived at by the firm will actually be optimal. However, with less than perfect information the demand function is interpreted as giving the demand expected at each price. This element of uncertainty is incorporated by substituting the variable Q^{ε}, defined as the expected amount demanded at the profit-maximizing price, for the actual demand (Q) in equation (2.10b). Expressing the function in logarithmic form gives

$$(2.10c)\quad \ln N_0^d = d_0 + d_1 \ln Q_0^{\varepsilon} + d_2\,[\ln R_0 - \ln w_0]$$

where: $d_0 = \frac{1}{\rho}\{\beta[\ln\alpha - \ln\beta] - \ln A\}$

$d_1 = 1/\rho > 0$

$d_2 = \beta/\rho > 0.$

The function (2.10c) defines the demand for labor services by a firm which incurs no cost in changing its production operations. Both factors of

production, labor and capital, are treated as completely variable. The only costs to the firm of using these factors in production are the variable costs associated with the current rental prices. In the absence of costs of adjustment, the firm does not have to consider the inter-temporal effects on profits of its current decisions. Production decisions are independent of each other in time, and the firm is able to change its operations to take full advantage of economic conditions in each period. The introduction of adjustment costs forces the firm to consider the probable effect of any current action on future profit.

Any factor of production can be altered at a cost. The magnitude of the cost of changing a factor in the production process compared to the revenue expected from the venture is important to the firm and determines the degree of fixity of that factor in the production process. To assume that a factor such as capital is fixed in the production process is to postulate that under the circumstances being considered the costs of adjusting the capital input are uniquely prohibitive. In the range of possible adjustments, the adjustment of the capital input is profit-minimizing under such a presumption. Similarly, treating labor as a variable input in production reflects a postulate that, within the range of technically feasible adjustments, the adjustment of labor input is profit-maximizing.

The ability of a firm to alter output is limited by its ability to attract the necessary factors of production or to increase the productivity of the existing facility, either by increased utilization or improved technology. In either case, the firm faces costs in adjusting output. The firm must be cognizant of the implications of their current output decisions on the flow of profits over the future. A policy which produces an

immediate reduction in current operating costs can cause the firm to bear much higher costs and less profits in the future.

Consider the situation faced by the firm as illustrated in Figure 2.2 below. The curves Q_i are in the capital-input labor-input plane; they trace the technically most efficient combinations of the two factors which can be used to produce the rates of output Q_i in a given period when the firm faces no costs of adjustment.

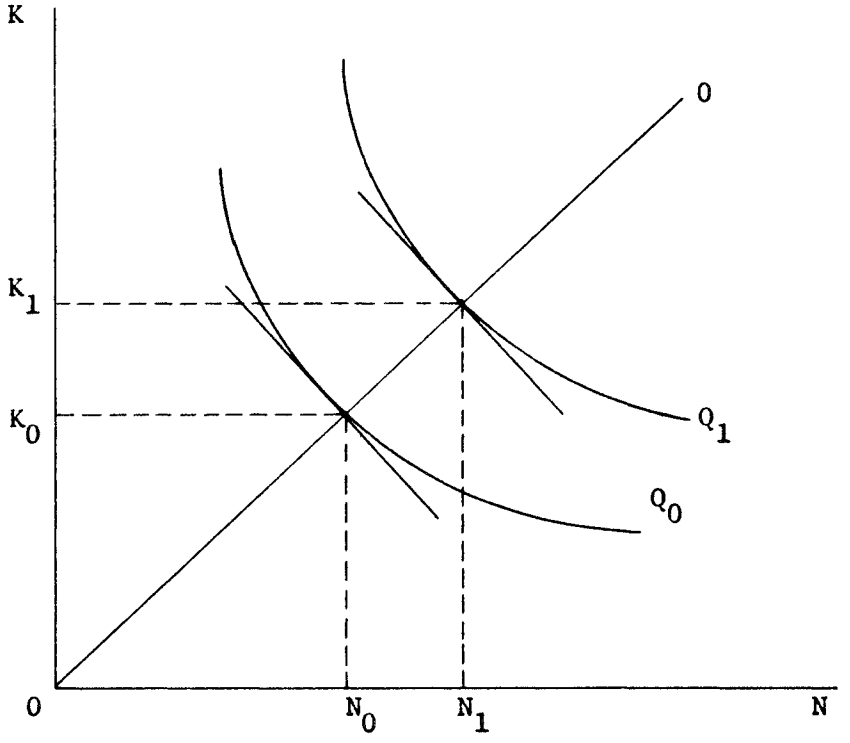


Fig. 2.2

For the purposes of exposition, the production function which generates these isoquants is assumed to exhibit constant returns to scale, so that for a given factor price ratio (R/w) the optimal factor input ratio is constant and the demand for capital and labor services relative to the scale of production expands along the ray 00. This diagram illustrates the case where production costs increase proportionately with output, at least

in the range of demand where relative and absolute factor prices are unaffected by the actions of the firm. Ignoring for the moment the potential effect on future demand of introducing variance into the output program of the firm, a profit-maximizing rate of output of Q_0 involves a production cost of $R_0K_0 + w_0N_0$. A change to an output rate of Q_1 would involve a cost of $R_0K_1 + w_0N_1$. The increase represents the variable cost associated with changing the magnitude of factor inputs.

With no costs of adjustment other than the strictly variable costs associated with the unit price of factors of production, the firm can reduce costs by reducing output and employment when it perceives a decrease in the demand for its product. If this estimate of demand proves to be incorrect, the firm can restore the rate of output to the original level by re-employing those factors which were idled earlier. However, there are several elements which make such adjustment unlikely. The first, and probably the most obvious, reason is concerned with the probability of being able to rehire the inputs which were mistakenly released. For example, the suppliers of labor services would suffer variability in income as the firm hired and laid-off workers with each apparent shift in demand. This lack of job security, or more importantly income security, would induce households to survey the variations in employment experienced in other firms, thereby seeking a more stable employment situation.

Another element which affects the employment decision is the fixed cost which is incurred by the firm in production. If the firm requires skills specific to its production scheme, it will make some expenditure on training or otherwise adapting the inputs it hires. The more specific the skill, relative to the requirements of other firms, the less likely is the

chance that the appropriate training will be provided and financed by some other economic unit. Thus, the decision to hire a factor will be influenced by the training or adaption costs that the firm will have to bear. The marginal cost of increasing labor input includes the training costs in addition to the wage. For positive training costs, the marginal revenue product of the factor would have to be higher than it would be in the case where such costs are zero, if the factor is to be employed. The present value of the incremental revenue expected from the last unit employed must cover not only the present value of the variable costs of employing that unit but also the current training costs.[1] Once the factor is employed by the firm, however, these training costs become sunk costs which cannot be retrieved by terminating the employment of that factor. If the training program is successful, the release of the factor would result in a decrease in current profit since the marginal revenue product of that factor exceeds the wage rate. The firm would have some incentive to continue the employment of that factor even as output is contracted, at least to the point where further profit savings are not possible.

Still another element which discourages the firm from engaging in input adjustment is its ability to alter its production process to accommodate a greater or lesser rate of output. Plants and production techniques in place often are not easily changed. The ability of the firm to reduce the stock of capital on the premises is limited by the rate of physical depreciation, leasing agreements, and the market for used machinery.

---

[1]Walter Y. Oi, "Labor as a Quasi-fixed Factor," Journal of Political Economy, LXX (December, 1962), 541.

The rate of capital input can be altered by changing the rate at which the existing machinery is utilized, but this alternative also is not without cost. Technical constraints embodied in the inherited capital stock may require substantial expenditure to achieve a change in factor utilization.

Given the existence of adjustment costs, the predictions of the theory of firm behavior where factor inputs are variable should not be expected to be consistent with observed behavior in the economy. At best, these predictions are relevant for the analysis of the long-run. The short-run actions of the firm facing positive costs of adjustment are quite different.

In this analysis it is postulated that, due to the fixed costs associated with hiring, adapting, and maintaining factor inputs, firms are reluctant to alter their work force with each and every change in expected demand. That is, firms find it optimal to maintain their work force in the face of short-run variations in rates of output and alter this factor only when convinced that a shift in demand is of sufficient magnitude or duration to warrant the costs of changing employment. As a first approximation, the adjustment costs of capital and labor are presumed to be equal; and, thus, only the current relative user costs are postulated to affect demand for factors. The effect of adjustment costs on labor demand is postulated to be reflected in a distributed lag on expected commodity demand. These postulates are incorporated by redefining the demand for labor services to the form[1]:

---

[1]The exact form of this demand function in the case where adjustment costs are non-trivial is found by maximizing a profit function which includes costs of adjustment. This function is of the form

$$\max: H = \int_0^T e^{-rt}[\pi(t)]dt$$

where $\pi(t)$ is profit defined as total revenue in each period minus total cost. The cost $c(t)$ is defined as $c(t) = f[K(t),\dot{K}(t),N(t),\dot{N}(t)]$, where the dots

$$(2.10d)\quad \ln N_0^d = d_0 + d_1 \ln\overline{Q^{\varepsilon}} + d_2\,(\ln R_0 - \ln w_0)$$

where d_0, d_1, and d_2 are the same coefficients as appeared in (2.10c), and $\ln\overline{Q^{\varepsilon}} = \sum_0^n q_i \ln Q_{-i}^{\varepsilon}$.[1]

The Price Level and Supply of Commodities

The previous section introduced the effect of adjustment costs on the firm's demand for labor services. The existence of these costs also has implications for the pricing plans of the firm. The equations (2.9a-b-c), which give the optimal level of labor employment for the firm, also yield the profit-maximizing price-output combination for the firm. Ignoring the adjustment costs for the moment, the optimal price is found by solving (2.9b) for γ and substituting into (2.9a). The result is

$$(2.11)\quad P = \left[\frac{\eta}{1+\eta}\right]\frac{w}{F_N}.$$

With the generalized Cobb-Douglas production function introduced earlier, $F_N = \alpha Q/N$; and, thus, (2.11) may be written as

$$(2.11a)\quad P = \left[\frac{\eta}{1+\eta}\right]\frac{1}{\alpha}\left[\frac{wN}{Q^{\varepsilon}}\right]$$

where Q^{ε} has been substituted for Q. This function shows the relationship between the profit-maximizing price and output. Price is found to be a

---

signify time derivatives. Finding the solution to this problem involves utilizing the calculus of variations; this results in a complicated and analytically difficult expression. For a discussion of the effects of this problem and the effects of the approach used here, see J. P. Gould, "Adjustment Costs in the Theory of Investment of the Firm," Review of Economic Studies, XXXV (January, 1968), 47-55.

[1] Two studies relating directly to the form of the demand function presented here are M. Ishag Nadiri and Sherwin Rosen, "Interrelated Factor Demand Functions," American Economic Review, LIX (September, 1969), 457-71 and Ronald Soligo, "The Short-run Relationship between Employment and Output," Yale Economic Essays, VI (Spring, 1966), 161-215.

function of the unit-labor costs incurred in producing the quantity Q^{ε}. The function predicts that price is unit elastic with respect to these costs. However, the introduction of adjustment costs into the considerations of the firm has implications for the price equation. In particular, the function (2.10d) predicts that the firm's demand for labor services does not adjust instantaneously to changes in expected demand. Thus a change in Q^{ε} will not result in an immediate adjustment in labor demand. This implies that the unit-labor costs that a firm incurs in producing to meet expected demand will vary over the period of adjustment of employment. The question is the extent to which the firm adjusts price in response to these changes in unit costs.

The revenue of the firm in any period is determined by the demand conditions faced in the market. The firm cannot be sure that the quantity that it offers for sale in the market during any period will command the price that had been anticipated when the decision to produce that commodity was made.[1] The decision to change price and output in response to an unexpected change of demand is made with reference to the expected profit consequences of the adjustment.

The costs relevant to the firm are those which result in a change in the flow of income to the owners of the firm. These costs are in terms of changes in the value of the firm to the owners, of which current profits are

---

[1]This is one reason that firms maintain inventories of both goods and orders. These inventories are carried at a cost and serve as a means to meet stochastic variations in demand which occur over short periods of time. This method of adjustment is an important one in the operation of the firm, but it is not the concern of this study. Instead, the concern here is the manner in which firms react to changes in demand of sufficient length or magnitude to make continued reliance strictly on inventory policy a prohibitively costly venture.

only one element. Attention must also be paid to the effect of current decisions on the future income prospects of the firm. For this reason actions which are difficult to reverse are undertaken cautiously, even if such actions promise to take full advantage of current economic conditions and yield a relatively high return in the immediate period.

For example, a firm could follow a policy of changing price over the course of a production period so as to sell its entire current production. As the period progressed the firm would be able to form an opinion of the status of its offering price and adjust the price to meet the demand of the moment. During periods of relatively sluggish sales the firm could lower its price; and during periods when queues form, the price could be increased. The cost to the firm of such a policy stems from the variability it introduces into its price. Each price change renders the market's previous price information worthless. Customers who are constantly confronted with changing prices are not able to plan consumption because the price prevailing at the moment that they desire to purchase may not be consistent with utility-maximization. A firm which maintains a constant price throughout the periodic changes in the price charged by a competitor is able to provide valuable information to consumers. By not changing its price, a firm is able to reduce the search costs of consumers by making their market information longer lasting.[1]

---

[1]Another consideration is the possibility that the program of price variance may introduce an element of speculation into the demand function facing the firm. Consumers who observe that the supply price falls during periods when sales are slow are tempted to withhold orders in the expectation that such action will spur a price decline upon which they can act later in the period.

A further consideration is the effect of price variability on future demand. This consideration is related to the effect on demand of changing price when the price on substitute commodities has a more constant price distribution. Trades consummated in the early stages of the trading period may not be at the same price as those completed later. In a situation in which the price declined over the period, those customers who traded early in the period cannot be expected to be indifferent to the lower prices paid by later customers. Similarly, consumers attracted to the firm by prices paid by others early in the period face the strong possibility that they will not be able to secure as attractive a price when the firm raises price in response to the "increasing demand." Such customer frustration can be quite costly in terms of the willingness of the affected parties to return to the firm in the future. In a system where information is an economic good, price stability can enhance long-run profits.

Given these considerations, it is postulated that future demand is a negative function of current price variability and that firms do not adjust price immediately to each and every change in expected current demand. Instead they will absorb short-term changes in profits in pursuit of long-run profits. This behavior is approximated by the following function

$$(2.11b)\quad P_0 = \left[\frac{\eta}{1+\eta}\right]\frac{1}{\alpha}\left[\frac{w_0 N_0}{\bar{Q}_0^{\varepsilon}}\right]$$

which in logarithmic form is

$$(2.11c)\quad \ln P_0 = \ln\left[\frac{\eta}{1+\eta}\left(\frac{1}{\alpha}\right)\right] + \ln w_0 + \ln N_0 - \ln \bar{Q}_0^{\varepsilon}$$

where $\ln \bar{Q}^{\varepsilon} = \sum_{0}^{n} q_i \ln Q_{-i}^{\varepsilon}$.

This function explains the price behavior of firms in terms of long-term sales prospects relative to current production costs. The price at which the firm is willing to offer commodities to the market in the current period is affected by current period sales prospects only to the extent that these prospects affect the firm's estimate of the trend of demand.

The Adjustment Mechanism in the Labor Market

In the derivation of the labor demand and supply functions in an earlier section, the postulate was advanced that the current wage information utilized by households was not necessarily consistent with the employment plans of firms. In order to close the system, it is necessary to specify the mechanism by which the wage offers of firms and the wage demands of households interact.

Consider Figure 2.3 below where the supply and demand functions in the labor market are plotted in the wage-employment plane. The supply curve traces the amount of labor services forthcoming at each wage when that wage is correctly perceived by households as the best wage available,

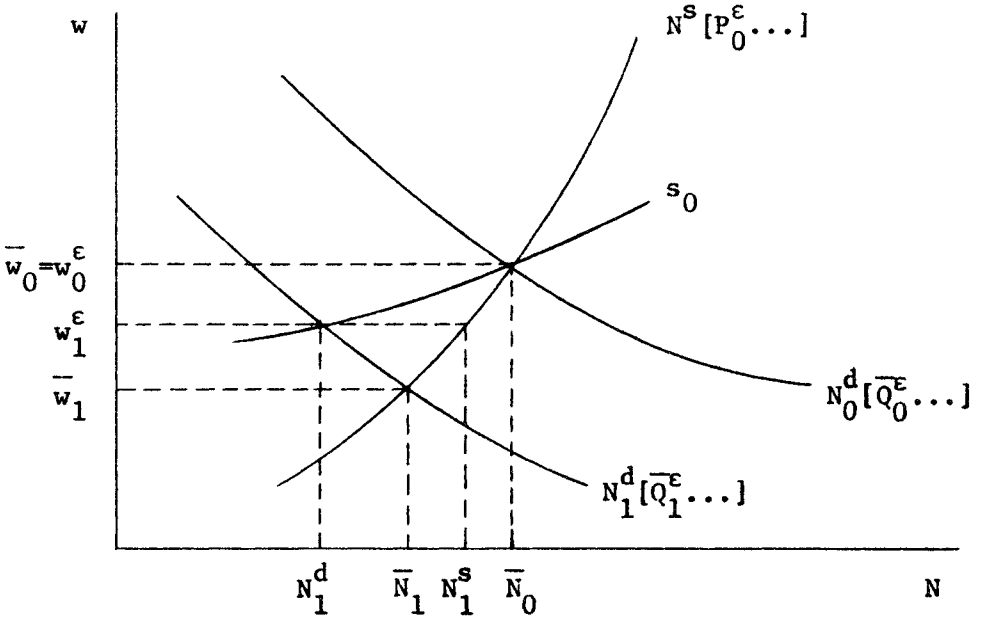


Fig. 2.3

on the average, in the market. Given the other arguments in the functions, if firms have long-term sales expectations of $\bar{Q}_0^{\varepsilon}$ the market for labor services is in equilibrium when the wage is $\bar{w}_0$, which is equal to that expected by the household sector. Assume that for some reason firms become pessimistic in their sales expectations, resulting in a decline to $\bar{Q}_1^{\varepsilon}$. The effect is to shift the demand for labor services leftward, relative to the wage rate.

Other things equal, the new equilibrium is at the wage $\bar{w}_1$, with employment of $\bar{N}_1$. However, the household estimate of the prevailing wage does not fall immediately to $\bar{w}_1$, reflecting the postulate that households do not immediately detect the general fall in demand for labor services. Instead the expected wage falls only to w_1^{ε} where N_1^s units of labor services are offered. However, at the wage $w_1 = w_1^{\varepsilon}$ only $N_1^d < N_1^s$ units of labor services are demanded by firms. The result is an increase in reported unemployment equal to $(N_1^s - N_1^d)$.[1]

The emergence of this unemployment is postulated to reflect search behavior which provides information about prevailing labor demand conditions. This information has a depressive effect on household wage aspirations and results in a decline in both w^{ε} and w proportional to the discrepancy $(N^s - N^d)$. Specifically the expected wage approaches $\bar{w}$, the wage which equates labor demand and the long-run supply of labor according to the adjustment function:

$$(2.12)\quad \Delta \ln w^{\varepsilon} = \lambda\,(\ln \bar{w} - \ln w_{-1}^{\varepsilon}) \qquad 0 < \lambda < 1.0.$$

---

[1]The system is not meant to convey the impression that at the wage where N^d and N^s are equilibrated the rate of unemployment is zero. These functions represent deviations from the normal frictional unemployment which naturally exists in a complex economy.

It is further postulated that firms are always on their demand functions; and, thus, $w^{\varepsilon} = w$ and $N^{d} = N$ in all time periods.[1] Equation (2.12) can be rewritten as

$$(2.12a)\quad \Delta \ln w = \lambda(\ln \bar{w} - \ln w_{-1})$$

The discrepancy between N^{d} and N^{s} will close at the constant rate of λ percent per period. The equilibrium wage ($\bar{w}$) is found by equating the demand and supply functions, (2.7) and (2.10d), and solving for the current wage.

The explanatory economic model developed thus far consists of five functional relationships in five endogenous variables. These variables are:

N^{s} = current period supply of labor services

N^{d} = current period demand for labor services

P = current period price of commodity services

w = current period wage rate

$\bar{w}$ = current period equilibrium wage.

The variables exogenous to the system are:

Q^{ε} = expected current period demand, at P

P^{ε} = household anticipation of current period price of commodity services

ρ^{ε} = household expectation of the rate of change of commodity service prices in the future, from $\ln (P_1^{\varepsilon}/P_0^{\varepsilon}) = \ln (1+\dot{P}^{\varepsilon}/P_0^{\varepsilon})$ $\underline{\sim}\ \dot{P}^{\varepsilon}/P_0^{\varepsilon} = \rho^{\varepsilon}$ in equation 2.7

---

[1] An alternative approach would be to specify a functional relationship between w^{ε} and other economic arguments. However, that procedure suffers from a lack of observations on household wage aspirations.

ω = household expectation of future real wage rates

r = interest rate at which future income can be converted to claims on current commodity services

A = stock of household non-human wealth at beginning of current period

R = current period user cost of capital services.

The exact form of the system to be tested is presented below where several additional postulates are introduced.

The supply and demand relationships derived in this chapter have been constructed from analyses of microeconomic theory. The supply function (2.7) describes the behavior of a single household, just as the labor demand and commodity supply functions relate to the behavior of a single firm. These functions must be aggregated across all households and firms if a model of aggregate behavior is to be constructed. Thus the labor supply function predicts the aggregate amount of labor services forthcoming, given total household non-human wealth, some average market rate of interest, and average expectations of current and future wage rates and prices. The labor demand function predicts the total amount of labor demanded, given the sum of all demand expectations and the average wage relative to the average user cost of capital. The price function predicts the average level of commodity prices, given the average wage, total employment, expected aggregate demand, and the price elasticity of aggregate demand.

Several external factors which can affect behavior in the aggregate commodity markets have been ignored to this point. However, they must be considered in order to state the model in a testable form. One of these elements is the role of the government's labor demand. Employment in government has increased significantly faster than has employment in the

private sector of the economy.[1] No attempt is made here to explain government demand for labor services. Instead, the effect of government demand on the market for labor services is treated as a reduction in the supply of labor available to the private sector. Thus government demand is postulated to be a negative component of the intercept of the labor supply function. In addition, a time trend variable is introduced into the labor supply function to capture the effect of increasing government demand over time. The trend effect of government demand on the supply of labor to the private sector is postulated to be negative. The effect of government demand on the trend in labor supply to the private sector is offset to some degree by growth in the civilian population of labor force age. The net effect of these two influences on the trend of labor supply is not postulated here and; thus, the coefficient on the time variable is left to be ambiguous.

In the derivation of the labor demand function, no allowance was made for the effect of changes in the technological productivity of factors. A time variable is included in the labor demand function to capture this effect. In a similar fashion, a trend variable is included in the price equation to account for secular drift in the distribution of firm income between wage earners and other claimants. Over the post-war period, the share of income going to wages has increased at about a one percent annual rate. Thus, the time trend in the price equation is postulated to have a negative sign.

---

[1]The level of civilian employment in government was slightly more than 13 percent of total civilian employment in 1971, compared to only 9.4 percent in 1955. See U.S. Department of Commerce, Survey of Current Business, National Income Issues (July), Table 6.6 for civilian employment in government; and U.S. Department of Labor, Employment and Earnings, Table A-1 for total civilian employment.

The specific form of the explanatory economic model to be tested, including the restrictions introduced above, is

Labor Supply function

$$(2.13)\quad \ln N^{s} = s_0 + s_1 t + s_2 [\ln w - \ln P^{\epsilon}] + s_3 rr$$

where, from (2.7):

$$s_0 = \alpha_0 \gtrless 0$$

$$s_1 \gtrless 0$$

$$s_2 = \alpha_1 > 0$$

$$s_3 = -(\alpha_2+\alpha_3) > 0 \text{ and } rr = [r - \rho^{\epsilon}]^{1}$$

Labor Demand function

$$(2.14)\quad \ln N = d_0 + d_1 t + d_2 \ln \bar{Q}^{\epsilon} + d_3 [\ln R - \ln w]$$

where, from (2.10d):

$$d_0 = \frac{1}{\rho}\{\beta[\ln\alpha - \ln\beta] - \ln A\} > 0$$

$$d_1 < 0$$

$$0 < d_2 = \frac{1}{\rho} \leq 1.0$$

$$0 < d_3 = \frac{\beta}{\rho} < 1.0$$

---

[1] The coefficient s_3 is derived as follows: recall in (2.7) the terms $(\alpha_2+\alpha_3)[\ln P_1^{\epsilon} - \ln P_0^{\epsilon}] - (\alpha_2+\alpha_3)\ln(1+r)$. Since $\ln(1+r) \approx r$, and since $\Delta \ln P^{\epsilon} \approx [dP^{\epsilon}/dt]\,[1/P_0^{\epsilon}]$, this term may be rewritten as $-(\alpha_2+\alpha_3)[r-\rho^{\epsilon}]$, where ρ^{ϵ} is the expected rate of change of prices. On the presumption that the nominal rate of interest is the sum of the real rate of interest and the expected rate of change of prices, current labor supply is a positive function of the real rate of interest. William P. Yohe and Denis S. Karnosky, "Interest Rates and Price Level Changes, 1952-69," Federal Reserve Bank of St. Louis Review, LI (December, 1969), 18-38.

Price function

$$(2.15)\quad \ln P = \rho_0 + \rho_1 t + \rho_2 [\ln w + \ln N - \ln \overline{Q}^{\varepsilon}]$$

where, from (2.11b):

$$\rho_0 = \ln \{\frac{1}{\alpha} [\frac{\eta}{1+\eta}]\} \gtrless 0$$

$$\rho_1 < 0$$

$$\rho_2 = 1.0$$

Wage Adjustment Equation

$$(2.16)\quad \ln w = \lambda \ln \overline{w} + (1-\lambda)\, w_{-1}$$

where, from (2.12):

$$0 < \lambda < 1.0$$

Equilibrium Wage function

$$(2.17)\quad \ln \overline{w} = \gamma_0 + \gamma_1 t + \gamma_2 \ln \overline{Q}^{\varepsilon} + \gamma_3 \ln R + \gamma_4 \ln P^{\varepsilon} + \gamma_5 rr$$

where, from (2.13) and (2.14):

$$\gamma_0 = \frac{1}{d_3+s_2}[d_0-s_0] < 0$$

$$\gamma_1 = \frac{1}{d_3+s_2}[d_1-s_1] > 0$$

$$\gamma_2 = \frac{d_2}{d_3+s_2} > 0$$

$$\gamma_3 = \frac{d_3}{d_3+s_2} > 0$$

$$\gamma_4 = \frac{s_2}{d_3+s_2} > 0$$

$$\gamma_5 = \frac{-s_3}{d_3+s_2} < 0$$

This system of equations and the set of premises which define the structural coefficients represent a theory of how behavior is determined in aggregate labor and commodity markets which are free from external control of price and resource movements. The only impediments to instantaneous market clearing are those arising from imperfect information, and this effect is postulated to be temporary. Thus, if the predictions of this model are consistent with observed relationships in the aggregate markets for labor and commodity services in the United States economy, then this would constitute evidence supporting the contention that aggregate employment, wage rates, and prices are determined by market forces in this economy.

CHAPTER III

TEST OF THE HYPOTHESIS

The model developed in the previous chapter, in conjunction with the set of economic postulates defining the structural coefficients, is offered as a theory of how aggregate markets for commodity and labor services operate. The model constitutes a universal statement which is applicable to any economic system over any period of time and serves as a general rule by which behavior in the aggregate commodity and labor markets can be analyzed. The model is offered as a foundation for the analysis of behavior in aggregate commodity and labor markets. The usefulness of this or any other theory is determined by the accuracy of the predictions which can be derived from it under a wide set of circumstances. Strong tests of the theory can be made by considering the accuracy of its implications in various circumstances. Such tests are the purpose of this chapter.

In order to test a profferred theory, the set of circumstances in which the theory is to be evaluated must be clearly stated. The particular set of circumstances chosen constitutes the set of initial conditions, which in conjunction with the theory, form the hypothesis to be tested.[1] The

---

[1]The role of initial conditions in the consideration of an explanatory theory and in the development of a fully implemented hypothesis is amply summarized by Nagel, "The indispensability of initial conditions for the deductive explanation of individual occurrences is obvious as a point in formal logic. For it is logically impossible to deduce a statement instantial in form from statements that have the form of a universal conditional. (For example, it is impossible to derive an instantial statement of the form 'x is B' from a universal conditional of the form 'For any x, if x is A then x is B.') But obvious though the point may be, it is an

method of testing by deductive analysis involves deriving the logical implications of the hypothesis and then comparing these implications with the empirical evidence.

Such testing is based on the fact that if a given theory is true, then some of the logical implications of that theory for behavior under a specific set of circumstances will be observed empirically.[1] A piece of evidence

---

important one that is frequently neglected in discussions of scientific procedure. Its neglect is at least partly responsible for the cavalier way in which broad generalizations are sometimes used to account for detailed matters of fact (especially in the study of human affairs) and for the low esteem which observers sometimes have for painstaking investigations of what are the actual facts. It is, however, often difficult to make concrete uses of laws and theories, simply because the specific initial conditions for their application are inaccessible and therefore unknown. And, conversely, mistaken explanations and false predictions are frequently proposed because the general assumptions that are employed, though sound enough in themselves, are applied to situations which do not constitute appropriate initial conditions for those assumptions. Though laws of one sort or another are indispensable in scientific explanations of the actual course of events, what actually transpires cannot be explained exclusively by reference to laws. In the pursuit of scientific understanding, as in the settlement of legal disputes, general principles alone do not determine any individual case." Ernest Nagel, The Structure of Science: Problems in the Logic of Scientific Explanation, p. 32.

An example of an analysis which ignores the role of initial conditions in the formulation of a hypothesis is found in Evan's discussion of the inability of the quantity theory to explain price movements over the period since the Korean War. Observing that contemporaneous rates of money growth and price change often diverge, reflecting output and velocity variability, he concludes: " . . . a need to find a new explanation for every postwar business cycle explaining why the previous version of the quantity theory did not hold has reduced its efficacy as a possible determinant of the price level." Evans, Macroeconomic Activity, p. 304.

[1] Denoting the statement of a theory as T and a set of initial conditions as I, the conjunction (T•I) is the statement of a hypothesis describing behavior under the conditions I. Denoting the logical consequences of the hypothesis as S, the method of testing used here can be written:

$$\vdash : \quad T \cdot I \supset S$$
$$\sim S$$
$$\therefore \sim (T \cdot I)$$

This is recognized as the classical modus tollens form of argument and reads: "if (T•I) then (S), but not (S), therefore not (T•I)." Thus the truth of the prediction statements (S) of the hypothesis is a necessary, but not

which is inconsistent with a single implication of the hypothesis is sufficient to warrant the rejection of the hypothesis. This approach can never yield results which prove the theory to be true; however, repeated testing which yields results consistent with the implications of the theory can serve to increase confidence that the hypothesis is an accurate representation of that which it purports to explain.

A set of prediction or test statements is derived in this chapter from the conjunction of the model presented in the previous chapter and a set of initial conditions. Following this derivation, the criteria for rejecting the hypothesis are presented, and the results of the tests are reported.

The Set of Initial Conditions

The set of initial conditions form the framework in which an explanatory model is evaluated. A given hypothesis is designed to represent a segment of the real world under a specific set of initial conditions, and a change in one or more of these conditions can result in a change in the derivable consequences of the hypothesis. Such a change can also lead to a change in the empirical evidence which is relevant for the falsification of the hypothesis. Evidence which is a potential falsifier of a given

---

sufficient, condition for the truth of the hypothesis.

The test of the theory T is of the form:

$$\vdash : \quad T \cdot I \supset S$$
$$\sim S \cdot I$$
$$\therefore \sim T.$$

Thus the refutation of the model (theory) requires not only that the prediction statements of the hypothesis not be in agreement with the evidence but also that the set of initial conditions are met. The truth table for the evaluation of the statement $T \cdot I \supset S$ is presented in Appendix A.

hypothesis under one set of initial conditions may not be appropriate as a falsifier under a different set of conditions.[1]

The set of initial conditions imposed in this chapter includes statements about the observed values of the exogenous variables in the model and statements about external conditions whose effect on behavior is either negligible or constant throughout the sample period. These conditions are summarized in the following set of invariant regression equations:

$$(3.1a\text{-}e)\quad \begin{bmatrix} \ln N_t^s \\ \ln N_t \\ \ln w_t \\ \ln \bar{w}_t \\ \ln P_t \end{bmatrix} = \begin{bmatrix} \pi^*_{11} & \pi^*_{12} & \cdots\cdots & \pi^*_{17} \\ \pi^*_{21} & \pi^*_{22} & \cdots\cdots & \pi^*_{27} \\ \pi^*_{31} & \pi^*_{32} & \cdots\cdots & \pi^*_{37} \\ \pi^*_{41} & \pi^*_{42} & \cdots\cdots & \pi^*_{47} \\ \pi^*_{51} & \pi^*_{52} & \cdots\cdots & \pi^*_{57} \end{bmatrix} \begin{bmatrix} \ln \bar{Q}^{\varepsilon}_t \\ \ln P^{\varepsilon}_t \\ \ln R_t \\ rr_t \\ \ln w_{t-1} \\ t \\ 1 \end{bmatrix} + \begin{bmatrix} \eta_{t1} \\ \eta_{t2} \\ \eta_{t3} \\ \eta_{t4} \\ \eta_{t5} \end{bmatrix}$$

where $rr = [r-\rho^{\varepsilon}]$, $\ln \bar{Q}^{\varepsilon} = \sum_{0}^{n} q_i \ln Q^{\varepsilon}_{-i}$, and the vectors

$$\eta_t = (\eta_{t1} \cdots \eta_{t5})$$

---

[1]For example, the implications of the model would be changed significantly in a situation where the government decreed that prices or wages were frozen and not allowed to change under any set of circumstances. The specification of the model would be unchanged, but the categorization of exogenous variables would be altered. For example, a wage-control program would result in the wage rate being treated as an exogenous instead of endogenous variable.

are independently and identically normally distributed with

$$E(\eta_t^*) = 0$$

and non-singular covariance matrix

$$\Sigma^* = [\sigma_{ij}^*], \ (i,j = 1, \text{---} 5).$$

The system of equations (3.1a-e) is the unrestricted reduced form of a wide class of models which contain the variables as listed; this system describes the set of alternative economic models which are considered in the present study. The model developed in the previous chapter is shown to be one of these alternatives.

This set of regression equations is interpreted as meaning that over a sample period characterized by: (1) a particular temporal sequence of observations on the four exogenous variables ($\ln\overline{Q}^{\varepsilon}$, $\ln P^{\varepsilon}$, lnR, rr); (2) a particular beginning-of-sample-period magnitude of one of the endogenous variables ($\ln w_{-1}$); and (3) the absence of external shocks which directly affect behavior or alter the legal, technological, and economic institutions; the mechanism that determines the magnitudes of the endogenous variables can be represented by the system (3.1a-e).[1]

The matrices of regression coefficients (Π^*) and error terms (η) define the observed relationships between the endogenous and exogenous variables. The demonstration that the model yields a set of prediction statements (Π) which are a proper subset of (Π^*) allows the model to be tested by comparing the observed relationships (Π^*) with those implied by

---

[1]The effects of government demand for labor, population growth, and productivity changes constitute the set of external shocks explicitly considered. Thus, consideration (3) in this paragraph is a restatement of the assumed effects of these factors.

the model. The model is tested against all of the alternative hypotheses whose implications form the proper subset ($\Pi^{*}-\Pi$). Although the tests conducted here are related only to the parameters $\pi_{i,j}$ (i=1,5; j=1,7), this approach is not to be interpreted as asserting that the properties of the system (3.1a-e) are taken as established. The system presented here is testable against a broader class of alternatives, where additional exogenous variables are considered, but these tests are not undertaken.

Solving the set of structural equations to get each of the endogenous variables as a function of exogenous and lagged endogenous variables only yields the following system:

$$(3.2a)\quad \ln N^{s} = \pi_{11}\ln\overline{Q^{e}} + \pi_{12}\ln P^{e} + \pi_{13}\ln R + \pi_{14}rr + \pi_{15}\ln w_{-1} + \pi_{16}t + \pi_{17}$$

where:
$$\pi_{11} = \frac{s_2\lambda d_2}{s_2+d_3} \qquad \pi_{15} = s_2(1-\lambda)$$

$$\pi_{12} = -\frac{s_2[d_3+s_2(1-\lambda)]}{s_2+d_3} \qquad \pi_{16} = \frac{s_1(d_3+s_2)+\lambda(d_1-s_1)s_2}{s_2+d_3}$$

$$\pi_{13} = \frac{s_2\lambda d_3}{s_2+d_3} \qquad \pi_{17} = \frac{s_0(d_3+s_2)+\lambda(d_0-s_0)s_2}{s_2+d_3}$$

$$\pi_{14} = \frac{s_3[d_3+s_2(1-\lambda)]}{s_2+d_3}$$

$$(3.2b)\quad \ln N = \pi_{21}\ln\overline{Q^{e}} + \pi_{22}\ln P^{e} + \pi_{23}\ln R + \pi_{24}rr + \pi_{25}\ln w_{-1} + \pi_{26}t + \pi_{27}$$

where:
$$\pi_{21} = \frac{d_2[s_2+d_3(1-\lambda)]}{s_2+d_3} \qquad \pi_{25} = -d_3(1-\lambda)$$

$$\pi_{22} = -\frac{d_3\lambda s_2}{s_2+d_3} \qquad \pi_{26} = \frac{d_1[s_2+d_3(1-\lambda)]+d_3\lambda s_1}{s_2+d_3}$$

$$\pi_{23} = \frac{d_3[s_2+d_3(1-\lambda)]}{s_2+d_3} \qquad \pi_{27} = \frac{d_0[s_2+d_3(1-\lambda)]+d_3\lambda s_0}{s_2+d_3}$$

$$\pi_{24} = \frac{d_3 \lambda s_3}{s_2+d_3}$$

(3.2c) $\ln w = \pi_{31} \ln \bar{Q}^{\varepsilon} + \pi_{32} \ln P^{\varepsilon} + \pi_{33} \ln R + \pi_{34} rr + \pi_{35} \ln w_{-1} + \pi_{36} t + \pi_{37}$

where: $\pi_{31} = \frac{\lambda d_2}{s_2+d_3}$ $\qquad \pi_{35} = (1-\lambda)$

$\pi_{32} = \frac{\lambda s_2}{s_2+d_3}$ $\qquad \pi_{36} = \frac{\lambda(d_1-s_1)}{s_2+d_3}$

$\pi_{33} = \frac{\lambda d_3}{s_2+d_3}$ $\qquad \pi_{37} = \frac{\lambda(d_0-s_0)}{s_2+d_3}$

$\pi_{34} = -\frac{\lambda s_3}{s_2+d_3}$

(3.2d) $\ln \bar{w} = \pi_{41} \ln \bar{Q}^{\varepsilon} + \pi_{42} \ln P^{\varepsilon} + \pi_{43} \ln R + \pi_{44} rr + \pi_{45} \ln w_{-1} + \pi_{46} t + \pi_{47}$

where: $\pi_{41} = \frac{d_2}{s_2+d_3}$ $\qquad \pi_{45} = 0$

$\pi_{42} = \frac{s_2}{s_2+d_3}$ $\qquad \pi_{46} = \frac{d_1-s_1}{s_2+d_3}$

$\pi_{43} = \frac{d_3}{s_2+d_3}$ $\qquad \pi_{47} = \frac{d_0-s_0}{s_2+d_3}$

$\pi_{44} = -\frac{s_3}{s_2+d_3}$

(3.2e) $\ln P = \pi_{51} \ln \bar{Q}^{\varepsilon} + \pi_{52} \ln P^{\varepsilon} + \pi_{53} \ln R + \pi_{54} rr + \pi_{55} \ln w_{-1} + \pi_{56} t + \pi_{57}$

where:

$\pi_{51} = \rho_2 \frac{(d_2-1)(s_2+d_3)+d_2\lambda(1-d_3)}{s_2+d_3}$ $\qquad \pi_{55} = \rho_2(1-\lambda)(1-d_3)$

$\pi_{52} = \rho_2 \frac{s_2\lambda(1-d_3)}{s_2+d_3}$ $\qquad \pi_{56} = \frac{\rho_2\lambda[(d_1-s_1)(1-d_3)]+(\rho_2 d_1+\rho_1)(s_2+d_3)}{s_2+d_3}$

$$\pi_{53} = \rho_2 \frac{d_3[s_2+d_3+\lambda(1-d_3)]}{s_2+d_3} \qquad \pi_{57} = \rho_2 \frac{\lambda(d_0-s_0)(1-d_3)+(d_0+\rho_0/\rho_2)(s_2+d_3)}{s_2+d_3}$$

$$\pi_{54} = \rho_2 \frac{s_3\lambda(1-d_3)}{s_2+d_3}$$

These relations comprise the set of prediction statements of the model. From this set of relations, the sign pattern of the implications can be derived. This sign pattern is summarized in Table 3.0 below. With the exception of $\pi_{51} = \partial \ln P / \partial \ln \overline{Q}^{\epsilon}$ and several of the intercepts and time coefficients, the signs implied by the hypothesis are unique. The hypothesis implies a complicated relationship between expected demand ($\ln \overline{Q}^{\epsilon}$) and price (lnP) which does not yield an unambiguous sign without the introduction of some additional order restrictions on the structural coefficients.[1] The same is true of the elements in the vectors π_{i6} and π_{i7} (i=1,2 . . . 5). Thus these coefficients are not potential falsifiers of the hypothesis.

The test of the hypothesis consists of investigating whether or not the empirical evidence on Π^* is in agreement with that implied by Π. The evidence considered here consists of ordinary least squares estimates of a portion of the system (3.1a-e) from quarterly data generated by the private sector of the United States economy over the period from the first quarter of 1955 to the second quarter of 1971. These estimates ($\hat{\Pi}^*$) are taken as

---

[1] Given the order restriction $0<d_3<d_2<1.0$, which is an element of the hypothesis, the sufficient condition for $\pi_{51}>0$ is $0<s_2<(\lambda d_2-d_3)<1.0$. The inclusion of this latter premise in the specification of the hypothesis would yield the implication that $\pi_{51}=\partial \ln P / \partial \ln \overline{Q}^{\epsilon}>0$. Evidence contrary to this implication would then be sufficient grounds for rejection of the hypothesis. This premise is not introduced because it depends critically on the speed of adjustment (λ) of household expectations of the best available wage. The theory of individual choice does not allow specification of this parameter, other than $0<\lambda<1.0$.

TABLE 3.0

SIGN PATTERN IMPLIED BY THE HYPOTHESIS*

Dependent Variables	Predetermined Variables						
	$\ln\bar{Q}^{\varepsilon}$	$\ln P^{\varepsilon}$	lnR	rr	$\ln w_{-1}$	t	Constant
$\ln N^{s}$	+	-	+	+	+	$\pm$	$\pm$
lnN	+	-	+	+	-	$\pm$	+
lnw	+	+	+	-	+	$\pm$	$\pm$
$\ln\bar{w}$	+	+	+	-	0	$\pm$	$\pm$
lnP	$\pm$	+	+	+	+	$\pm$	$\pm$

*The signs are those the partial derivatives of the matrix Π. For example, the plus-sign in the first row--first column signifies that the model predicts a positive relationship between labor supply ($\ln N^{s}$) and long-term sales expectations ($\ln\bar{Q}^{\varepsilon}$). The sign pattern was determined by means of an algorithm which has been developed by Lancaster. See Kelvin Lancaster, "The Solution of Qualitative Comparative Static Problems," Quarterly Journal of Economics, LXXX (May, 1966), 278-95.

representative of the "event" described by the system (3.1a-e) and are compared with the predictions of the hypothesis.

The data used in any test are a very important portion of the set of initial conditions. Data are real numbers which purport to represent objects of experience. Thus, the validity of any hypothesis which is stated with reference to a specific set of initial conditions is dependent upon how well the data correspond to real world events.

Current labor demand (N^{d}).--current labor demand is measured by current employment, reflecting the postulate that firms are always on their

demand curve relative to the wage rate. The data consist of total payroll man-hours in the private sector.[1]

Current wage rate (w).--average compensation per man-hour in the private sector.

Current commodity price (P).--implicit price deflator for private sector product.

Current user cost of capital (R). = $P_k(r+\mu)$.--where P_k is the price deflator for business fixed investment in the National Income accounts, r is the interest rate on seasoned Aaa-rated corporate bonds, and μ is the rate of physical depreciation. The rate of depreciation is postulated to be constant at 0.16.[2]

Real rate of interest (rr) = $r - \rho^{\varepsilon}$.--where (r) is the market yield on Moody's Aaa-rated corporate bonds. The series (ρ^{ε}) is the expected rate of change of private sector prices over the future. This series is constructed from survey data collected, from a diverse group of 60-80 persons, and published semi-annually by J.A. Livingston. The survey appears semi-annually in late June and December in the Philadelphia Sunday Bulletin. The series used here is constructed from the consensus forecasts of the rate of change of the consumer price index over the year following the date of the survey. Since the survey is conducted semi-annually, it is necessary to

---

[1]The data, with the exception of the expectation variables, the rate of interest, and the rental price of capital, are indices supplied upon request by the United States Department of Labor, Bureau of Labor Statistics. A listing of all of the data is presented in Appendix B.

[2]The value was not chosen arbitrarily but is based upon experiments which were conducted during the construction of the FRB-MIT econometric model of the United States economy. For a summary of this construction see Franco Modigliani, "Econometric Models of Stabilization Policies" (paper presented at the Third Far Eastern Meeting of the Econometric Society, June 27, 1968).

construct a quarterly series. This is accomplished by assigning the forecast published each June to the third quarter of the corresponding year and by assigning the forecast reported in December of the previous year to the first quarter. Data for the second and fourth quarters of each year is constructed by linear interpolation.

Expected demand (Q^{ε}).--this series is also constructed from the Livingston survey data and is based on the consensus forecast of movements in industrial production. The survey asks participants to report their best estimate of the levels of various measures of economic activity six and twelve months into the future. Much of the data in the survey is in the form of indexes, the bases of which changed over the sample period. Thus, it is necessary to compute forecasted rates of change in order to get a consistent time series. The expected rate of change of industrial production over the six months following the date of survey ($_{t}\dot{Q}^{\varepsilon}_{t+6}$) is computed as:

$$_{t}\dot{Q}^{\varepsilon}_{t+6} = \left[\frac{{}_{t}Q^{\varepsilon}_{t+6}}{Q_{t}}\right]^{\frac{1}{4}} - 1$$

where $_{t}Q^{\varepsilon}_{t+6}$ is the forecast made at time t of the level of industrial production at time (t+6) months in the future, and Q_{t} is the actual level of industrial production at time t.

This implied annual rate of change for each of the June surveys is taken as the measure of the expected rate of change of demand from the second to the third quarter of that year. The implied rate of change for each of the December surveys is taken as the measure of the expected rate of change of demand from the fourth quarter of the year in which the December survey was conducted to the first quarter of the next year.

The expected rates of change for the second and fourth quarters of each year are constructed from a combination of the forecasts from (t) to

(t+6) and from (t+6) to (t+12). The expected rate of change applied to the second quarter of each year is computed as:

$$\dot{Q}^{\varepsilon}(II) = \frac{1}{2}\{[\frac{{}_{t}Q^{\varepsilon}_{t+6}}{Q_t}]^{\frac{1}{4}} + [\frac{{}_{t}Q^{\varepsilon}_{t+12}}{{}_{t}Q^{\varepsilon}_{t+6}}]^{\frac{1}{4}}\} - 1$$

where t refers to December of the previous year. The expected rate of change for the fourth quarter of each year is computed in a similar fashion, but from a base of t = June.[1]

The expected level of demand in each quarter was computed according to the following scheme:

$$\ln Q^{\varepsilon}(i) = \ln Q_{i-1} + .25\ln\,[1.0 + (0.1)\,\dot{Q}^{\varepsilon}(i)] \qquad i = 1,2,3,4$$

where i refers to the quarter to which the particular magnitude is assigned and (Q_{i-1}) refers to the level of output produced in the private sector in the previous quarter.

Expected level of commodity prices (P^{ε}).--this series is also computed from the Livingston survey data. The method of construction was identical to that used to derive Q^{ε}. The price data used to construct P^{ε} are the forecasted levels of the consumer price index P_C. The expected level of prices in the current period is computed as:

$$\ln P^{\varepsilon}(i) = \ln P_{i-1} + .25\ln\,[1.0 + (.01)\,\dot{P}^{\varepsilon}_{c}(i)]$$

where (P_{i-1}) is the implicit price deflator for private sector output in the previous quarter.[2]

---

[1] A chart of this series is presented in Appendix C.

[2] A chart of the expected rate of change of prices is presented in Appendix D.

The Results of Time Series Regression

The test of the hypothesis consists of comparing the estimates of the coefficients ($\hat{\pi}^{*}_{ij}$) with the coefficients (π_{ij}) as implied by the hypothesis. The estimates are those generated by ordinary least squares regression on the equations (3.2a-e). The confirmation of the hypothesis requires that the estimated coefficients be in agreement with the implications of the hypothesis. Every implication which is unambiguous in sign is a potential falsifier of the hypothesis. There are 25 such implications of the hypotheses to be tested and each is a potential falsifier of the entire hypothesis. None of these coefficients is to be interpreted as uninteresting or unimportant.

The explanatory model in conjunction with the set of premises which restrict the structural coefficients implies a definite sign pattern to the coefficients in the equations (3.2a-e). Thus, the criteria by which the hypothesis is judged is based, in part, on the estimated signs of the coefficients. In addition, all of the structural coefficients are so restricted as to imply non-zero values for all but one of the reduced form coefficients; and thus, the significance of the deviation of the estimated coefficients from zero is also an important consideration.

The test of the hypothesis consists of estimating the coefficients in equations (3.2b-c-e). Lack of observations on the long-run equilibrium wage ($\bar{w}$) and the current period supply of labor services (N^{s}) precludes estimation of the coefficients in equations (3.2a-d). Thus, the tests are only partial in nature, in that a significant portion of the implications are not confronted with evidence.

The results of the regressions on equations (3.2b-c-e) are presented in Table 3.1. The signs of all but one of the estimated coefficients are in agreement with those implied by the hypothesis. The one exception is the

TABLE 3.1

ESTIMATED COEFFICIENTS[a]

Dependent Variable	Predetermined Variables									
	$\ln\overline{Q}^{\varepsilon}$[b]	$\ln P^{\varepsilon}$	lnR	rr	$\ln w_{-1}$	t	Constant	$\overline{R}^2$	D.W.	h
(3.2b)lnN	.842 (11.753)	.272 (.885)	.084 (1.024)	.031 (.070)	-.121 (.616)	-.007 (6.274)	.105 (.126)	.9733	.699	
(3.2c)lnw	.133 (2.859)	.429 (2.154)	.061 (1.141)	-.216 (-.762)	.539 (4.232)	.002 (2.749)	-.736 (-1.367)	.9995	1.818	2.782
(3.2e)lnP	.039 (1.994)	.875 (10.430)	.014 (.626)	.153 (1.281)	.098 (1.820)	-.001 (-3.999)	-.041 (-.180)	.9995	1.584	

[a]Values in parentheses below the estimated coefficients are t-scores. $\overline{R}^2$ is the coefficient of determination, adjusted for degrees of freedom. D.W. is the Durbin-Watson statistic, and h is Durbin statistic used to test for auto-correlation in the presence of lagged endogenous variables.

[b]The coefficient on $\ln\overline{Q}^{\varepsilon}$ is the sum coefficient generated by the Almon-lag estimator, with n=4. The Almon-constraints used were d=2, t+1≠0, t-n-1=0. The estimated weights are reported in Appendix F.

coefficient of the expected price level in the employment equation, where the estimate (.272) is not consistent with the negative coefficient implied by the hypothesis. This result is sufficient to reject the hypothesis; however, closer examination reveals evidence which suggests where revisions might be made. The coefficients on lnR and rr in the wage equation are of the implied signs but are not significantly different from zero.[1] These estimates are tentative evidence against the premises that labor demand is a function of relative factor costs and that labor supply is a negative function of the real rate of interest. Recall equation (3.2c) where

$$\frac{\partial \ln w}{\partial \ln R} = \frac{\lambda d_3}{d_3+s_2} > 0 \qquad \frac{\partial \ln w}{\partial rr} = \frac{-\lambda s_3}{d_3+s_2} < 0 \qquad \frac{\partial \ln w}{\partial \ln P^e} = \frac{\lambda s_2}{d_3+s_2} > 0.$$

Since the estimated coefficient of expected prices in the wage equation is 0.429 and is significantly different from zero, and since the sign and significance of this coefficient are dependent on the sign and significance of s_2, the estimated zero coefficients on lnR and rr can result only from $d_3 = s_3 = 0$, or $\lambda = 0$. However, the estimated coefficient on $(\ln w_{-1})$ in that equation is positive and significantly different from zero, but less than unity. This result is consistent with the premise that $0 < \lambda < 1.0$; and, thus, $d_3 = s_3 = 0$ is suggested.

Further evidence which is suggestive of the inaccuracy of the premises that $d_3 > 0$ and $s_3 > 0$ is found in the estimates of the coefficients of the employment equation (3.2b). There are four coefficients in this relationship for which $d_3 = 0$ is a sufficient condition for a zero value. These are

$$\frac{\partial \ln N}{\partial \ln P^e} = \pi_{22} = -\frac{d_3 \lambda s_2}{s_2+d_3} < 0 \qquad \frac{\partial \ln N}{\partial \ln R} = \pi_{23} = \frac{d_3[s_2+d_3(1-\lambda)]}{s_2+d_3} > 0$$

$$\frac{\partial \ln N}{\partial rr} = \pi_{24} = \frac{d_3 \lambda s_3}{s_2+d_3} > 0 \qquad \frac{\partial \ln N}{\partial \ln w_{-1}} = \pi_{25} = -d_3(1-\lambda) < 0.$$

---

[1] The 5 percent level is used throughout to determine significance.

The signs of the estimates of each of these coefficients, with the exception of $(\hat{\pi}^{*}_{22})$, are in agreement with those implied by the hypothesis; but none of the estimates are significantly different from zero. Since $\lambda \neq 0$ and $s_2 \neq 0$ are suggested by other estimated coefficients in the wage and price relationships, the evidence suggests that $d_3 = s_3 = 0$.

These results do not support the postulated effect of relative factor prices on the short-run labor demand of firms. The dominant consideration in labor demand in this context is the expected level of long-term sales $(\overline{Q}^{\epsilon})$, as would be the case for firms which operate with either fixed factor proportions or a fixed capital input. In either case, the demand for labor services would be expected to vary with the scale of output, at least over the period of time where adjustment costs prohibit capital adjustments.

Also, the results do not support the premise that labor supply is a negative function of the real rate of interest. Recall that the real rate of interest was computed by using a measure of expected price change during the next year. The suggestion that $s_3 = 0$ implies that: (1) the measure of the real rate of interest is incorrect, or (2) leisure and consumption are not inter-temporal substitutes given the degree of variance in the real rate of interest experienced in the sample period.

A further consideration which cannot be ignored in the evaluation of the estimated coefficients is the efficacy of the testing procedure in determining Π^{*}. For example, each of the reported regressions exhibits a high probability of auto-correlation in the residuals. However, one of the initial conditions explicitly states that the error terms in the regression equations (3.1a-e) are serially independent. Since auto-correlation of residuals tends to cause the least-squares estimator to generate under-estimates of the variance of the parameters, the t-statistics in these regressions must be interpreted with caution.

As a test of the potential effect of auto-correlation, the estimation procedure is amended to include a technique for reducing the effects of auto-correlation.[1] The results are presented in Table 3.2. These results are similar to those reported earlier. Of the estimates which are not significantly different from zero in Table 3.1 only the variances of $\hat{\pi}^*_{13} = \partial \ln N/\partial \ln R$ and $\hat{\pi}^*_{55} = \partial \ln P/\partial \ln w_{-1}$ are reduced sufficiently to yield estimates significantly different from zero.

Although auto-correlation affects only the variance of the estimated coefficients of exogenous variables, the method used here to correct for auto-correlation resulted in substantial changes in several of the estimates.[2] The coefficient of expected prices in the employment function is now estimated to be negative, as implied by the hypothesis, but it is not significantly different from zero. Other changes in sign which result in

---

[1]The assumption is made that the error terms in each of the three regression equations are generated according to the scheme $\eta_{it} = \rho_i \eta_{i(t-1)} + \gamma_{it}$. This information is incorporated into the regression procedure by transforming each of the variables in each of the three equations according to the scheme $\chi_t = X_t - \hat{\rho} X_{t-1}$, where $\hat{\rho}$ is the estimate from successive iterations on $\eta_{it} = \rho_i \eta_{i(t-1)} + \gamma_{it}$. An auto-regressive term ($\hat{\rho}$) is estimated for each of the three equations, and the variables in each relationship are transformed accordingly. See D. Cochrane and G. H. Orcutt, "Application of Least Squares Regressions to Relationships Containing Auto-correlated Error Terms," Journal of the American Statistical Association, XLIV (March, 1949), 32-61.

[2]Auto-correlation of residuals can yield biased estimates of the parameters in a relationship which includes lagged endogenous variables on the right-hand side, since in general the lagged dependent variable is not independent of the error term. If the auto-correlation is positive, as suggested in Table 3.1, the ordinary least-squares estimate of the coefficient on the lagged endogenous variable will be biased upward. This effect can be seen by comparing the estimated coefficient of 0.539 on $\ln w_{-1}$ in eq. 3.2c in Table 3.1 with the estimate of 0.186 in Table 3.2. For a discussion of the problems of estimating a function which contains lagged endogenous variables on the right-hand side, see Zvi Griliches, "Distributed Lags: A Survey," Econometrica, XXXV (January, 1967), 24-46.

TABLE 3.2

ESTIMATED COEFFICIENTS
(With Adjustment for Auto-correlation)

Dependent Variable	Predetermined Variables									
	$\ln\overline{Q}^{\varepsilon}-\hat{\rho}_i \ln\overline{Q}^{\varepsilon}_{-1}$	$\ln P^{\varepsilon}-\hat{\rho}_i \ln P^{\varepsilon}_{-1}$	$\ln R-\hat{\rho}_i \ln R_{-1}$	$rr-\hat{\rho}_i rr_{-1}$	$\ln w_{-1}-\hat{\rho}_i \ln w_{-2}$	t	1	$\hat{\rho}_i$	$\overline{R}^2$	D.W.
$\ln N-\hat{\rho}_1 \ln N_{-1}$	.699 (7.668)	-.152 (-.612)	.199 (2.005)	-.423 (-.910)	.006 (.035)	-.006 (3.469)	1.723 (1.827)	.718	.9857	1.969
$\ln w-\hat{\rho}_2 \ln w_{-1}$	.183 (3.270)	.742 (3.469)	.093 (1.318)	-.199 (-.567)	.186 (1.238)	.004 (3.885)	-1.003 (-1.570)	.341	.9995	2.045
$\ln P-\hat{\rho}_3 \ln P_{-1}$	.030 (1.357)	.804 (9.148)	.015 (.551)	.186 (1.356)	.158 (2.522)	-.001 (-3.741)	.066 (.262)	.239	.9995	2.039

estimates which are inconsistent with the implications of the hypothesis are observed in the estimates of the coefficients of the real rate of interest and the lagged wage in employment function.

As with the results presented in Table 3.1, the estimated coefficients on the distributed lag of expected demand and of the time trend are significant in the employment function. Contrary to the previous estimates, the estimated coefficient on lnR in this function is now significantly positive. However, this latter result is inconsistent with other estimates reported in Table 3.2. Necessary conditions for $\pi^*_{13} \neq 0$ are $s_2 \neq 0$ and $d_3 \neq 0$. The premise that labor supply is a non-zero function of the perceived real wage, $s_2 \neq 0$, is supported by the estimated coefficients on expected prices in the price and wage equations. Both of these estimates are positive and significantly different from zero, as implied by the hypothesis. However, with $s_2 \neq 0$ and $\lambda > 0$ as suggested by the $\hat{\pi}^*_{35}$ and $\hat{\pi}^*_{55}$, $d_3 = 0$ is a necessary condition for the coefficients on lnR in the wage and price equations (π^*_{33} and π^*_{52}) to be zero. Thus the estimates that $\pi^*_{33} = \pi^*_{53} = 0$ are inconsistent with $\hat{\pi}^*_{13} \neq 0$.

The previous finding that the empirical evidence does not support the postulated effect of the real rate of interest on labor supply is also suggested by the estimates in Table 3.2. In particular, with $s_2 \neq 0$ and $\lambda \neq 0$ the necessary condition for $\pi^*_{34} = \partial \ln W / \partial rr = 0$ is that labor supply be unresponsive to changes in the real rate of interest, i.e., that $s_3 = 0$. Thus the estimate $\hat{\pi}^*_{34} = 0$ suggests $s_3 = 0$. Also given $s_2 \neq 0$ and $\lambda \neq 0$, a zero value for $\hat{\pi}^*_{54}$, the effect of the real rate of interest on the current price level, can arise only from $\rho_2 = 0$, $s_3 = 0$ or $d_3 = 1$. The evidence cited in the previous paragraph indicates the caution with which the contention $d_3 \neq 0$ is accepted. Thus, a zero value for $\hat{\pi}^*_{54}$ is more probably reflective of ρ_2

or s_3 being zero. However, $\rho_2 = 0$ is a sufficient condition for all of the coefficients in the price equation to be zero; and since $\hat{\pi}^*_{52}$, $\hat{\pi}^*_{55}$, and $\hat{\pi}^*_{56}$ are non-zero, the premise $\rho_2 = 0$ is doubtful.

In summary, the evidence is consistent with $d_2 > 0$, $s_2 > 0$, $\rho_2 > 0$ and $0 < \lambda < 1.0$, but does not support $d_3 > 0$ and $s_3 > 0$. Thus the hypothesis must be rejected. The implications of the conjunction of the model, the economic premises which restrict the structural parameters of that model, and the set of initial conditions (including the data used to measure the variables) are not in agreement with empirical evidence. However, recalling the deductive nature of the test, the evidence is not sufficient to reject the explanatory model.[1] A false prediction is conclusive evidence against the validity of the model if and only if the set of initial conditions are valid. A false prediction can be derived from the conjunction of a valid model and a set of false initial conditions. The task at hand is to determine the source of the predictions which were shown above to be false.

The Revised Hypothesis

The task of providing strong empirical evidence bearing on the validity of a particular set of initial conditions is one of the most difficult in the procedure of testing a hypothesis. This difficulty is probably a major factor explaining the infrequency of the task being undertaken. The severity of the problem is the reason for the adoption of several of the specifications employed in this study, including the sample period and the data used. The sample period is truncated in mid-1971 to

---

[1] Basmann, "On Predictive Testing," p. 16.

exclude observations which were generated in the environment of the wage-price control program adopted by the Federal government in August of that year and pursued with varying degrees of intensity through 1973. The control program represents a substantial and easily identifiable external shock to the system under consideration. The program is not consistent with the set of initial conditions which excluded the possibility that the government directly determines market prices. Since the observations generated under the control program come toward the end of the available data set they are easily excluded from the sample.

The considerations which enter into the selection of the data also are intended to reduce the problem of verifying the set of initial conditions.[1] At one level, all of the data selected are generated by the private sector of the economy, which excludes from consideration the labor market activities of the general government. This choice is made on the presumption that government activities are less constrained by economic considerations than are the activities of the rest of society.

A further data consideration involved the expectations variables. In the absence of observations of market expectations, an explanatory economic model which postulates a role for expectations must include a

---

[1]One test of the effect of the data selection was run. The user cost of capital series which was utilized included no provision for the effect of tax rate changes in the computation of the series. An alternative series which incorporates the corporate tax rate and the effective rate of tax credit on durable equipment was tried. The results are presented in Appendix E. This alternative series did not change the test results.

postulate describing the procedure whereby expectations data are generated from available measures of other series.[1] This postulate becomes a non-separable part of the hypothesis. In order to avoid the problematic choice of an expectations generator, time series based on reported measures of market expectations are used. While it cannot be shown that these variables are accurate representations of market expectations in general, they do represent the consensus forecasts of at least one portion of the market participants. The use of these variables precludes the introduction of ad hoc expectation-forming mechanisms which are impossible to verify as accurate.[2]

Prior to consideration of the initial conditions several additional characteristics of the test results should be noted. First, the test results support each and every postulate describing the effect of expectations on market behavior. Second, none of the test results supports the postulated effect of the real rate of interest on labor supply, and only one estimate supports the postulated effect of relative factor costs on labor demand. Zero values are estimated for all but one of the coefficients where $s_3 = 0$ or $d_3 = 0$ is a sufficient condition for a zero value, and zero values are estimated for those coefficients only.

---

[1]For example, Lucas-Rapping clearly recognized the problem when they postulated that economic units form expectations of real wages and prices which are adaptive on the levels of the variables. This mechanism reflects the assumption that economic units expect wages and prices to return to normal levels. They used this postulate to solve for the expectation variables in terms of the associated observed magnitudes. Lucas and Rapping, "Real Wages," 731.

[2]For an attempt to determine how well the Livingston forecast data can be explained by various, commonly used expectation generators see Stephen J. Turnovsky, "Empirical Evidence on the Formation of Price Expectations," Journal of the American Statistical Association, LXV (December, 1970), 1441-54.

On the basis of these characteristics of the estimates, a test of a revised hypothesis where $s_3 = 0$ and $d_3 = 0$ is of interest. However, care must be taken that the results of this second test are not accepted as evidence relevant to the validity of the original hypothesis. The second test is conducted on an entirely different hypothesis, and evidence consistent with the implications of the new hypothesis says nothing about the original contention. The exercise is supplementary to the original test and is conducted only in an attempt to provide additional information on the effect of expectations on behavior in the labor and commodity markets.

A revision of the hypothesis designed to take account of the suggestion that current labor demand is only minimally affected by relative factor prices and that current labor demand is not affected much by the real rate of interest yields the following model:

$$(3.3a)\quad \ln N^{S} = s_0 + s_1 t + s_2\,[\ln w - \ln P^{\epsilon}]$$

$$(3.3b)\quad \ln N = d_0 + d_1 t + d_2 \sum_{0}^{n} q_i \ln Q^{\epsilon}_{-i}$$

$$(3.3c)\quad \Delta \ln w = \lambda(\ln \bar{w} - \ln w_{-1})$$

$$(3.3d)\quad \ln \bar{w} = \frac{1}{s_2}\,[(d_0 - s_0) + (d_1 - s_1)t + d_2 \sum_{0}^{n} q_i \ln Q^{\epsilon} + s_2 \ln P^{\epsilon}]$$

$$(3.3e)\quad \ln P = \rho_0 + \rho_1 t + \rho_2 [\ln w + \ln N - \sum_{0}^{n} q_i \ln Q^{\epsilon}_{-i}]$$

where the economic premises which define the model are

$$d_0 > 0 \qquad s_0 \gtrless 0 \qquad \rho_0 < 0$$

$$d_1 < 0 \qquad s_1 \gtrless 0 \qquad \rho_1 < 0$$

$$0 < d_2 \leq 1.0 \qquad s_2 > 0 \qquad \rho_2 = 1.0$$

$$0 < \lambda < 1.0$$

The implications of this hypothesis are prediction statements bearing on the signs of the following set of invariant relationships, where $\ln\bar{Q}^{\varepsilon} = \sum_{0}^{n} q_i \ln Q^{\varepsilon}_{-i}$:

$$(3.4a\text{-}e)\quad \begin{bmatrix} \ln N^{s} \\ \ln N \\ \ln w \\ \ln\bar{w} \\ \ln P \end{bmatrix} = \begin{bmatrix} \pi^{*}_{11} & \pi^{*}_{12} & \cdots & \pi^{*}_{15} \\ \pi^{*}_{21} & \pi^{*}_{22} & \cdots & \pi^{*}_{25} \\ \pi^{*}_{31} & \pi^{*}_{32} & \cdots & \pi^{*}_{35} \\ \pi^{*}_{41} & \pi^{*}_{42} & \cdots & \pi^{*}_{45} \\ \pi^{*}_{51} & \pi^{*}_{52} & \cdots & \pi^{*}_{55} \end{bmatrix} \begin{bmatrix} \ln\bar{Q}^{\varepsilon} \\ \ln P^{\varepsilon} \\ \ln w_{-1} \\ t \\ 1 \end{bmatrix} + \begin{bmatrix} \eta^{*}_{1} \\ \eta^{*}_{2} \\ \eta^{*}_{3} \\ \eta^{*}_{4} \\ \eta^{*}_{5} \end{bmatrix}$$

where residuals are independently and normally distributed with

$$E(\eta^{*}_{i}) = 0$$

and non-singular covariance

$$\Sigma^{*} = [\sigma^{*}_{ij}],\ i,j = 1,2, \ldots 5.^{1}$$

The hypothesis implies:

$$(3.5a)\quad \ln N^{s} = \pi_{11}\ln\bar{Q}^{\varepsilon} + \pi_{12}\ln P^{\varepsilon} + \pi_{13}\ln w_{-1} + \pi_{14}t + \pi_{15}$$

$$\pi_{11} = \lambda d_2 \qquad \pi_{14} = s_1(1-\lambda)+d_1$$

$$\pi_{12} = s_2(\lambda-1) \qquad \pi_{15} = s_0(1-\lambda)+d_0$$

$$\pi_{13} = 1-\lambda$$

---

[1] The time-subscript has been deleted in this specification.

(3.5b) $\ln N = \pi_{21}\ln\overline{Q^{\varepsilon}} + \pi_{22}\ln P^{\varepsilon} + \pi_{23}\ln w_{-1} + \pi_{24}t + \pi_{25}$

$\pi_{21} = d_2$ $\qquad$ $\pi_{24} = d_1$

$\pi_{22} = 0$ $\qquad$ $\pi_{25} = d_0$

$\pi_{23} = 0$

(3.5c) $\ln w = \pi_{31}\ln\overline{Q^{\varepsilon}} + \pi_{32}\ln P^{\varepsilon} + \pi_{33}\ln w_{-1} + \pi_{34}t + \pi_{35}$

$\pi_{31} = \dfrac{\lambda d_2}{s_2}$ $\qquad$ $\pi_{34} = \dfrac{\lambda(d_1-s_1)}{s_2}$

$\pi_{32} = \lambda$ $\qquad$ $\pi_{35} = \dfrac{\lambda(d_0-s_0)}{s_2}$

$\pi_{33} = (1-\lambda)$

(3.5d) $\ln\overline{w} = \pi_{41}\ln\overline{Q^{\varepsilon}} + \pi_{42}\ln P^{\varepsilon} + \pi_{43}\ln w_{-1} + \pi_{44}t + \pi_{45}$

$\pi_{41} = \dfrac{d_2}{s_2}$ $\qquad$ $\pi_{44} = \dfrac{d_1-s_1}{s_2}$

$\pi_{42} = 1.0$ $\qquad$ $\pi_{45} = \dfrac{d_0-s_0}{s_2}$

$\pi_{43} = 0$

(3.5e) $\ln P = \pi_{51}\ln\overline{Q^{\varepsilon}} + \pi_{52}\ln P^{\varepsilon} + \pi_{53}\ln w_{-1} + \pi_{54}t + \pi_{55}$

$\pi_{51} = \rho_2 \left[\dfrac{s_2(d_2-1)+d_2\lambda}{s_2}\right]$ $\qquad$ $\pi_{54} = \dfrac{s_2(\rho_2 d_1+\rho_1)+\rho_2\lambda(d_1-s_1)}{s_2}$

$\pi_{52} = \rho_2\lambda$ $\qquad$ $\pi_{55} = \dfrac{s_2(\rho_2 d_0+\rho_0)+\rho_2\lambda(d_0-s_0)}{s_2}$

$\pi_{53} = \rho_2(1-\lambda)$

Table 3.3 presents the implied signs of (Π). As with the original hypothesis, the coefficient $\pi^{*}_{51} = \partial \ln P / \partial \ln \overline{Q}^{\epsilon}$ is not a potential falsifier,

TABLE 3.3

SUMMARY OF SIGNS IMPLIED BY REVISED HYPOTHESIS*

	$\ln\overline{Q}^{\epsilon}$	$\ln P^{\epsilon}$	$\ln w_{-1}$	t	1
$\ln N^{s}$	+	-	+	±	±
ln N	+	0	0	-	+
ln w	+	+	+	±	±
$\ln\overline{w}$	+	+	0	±	±
ln P	±	+	+	±	±

*The signs refer to the implied coefficients π_{ij}, i,j = 1,2,...5. Thus the positive sign in the first row--first column refers to π_{11}.

since the relationship implied by the hypothesis (π_{51}) is ambiguous in sign.[1] The same is true for several of the intercepts and time coefficients. The implications of the revised hypothesis are more restrictive than those of the original hypothesis. The testable prediction statements (3.5b-c-e) contain zero-valued coefficients, while this was not true in the original formulation. Specifically, the revised hypothesis implies that there exists no significant relationship between current employment magnitudes and either current price expectations or lagged wages. This result follows directly

[1]Given the premises $s_2>0$, $0<d_2<1.0$, and $\rho_2>0$, the sign of π_{11} is determined by:

$$\pi_{11} \gtrless 0 \text{ as } \lambda \gtrless s_2 \left[\frac{1-d_2}{d_2}\right].$$

from the premise that the schedule of current labor demand is vertical in the wage-employment plane. The hypothesis contains as one of its elements the contention that employment is strictly demand-determined whereas wages are strictly supply determined. Within the confines of the model, the household sector can determine the prevailing wage but not the amount of labor services employed at that wage.

The postulated vertical labor demand schedule also has interesting implications for price behavior. The effect of price expectations on unit-labor costs and, thus, prices, given the mark-up factor ρ_2, is determined by the speed of adjustment of household wage perceptions λ. Since the model does not explicitly consider a feedback of labor supply on employment, the relationship between price expectations and current prices is determined by the speed at which wage information is disseminated in the labor market. The slower this adjustment, i.e., the smaller the magnitude of λ, the more prolonged is the adjustment of prices to changes in current price expectations.

The test of the revised hypothesis is presented in Table 3.4. The empirical evidence is not in agreement with two of the implications of the hypothesis. The estimate of π^*_{22} $(\partial \ln N/\partial \ln P^{\varepsilon})$ is 0.477 and is significantly different from zero at the five percent level. The hypothesis implies a zero value for this coefficient. The other estimate which is not in agreement with the implications is $\hat{\pi}^*_{25}$, the intercept in the employment equation (3.5b). All of the other estimates are consistent with the implications of the hypothesis. However, on the basis of $\hat{\pi}^*_{22}$ and $\hat{\pi}^*_{25}$, this test indicates that the hypothesis is false.

TABLE 3.4

ESTIMATED COEFFICIENTS
(Revised Hypothesis: $d_3 = s_3 = 0$)

Dependent Variable	Predetermined Variables							
	$\ln\bar{Q}^{\varepsilon}$	$\ln P^{\varepsilon}$	$\ln w_{-1}$	t	Constant	$\bar{R}^2$	D.W.	h
(3.3b) lnN	.860 (16.521)	.477 (2.171)	-.139 (-.736)	-.007 (-6.885)	-.554 (-1.276)	.973	.722	
(3.3c) lnw	.167 (4.938)	.594 (4.171)	.503 (4.114)	.002 (2.525)	-1.290 (-4.578)	.9995	1.740	8.939
(3.3e) lnP	.029 (2.000)	.898 (11.802)	.109 (2.104)	-.001 (-4.284)	-.101 (-.845)	.9995	1.640	

As in the test of the original model, the statistics indicate that the residuals in these regressions probably exhibit positive first-order auto-correlation. As a check against the possibility that the estimates are influenced by non-independence of the error distributions, the relationships were re-estimated using the Cochrane-Orcutt technique employed earlier. These results are presented in Table 3.5.

The signs of all estimated coefficients are consistent with the implications of the revised hypothesis. However, the coefficient $\hat{\pi}^*_{25}$, while positive, is not significantly different from zero at the five percent level. The estimated coefficient $\hat{\pi}^*_{25}$ is an estimate of the intercept term in the labor demand function (3.3b) and is postulated to be positive. The implied sign on this coefficient is unambiguous and thus it is potential falsifier of the hypothesis. On the basis of the estimated constant in the employment function the hypothesis must be rejected. However, the validity of the explanatory model is still unsettled until the evidence bearing on the initial conditions is considered.

Inferences from the Tests

Although both the original and revised hypotheses must be rejected on the basis of the empirical evidence presented here, the exercise does allow inferences to be made about the effect of market expectations on employment, wage rates, and prices. Although the tests do not support the conjunction of the model and the economic postulates as a system, no evidence has been found contradicting the postulated effects of expectations on behavior. These postulates were supported in tests of both hypotheses. Even though the initial conditions have not been investigated, the results of the test are suggestive of some important aspects of the model.

TABLE 3.5

ESTIMATED COEFFICIENTS
(Revised Hypothesis: $d_3 = s_3 = 0$)
Adjusted for Auto-correlation

Dependent Variable	Predetermined Variables							
	$\ln\bar{Q}^{\epsilon}-\hat{\rho}_i\ln\bar{Q}^{\epsilon}_{-1}$	$\ln P^{\epsilon}-\hat{\rho}_i\ln P^{\epsilon}_{-1}$	$\ln w_{-1}-\hat{\rho}_i\ln w_{-2}$	t	Constant	$\hat{\rho}$	$\bar{R}^2$	D.W.
(3.3b) $\ln N-\hat{\rho}_1\ln N_{-1}$	.768 (9.930)	.169 (.894)	.084 (.537)	-.007 (-5.397)	.282 (.486)	.703	.9852	1.797
(3.3c) $\ln w-\hat{\rho}_2\ln w_{-1}$	.207 (4.907)	.864 (5.074)	.255 (2.728)	.003 (3.537)	-1.648 (-4.812)	.288	.9995	1.999
(3.3e) $\ln P-\hat{\rho}_3\ln P_{-1}$	.017 (.990)	.824 (11.528)	.174 (2.825)	-.001 (-4.405)	.014 (.102)	.210	.9995	2.036

Recall that the evidence in Table 3.5 which led to rejection of the revised hypothesis referred to the implication π_{25}, where

$$\pi_{25} = d_0 > 0.$$

Each of the other implications was found to be consistent with the empirical evidence. The result $\hat{\pi}^*_{25} \neq \pi_{25}$ is evidence against the premise $d_0 > 0$. From equations (3.5b-c-e), the only other implied coefficients which are affected by d_0 are π_{35} and π_{55}, the intercepts of the wage and price equation. However, these latter two coefficients are derived as being ambiguous in sign and, thus, they are not potential falsifiers and do not offer evidence relevant to d_0. The independence from d_0 of all of the other coefficients allows some confidence that the misspecification $d_0 > 0$, given the initial conditions, did not influence the other implications.[1]

The constant in the labor demand function is interpreted as the measure of the average effect on labor demand of all variables excluded from the specification of the function. These are the effects introduced in the set of initial conditions as being constant through the sample. The postulate that the intercept in the labor demand function is greater than zero reflects the presumption that the total effect of these excluded variables is positive. However, when taking the estimates at their face value, the suggestion is that these effects are insignificant in total, and

---

[1]The estimate of the constant term in a regression is not independent of the estimates of the other coefficients in that function. Statistical problems which result in biased estimates of the structural coefficients also lead to biased estimates of the constant term. One potential source of bias in the estimate of the employment equation is the possible exclusion of an independent variable which is correlated with the expected sales variable and has a positive effect on labor demand. In such a situation the estimate of π^*_{21} is biased upward and the estimate of the constant (π^*_{25}) is thus biased toward zero. Such a situation would be an example of the inappropriateness of the set of initial conditions. See Potluri Rao and Roger Leroy Miller, Applied Econometrics, pp. 26-32.

that labor demand throughout the sample period is dominated by long-term sales expectations. Thus, while the tests do not support the premise $d_0 > 0$, this result tends to strengthen the evidence in support of the postulated effect of expectations.

The results reported in Table 3.5 show the elasticity of labor demand with respect to long-term sales expectations to be 0.768. This coefficient is actually an estimate of $d_2 \sum_0^n q_i$ and is thus the "long-run" elasticity in the context of this model. The estimates of $d_2 q_i$ for $i = 0, 1, ..4$, with t-values in parentheses, are

$d_2 q_0 = .3724$ $\quad$ $d_2 q_3 = .0442$

(7.3892) $\quad$ (1.6965)

$d_2 q_1 = .2280$ $\quad$ $d_2 q_4 = .0046$

(10.4862) $\quad$ (.2362)

$d_2 q_2 = .1186$

(5.4761)

The impact elasticity is estimated to be 0.3724. Thus, the contention that labor inputs are quasi-fixed with respect to short-run output plans is supported by the test results. This estimate is quite similar to that of 0.248 reported by Soligo from quarterly observations over the period 1947-61.[1] Lucas-Rapping, using annual data for the period

---

[1] Ronald Soligo, "Employment and Output," p. 190. Contrary to the form estimated here, Soligo specified labor demand as a function of actual output. The long-run effect associated with the impact coefficient reported was 0.483 which is significantly less than that found in this study.

1930-65, estimated the impact coefficient to be 0.79 which is consistent with the five quarter estimate of 0.77 reported here.[1]

The immediate impact on the wage of a unit change in expected demand was estimated as 0.101.[2] The total effect of a unit change in sales expectations on the average wage rate suggested by the regression results is found by considering $\hat{\pi}^*_{31}(1-\hat{\pi}^*_{33})^{-1} = 0.207(1-.255)^{-1} = 0.278$. The coefficient $\hat{\pi}^*_{31}$ is the estimate of direct effect on wages of a unit change in long-run sales expectations ($\overline{Q}^e$). The term, $(1-\hat{\pi}^*_{33})^{-1}$, measures the lagged response of wage expectations to a shift in the demand for labor services. The slope of the labor supply function (s_2) implied by the ratio of the response of wages and employment to a unit change in expected sales is 0.768/0.278 = 2.763.[3] The suggested short-run slope is found by computing the ratio of the impact coefficients of $\ln\overline{Q}^e$ in the wage and employment regressions. This estimate is (.372)/(.101) = 3.683. This result, compared to the estimates of the slope of the long-run labor supply, suggests that the short-run labor supply function is more wage elastic than is the long-run function, but the difference does not appear to be substantial. This result suggests that wage expectations adapt rapidly to disequilibria in the labor market.

---

[1] Lucas and Rapping, "Real Wages," p. 746. The long-run elasticity was constrained to unity in their study.

[2] The estimates of all coefficients containing the term $\sum_{0}^{n} q_i$ are reported in Appendix F.

[3] The structural coefficient (s_2) is over-identified in this system. From equations (3.5b) and (3.5c), $\hat{s}_2 = \hat{\pi}_{32}\hat{\pi}_{21}/\hat{\pi}_{31} = (1-\hat{\pi}_{33})\hat{\pi}_{21}/\hat{\pi}_{31}$. The latter estimate is presented above. The former estimate is (.864)(.768)/(.207) = 3.206.

These estimates of the slope of the long- and short-run labor supply functions are computed relative to the nominal wage. However, since household expectations of commodity service prices (P^{ϵ}) are held constant, these estimates can be interpreted as being estimates of the slope of the labor supply function relative to the perceived real wage. The model gives only very weak information about the slope relative to the actual real wage, since the model allows for no interaction between actual and expected magnitudes.

In each of the tests, the implication of the premise that the supply of labor services reacts positively to changes in the perceived real wage is supported by observed experience. The model makes no attempt to link actual and perceived prices of commodity services; and, thus, the manner in which joint observations of labor employment and the real wage are generated is not complete. However, within the context of the model, the behavior of households is consistent with money illusion. This does not mean that households ignore commodity price patterns in making market decisions. Instead, the model predicts that households conduct their affairs according to their best estimate of current prices. These estimates may or may not be accurate. Thus, if actual price movements differ from household estimates, observations can be generated which appear to be inconsistent with the theory of the effect of relative prices.

From equation (3.5c), the estimates $\hat{\pi}^{*}_{32}$ and $\hat{\pi}^{*}_{33}$ are alternative estimates of λ, the speed at which households adjust their wage expectations to the emergence of excess demand in the labor market. The premise introduced was $0 < \lambda < 1.0$, which is interpreted as postulating only that wage expectations, and thus the wage rate, moved toward equilibrium with some speed greater than zero. To postulate $\lambda = 0$ is to advance the

contention that households refuse, in the face of any evidence, to alter their wage expectations and are willing to bear permanent unemployment to insure that their expectations are realized. Such behavior is grossly inconsistent with the theory of individual utility maximization presented here.[1] With $\lambda = 0$, any economic shock which permanently displaces the demand for labor from an existing equilibrium would result in a permanent change in the rate of labor service unemployment. A situation where $\lambda = 1.0$ would be one where market wage expectations instantaneously adjust to excess demand in the labor market.

Given the behavior observed during the sample period, the forces which determine the speed at which wages adjust to labor market disequilibrium are difficult to determine. The only definite statement which can be made is that competitive labor markets require $0 < \lambda \leq 1.0$; pressures must exist which move the average wage rate toward equilibrium. The experience in the United States over the period from 1955 to 1971 was characterized by neither prolonged periods of rising unemployment nor long periods of high but constant unemployment. Thus, $\lambda < 1.0$ could result from one extreme which reflects the effect of imperfect information on a market which is very competitive to the other extreme where forces exist which resist wage cuts, even with perfect information. As a hypothetical example, the latter effect might result from collusive action among households to resist any wage cut with the hope that the government's commitment to full-employment is sufficiently strong that the stabilization authorities will validate their

---

[1]The utility function from which household behavior was derived considered each individual as attempting to maximize his own self-interest. A much more general function, which includes "public interest," would have to be developed to account for behavior where one economic unit sacrifices consumption willingly so that other units may increase their consumption.

actions. The test of the model is not sufficient to prove the labor-market is competitive, given the sample period considered. However, the tests can yield results which contradict the contention of competitiveness.

The evidence bearing on the magnitude of λ is contained in the estimates of the wage and price equations in Table 3.5. The coefficient λ is over-identified in the model. From the wage equation (3.5c), $\pi_{32} = \lambda$ and $\pi_{33} = (1-\lambda)$. The respective estimates are $\hat{\pi}^*_{32} = 0.864$ and $\hat{\pi}^*_{33} = 0.255$. The latter estimate implies $\lambda = 0.745$. It is important to determine whether these two estimates are significantly different from each other. An F-test was used to determine whether $\hat{\pi}^*_{33} = 1-\hat{\pi}^*_{32}$, and on the basis of this test the hypothesis is rejected.[1] Thus, even though the estimated coefficients in the wage equation are consistent in sign with the implications of the model, the relative magnitudes of the estimates do not support the hypothesis.

From equation (3.3e) in Table 3.5, the elasticity of prices with respect to long-term sales expectations is estimated as $\hat{\pi}^*_{51} = .017$, but the estimate is not significantly different from zero at the five percent level.

---

[1] The specification of the wage equation reported in Table 3.5 is

$$\ln w = \hat{\pi}^*_{31}\ln\overline{Q^e} + \hat{\pi}^*_{32}\ln P^e + \hat{\pi}^*_{33}\ln w_{-1} + \hat{\pi}_{34}t + \hat{\pi}^*_{35} + \hat{\rho}_2\eta_{-1} + \varepsilon,$$

where $(\hat{\rho}_2)$ is the estimate of the auto-regressive term in the errors. This estimate yielded a residual sum of squares (RSS_1) of .00169. The implication that $\hat{\pi}^*_{33} = 1-\hat{\pi}^*_{32}$ is tested by constraining the coefficient on expected prices, and then using an F-statistic to compare the residual sum of squares in the original and constrained estimates. The constrained estimate is

$$\ln w - \ln w_{-1} = \hat{\alpha}_1\ln\overline{Q^e} + \hat{\alpha}_2[\ln P^e - \ln w_{-1}] + \hat{\alpha}_3 t + \hat{\alpha}_4 + \hat{\rho}u_{-1} + \varepsilon',$$

which yields a residual sum of squares (RSS_2) of .00179. The F-statistic is computed as

$$F = \frac{(RSS_2 - RSS_1)/n}{RSS_1/(T-K)} = 5.89$$

with one parameter restriction (n=1) and T-K = 60 degrees of freedom. The critical value for the F distribution for the 95 percent level of confidence is 4.00, which is less than the computed value. Thus, the null hypothesis $\hat{\pi}^*_{33} = 1-\hat{\pi}^*_{32}$ is rejected. Rao and Miller, Applied Econometrics, pp. 145-8.

Given the hypothesis, this result suggests that the net effect of a permanent change in expected demand on expected unit labor costs is zero. The necessary condition for this effect is

$$\frac{\partial \ln w}{\partial \ln \overline{Q^e}} + \frac{\partial \ln N}{\partial \ln \overline{Q^e}} = 1.0$$

or,

$$\hat{\pi}^*_{31} + \hat{\pi}^*_{21} = 1.0.$$

Since $\hat{\pi}^*_{31} = .207$ and $\hat{\pi}_{21} = .768$, with standard errors of 0.04 and 0.08, respectively, this condition is probably met.

Prices are postulated to be unit-elastic with respect to expected long-term unit-labor costs, i.e., that $\rho_2 = 1.0$. If the premise $\rho_2 = 1.0$ is true then the coefficients on expected prices and lagged wages can be written $\pi_{52} = 1.0\lambda = \lambda$ and $\pi_{53} = 1.0\ (1-\lambda) = 1-\lambda$ respectively. A test of this hypothesis is conducted by constraining the coefficient on lagged wages to be equal to one minus the coefficient on expected prices in the price equation and then by comparing the residual sum of squares from this run with that from original price regression. This test provides evidence not only on the premise $\rho_2 = 1.0$, but also additional evidence on the specification of the wage adjustment function and the magnitude of (λ).[1]

---

[1] One test of this premise might have been found in the ratios $\hat{\pi}^*_{32}/\hat{\pi}^*_{52}$ and $\hat{\pi}^*_{33}/\hat{\pi}^*_{53}$, since $\pi_{32} = \lambda$, $\pi_{52} = \rho_2\lambda$, $\pi_{33} = (1-\lambda)$, and $\pi_{53} = \rho_2(1-\lambda)$. The test would involve investigating whether the ratios of these estimates are significantly different from unity. However, the test is questionable on the basis of the earlier rejection of the hypothesis that $\hat{\pi}^*_{33} = 1-\hat{\pi}^*_{32}$. An alternative test was selected which does not require the use of the estimates $\hat{\pi}^*_{32}$ and $\hat{\pi}^*_{33}$ from the wage equation.

The computed F-statistic from this test is zero, and thus the premise $\hat{\pi}^*_{53} = 1-\hat{\pi}^*_{52}$ cannot be rejected.[1]

This result, in turn, is interpreted as supporting the contention that prices during the sample period were, on the average, a constant mark-up over long-term expected unit-labor costs, with adjustment for a negative secular trend.[2] Given that there is no linkage provided in the model between expected and actual demand at the price (P), the model does not provide direct evidence on the joint observations of actual prices and unit-labor costs. However, the model is consistent with observed variability in the ratio of prices to unit-labor costs. The variability reflects discrepancies between actual and expected demand at prevailing prices.

---

[1] Under the null hypothesis, $\hat{\pi}^*_{53} = 1-\hat{\pi}^*_{52}$, the following equation is estimated:

$$\ln P - \ln w_{-1} = \beta_1 \ln \bar{Q}^{\epsilon} + \beta_2[\ln P^{\epsilon} - \ln w_{-1}] + \beta_3 t + \beta_4 + \beta n_{-1} + \epsilon'$$

The sum of squared residuals from this regression is .00029, equal to that from the regression reported in Table 3.5. Thus, $RSS_1 = RSS_2$ and $F = 0$. The estimate of β_2 in this regression is 0.830, which compares closely with the estimate $\hat{\pi}^*_{32} = (\hat{\rho}_2\lambda) = .824$ in the price equation reported in Table 3.5.

[2] An alternative test of the implied coefficients in the price equation is to consider $\hat{\pi}^*_{52} = \hat{\rho}_2 - \hat{\pi}^*_{53}$. Using this relationship to substitute for π_{53} in equation (3.5e), the following regression equation is derived:

$$\ln P = \pi_{51} \ln \bar{Q}^{\epsilon} + \pi_{52}[\ln P^{\epsilon} - \ln w_{-1}] + \rho_2 \ln w_{-1} + \pi_{54} t + \pi_{55} + \rho_3 \eta_{-1} + \epsilon.$$

The estimate of this equation yields a residual sum of squares of .00030. The original estimate presented in Table 3.5 yielded a residual sum of squares of .00029. The computed F-statistic using these residuals is 2.03, which is less than the critical value at the 95 percent confidence level. Thus the null hypothesis $\hat{\pi}^*_{52} = \hat{\rho}_2 - \hat{\pi}^*_{53}$ cannot be rejected. This result also supports the premises in the model.

The estimate of the equation derived above is

$$\ln P = \underset{(.990)}{.017} \ln \bar{Q}^{\epsilon} + \underset{(11.587)}{.824}[\ln P^{\epsilon} - \ln w_{-1}] + \underset{(57.743)}{.998} \ln w_{-1} - \underset{(-4.405)}{.002} t + \underset{}{.014} + \underset{(.103)}{.211} \eta_{-1},$$

where the values in parentheses are t-values for the associated coefficients. The estimated coefficient on the lagged wage term (.998) is an estimate of ρ_2 and is consistent with the contention that ρ_2 is unity. The estimated coefficient on $[\ln P^{\epsilon} - \ln w_{-1}]$ is an estimate of $\rho_2\lambda$ and, with $\hat{\rho}_2 \simeq 1.0$, is thus an estimate of λ. The value (.824) is quite close to that obtained in the other tests of the price equation.

CHAPTER IV

SUMMARY AND CONCLUSIONS

This dissertation has been addressed to the problem of identifying the factors which determine the relationship between aggregate employment, wage rates, and prices. Directly observed measures of price and output expectations have been used to test a model of the aggregate commodity and labor markets. While the tests results do not support all of the postulated relationships of the model, the results are suggestive of the effect of imperfect information on the behavior of economic units.

The implied relationships between the aggregate price level and the measures of market expectations are consistent with the empirical evidence, as are the implied relationships between these expectations and the level of employment. However, the evidence on the implied wage relationships did not support the hypothesis, particularly the form of the adjustment mechanism postulated for the aggregate labor market.

The wage rate is postulated to be an endogenous variable in the economic system, determined by the interaction of demand and supply in the labor market. The wage rate included in the model is interpreted as being the household perception of the best wage available in the current period. This wage represents the consensus of households as to the best wage which can be secured, given their expectation of current demand in the labor market, an estimate which may or may not be accurate. To my knowledge no appropriate measures of this variable exist; and, thus, a mechanism for generating these expectations was required. The model postulates that household wage

aspirations adjust proportionately, and at a constant rate, to the magnitude of excess demand or supply in the labor market. For example, a general decline in the demand for labor, requiring a wage cut to clear the market, is postulated to result in a temporary rise in unemployment as households, basing their employment decisions on incorrect wage expectations, seek alternative employment. This period of unemployment provides the households with information about the new conditions in the market and results in the necessary decline in average wage aspirations of the unemployed.[1]

In addition to the wage adjustment function, the model consists of supply and demand functions for labor services and an implicit commodity supply function in the form of a price-setting relationship. The basis on which the model embodied in the hypothesis tested here was constructed can be summarized in two premises. First, the aggregate markets for commodity and labor services are interdependent in a simultaneous system, where behavior in one market is determined jointly with behavior in the other. Secondly, market participants have only imperfect information about conditions in each market and base their plans on their expectations of prices. The behavioral relations, while descriptive of aggregate magnitudes, were derived with reference to the theory of microeconomic behavior.

The labor supply function was derived from the premise that individuals attempt to maximize inter-temporal utility which is defined in terms of current and future magnitudes of leisure and consumption. In a situation where the attainable utility level is constrained by the human and non-human wealth of the household sector, current supply of labor services is shown to

---

[1]The emphasis is on the wage aspirations of the unemployed. The model does not suggest that all wage rates fall in such a situation. The average wage in the market is held to fall as the unemployed become prepared to take lower paying jobs than they had held previously.

be a function of the expected current and future real wage, the real rate of interest, and the stock of real non-human wealth. The effects of changes in the rate of time preference and the stock of non-human wealth were subsumed in the analysis, and the effect of the expected future real wage was combined into the real rate of interest and current wage expectations. The supply function tested was then defined in terms of the current real wage expected by households and the real rate of interest. However, the postulated effect of the real rate of interest on the supply of labor services was not supported by the evidence, and the specification was dropped without further investigation.

Theoretically, the specification of labor supply as a function of the real wage rate explains the work plans of households as a joint decision, made in conjunction with consumption plans. The real wage rate serves as a measure of the opportunity cost of leisure which rises with an increase in the nominal wage rate and falls with an increase in commodity prices. In a system where market participants have perfect information on all available alternative uses of their resources, this specification predicts that households will attempt to adjust their employment and consumption to equate the wage they receive with the marginal disutility of employment at that wage. Where market information is not perfect and behavior is based on expectations, the household employment decision may prove to be sub-optimal in that the consumption which can be achieved from that level of employment may not be of the magnitude expected. If actual prices in the commodity market are found to exceed expected prices in a given period, the household is not able to realize the utility level planned when employment was accepted at a given wage. The leisure time sacrificed is excessive in terms of the commodity services realized. The response of

labor supply in such a situation is determined by the degree to which households alter their commodity price expectations in view of the prior incorrect estimate.

The manner in which price expectations are generated is not considered in the model in that household price expectations are taken as exogenous. Directly observed measures of price expectations were used to test the implications of the model. The labor supply function predicts that a ceteris paribus increase in commodity prices will decrease current labor supply only to the extent that the price increase affects household expectations. To the extent that household price expectations are affected by factors other than actual price experience, the short-run relationship between labor supply and actual price movements is further weakened. Thus the manner in which price expectations are generated is an important question requiring investigation.

Just as labor supply is postulated to be jointly determined with the demand for consumables, the demand for labor is postulated to be determined simultaneously with the plans of firms in the commodity market. The level of employment and the rate of output desired by firms are derived jointly from the premise that firms seek to maximize net worth, under the constraints of expected current and future demand, current factor costs, and the costs of adjusting operations in the future.

The demand for labor services is postulated to be a function of long-term sales expectations and the current wage rate relative to the current user cost of capital. Long-term sales expectations are postulated to be a five quarter distributed lag function of sales expectations in the current period. The test results did not support the postulated effect of relative factor prices on labor demand, and like the real interest rate in

the supply function, this specification was dropped without further investigation. The inclusion of the relative price of factors reflected the premise that capital and labor, while not variable at zero costs, are variable at equal cost. That is, the adjustment costs of altering the absolute magnitude of the capital stock are approximately the same as those incurred in changing the amount of labor employed. This approach was selected as an alternative of treating the capital stock as a fixed factor, with infinite costs of adjustment. While I still consider the latter approach to be unsatisfactory, the treatment of labor and capital adjustment costs as equal is not supported by the evidence. The question of the relative fixity of factors remains to be investigated.

The revised labor demand function treats labor as a quasi-fixed factor of production, with demand being a distributed lag function of sales expectations. Thus, the degree of association between labor demand and actual output in a given period is dependent upon the relationship between actual and expected sales in that period and the effect of current sales on long-term sales prospects. In terms of lags, the employment decision is affected by the adjustment of long-term sales prospects to changes in current period sales expectations and by the adjustment of current expectations to actual sales. It is by this process that the model seeks to explain variance in the observed output per man-hour ratio. Variance in this ratio is interpreted as reflecting incorrect estimates of aggregate demand at current prices and the costs of adjusting labor inputs, in addition to the technical productivity of labor. The costs of adjusting the labor force result in the aggregate employment remaining relatively fixed throughout periods of short-term variation of sales.

The effect of adjustment costs on firm behavior is carried over to the commodity supply plans and is included in the price equation. Prices were postulated to be jointly determined with labor demand and sales expectations. Functionally, prices are alleged to be determined by long-term sales and cost expectations. The price equation treats prices as a function of expected long-term unit-labor costs, the cost per unit that the firms incur in producing to meet long-term sales expectations. This equation then explains variance in the ratio of observed prices and unit-labor costs in terms of divergence between current output and the long-term expectations of aggregate demand at current prices.

The model is not sufficient to determine the effect of autonomous changes in aggregate demand upon employment, wages, and prices. The model was constructed in block-recursive form in order to test the effect of expectations on market behavior. No explicit mechanism is incorporated in the model by which actual experience in the commodity market is transmitted back to the labor market. The linkages are considered only implicitly through the observed series on price and sales expectations. Thus definite statements about the effect of government aggregate demand policies on employment, wages, and prices are not possible from the model. However, the model does suggest several considerations which are important for policy purposes.

Most importantly, the postulate that the aggregate labor and commodity markets interact as free markets where resources tend to flow to their highest expected reward in a manner which will result in systemic equilibrium is supported by the evidence. Wages and prices are endogenous variables in the system and are determined by the interaction of market

forces. Inflation, in terms of a persistent rise in general prices, reflects the effect of excessive aggregate demand in the commodity market.

The observed relationship between prices and unit-labor costs is explained as resulting from the joint action of firms and households in the commodity and labor markets. The model does not predict a causal relationship from unit-labor costs to prices independent of the level of aggregate demand.

The dominant role which expectations play in the model suggests that the effects of policy actions on market activity cannot be expected to be instantaneous. The speed at which prices and employment respond to an autonomous shock to aggregate demand is dependent on the degree to which market expectations are affected, the manner in which various expectations interact, and the speed at which economic units adjust behavior to new information.

APPENDIX A

In the terminology employed here, the statement $T \cdot I \supset S$ comprises a hypothesis reading as "if T and I then S." As illustrated in the table below, there are exactly eight ways in which truth values can be assigned to the three statements which form the hypothesis.

	T	I	S	$T \cdot I$	$T \cdot I \supset S$	$\sim S \cdot I$
1	T	T	T	T	T	F
2	T	T	F	T	F	T
3	T	F	T	F	T	F
4	T	F	F	F	T	F
5	F	T	T	F	T	F
6	F	T	F	F	T	T
7	F	F	T	F	T	F
8	F	F	F	F	T	F

The demonstration that a set of prediction statements is the logical consequence of the conjunction of the theory and the set of initial conditions results in the exclusion of row 2 from consideration. Once an argument is shown to be logically valid in form, i.e., once $T \cdot I \supset S$ is shown to be true, the argument cannot be dismissed on grounds other than the weight of contrary empirical evidence on the validity of its components.

The inconclusiveness of deductive analysis in determining the truth of a theory is demonstrated in lines 5 and 6. There are two ways in which a true prediction statement can be derived from a false theory. In one case,

(line 5) the initial conditions are fulfilled and in the other (line 6) they are not. Thus, even though a set of prediction statements is found to be in agreement with empirical observations and the set of initial conditions is found to hold, the evidence is not sufficient, in principle, to justify the assertion of the truth of the proferred theory.

The importance of initial conditions in deductive analysis can be seen by comparison of lines 4, 6, and 8. In each case the set of prediction statements is not in agreement with empirical observation. However, this evidence is not sufficient to reject the theory since in line 4 the theory is seen to be true and in line 8 it is false. The conclusiveness of the truth of $\sim S$ for $\sim T$ is shown in line 6 to depend upon the demonstration of the truth of the set of initial conditions. Thus, deductive analysis can lead to the rejection of a theory, but only in the case where the prediction statements are found inaccurate <u>and</u> the set of initial conditions is found to be fulfilled.

APPENDIX B

DATE	P	w	N	Q^{ϵ}	P^{ϵ}	rr	R
1954	79.100	53.700	89.500	58.508	77.825	3.844	16.416
	79.100	54.500	88.300	57.998	78.925	3.521	16.328
	79.000	54.700	87.900	58.700	78.179	3.285	16.372
	79.100	55.300	88.800	59.636	79.012	3.163	16.488
1955	79.400	55.300	90.200	61.697	79.074	3.110	16.628
	79.500	56.000	91.200	63.336	79.370	2.958	16.806
	79.900	55.900	92.800	64.198	79.604	2.800	17.056
	80.300	56.500	94.100	65.334	79.952	2.727	17.301
1956	81.100	57.900	93.700	65.895	80.449	2.616	17.588
	81.900	59.000	94.000	65.185	81.193	2.740	17.950
	82.900	59.800	93.600	65.500	81.961	2.864	18.394
	83.500	61.300	93.200	65.300	83.020	2.580	18.870
1957	84.400	62.300	93.100	66.585	84.044	2.069	19.109
	85.000	63.100	92.600	66.784	84.729	2.307	19.378
	85.800	63.500	92.700	66.600	85.273	2.768	19.869
	86.100	64.500	90.600	67.017	86.080	3.229	19.957
1958	86.700	65.100	88.400	64.982	86.130	3.379	19.489
	86.900	65.400	87.600	64.069	86.751	3.316	19.521
	87.200	66.400	88.200	65.262	86.900	3.571	19.890
	87.500	67.200	89.300	67.293	87.271	3.573	20.254
1959	88.000	68.100	90.200	68.719	87.591	3.388	20.492
	88.200	68.500	92.200	69.889	88.170	3.501	20.862
	88.500	69.400	91.400	71.395	88.322	3.511	21.088
	88.700	70.200	91.200	70.632	88.721	3.432	21.187
1960	89.000	71.700	91.700	73.112	89.032	3.240	21.232
	89.400	71.600	92.400	73.664	89.289	3.252	21.169
	89.600	71.500	92.600	72.760	89.673	3.223	21.004
	90.000	72.000	91.300	71.922	89.842	3.234	20.991
1961	90.200	72.400	91.000	70.909	90.212	3.190	20.858
	90.300	74.400	89.800	71.719	90.447	3.095	21.034
	90.200	74.900	90.400	74.581	90.603	3.142	21.336
	90.700	75.900	91.200	75.704	90.492	3.084	21.369
1962	91.000	76.300	92.500	77.178	91.002	3.053	21.328
	91.100	77.400	92.800	77.775	91.310	3.052	21.291
	91.300	78.100	92.400	78.323	91.359	3.203	21.394
	91.500	79.000	91.800	79.015	91.559	3.084	21.290

DATE	P	w	N	Q^{ϵ}	P^{ϵ}	rr	R
1963	91.800	79.600	92.400	79.884	91.759	2.985	21.267
	92.100	80.200	92.800	80.472	92.080	3.092	21.393
	92.300	81.300	93.000	81.531	92.327	3.244	21.565
	92.500	82.200	93.400	82.744	92.543	3.299	21.635
1964	92.800	83.600	93.400	84.037	92.721	3.344	21.735
	93.100	84.200	94.400	85.350	93.040	3.262	21.917
	93.400	85.400	94.800	86.891	93.358	3.147	22.043
	93.800	86.300	95.500	87.808	93.701	3.171	22.146
1965	94.300	86.800	96.300	88.291	94.091	3.165	22.176
	94.800	87.600	97.300	90.087	94.597	3.154	22.283
	94.900	88.900	97.600	91.193	95.124	3.173	22.423
	95.200	90.200	98.600	92.982	95.213	3.144	22.695
1966	95.900	92.000	99.100	95.587	95.619	3.198	22.978
	96.800	93.900	99.500	97.505	96.283	2.862	23.377
	97.600	95.200	100.100	97.997	97.497	2.653	23.921
	98.400	96.900	100.200	98.847	98.249	2.739	24.185
1967	98.900	97.600	100.200	99.927	99.132	2.499	24.077
	99.400	99.500	99.200	99.472	99.543	2.770	24.410
	100.400	100.800	100.000	100.697	99.915	3.249	25.227
	101.300	102.100	100.600	101.729	101.002	3.229	25.969
1968	102.100	104.400	100.800	102.899	102.178	2.898	26.176
	103.100	106.300	101.800	103.866	102.923	2.796	26.659
	104.000	108.600	102.200	105.254	104.230	2.392	26.713
	105.100	110.900	102.500	106.121	104.949	2.693	27.204
1969	106.200	112.500	103.600	106.708	106.054	3.285	28.148
	107.600	114.700	104.200	107.903	107.102	3.079	28.723
	108.900	116.700	104.700	107.753	108.827	2.865	29.360
	110.400	119.500	104.200	108.414	110.041	3.292	30.202
1970	111.800	121.500	103.900	106.959	111.659	3.743	31.085
	112.800	123.300	103.200	107.011	112.957	3.822	31.720
	113.900	126.100	102.100	107.436	114.225	3.736	31.970
	115.600	127.700	101.300	108.446	115.172	3.825	32.417
1971	117.000	130.600	101.600	109.832	116.601	3.540	31.900
	118.200	132.500	101.900	110.590	118.086	3.287	32.816

P--index of implicit price deflator for private sector product, (1967=100). Supplied on request by United States Department of Labor, Bureau of Labor Statistics.

w--index of compensation per man-hour in the private sector, (1967=100). Supplied on request by United States Department of Labor, Bureau of Labor Statistics.

N--index of manhours employed in the private sector, (1967=100). Supplied on request by United States Department of Labor, Bureau of Labor Statistics.

Q^{ε}--index of expected demand for private sector output, (1967=100).

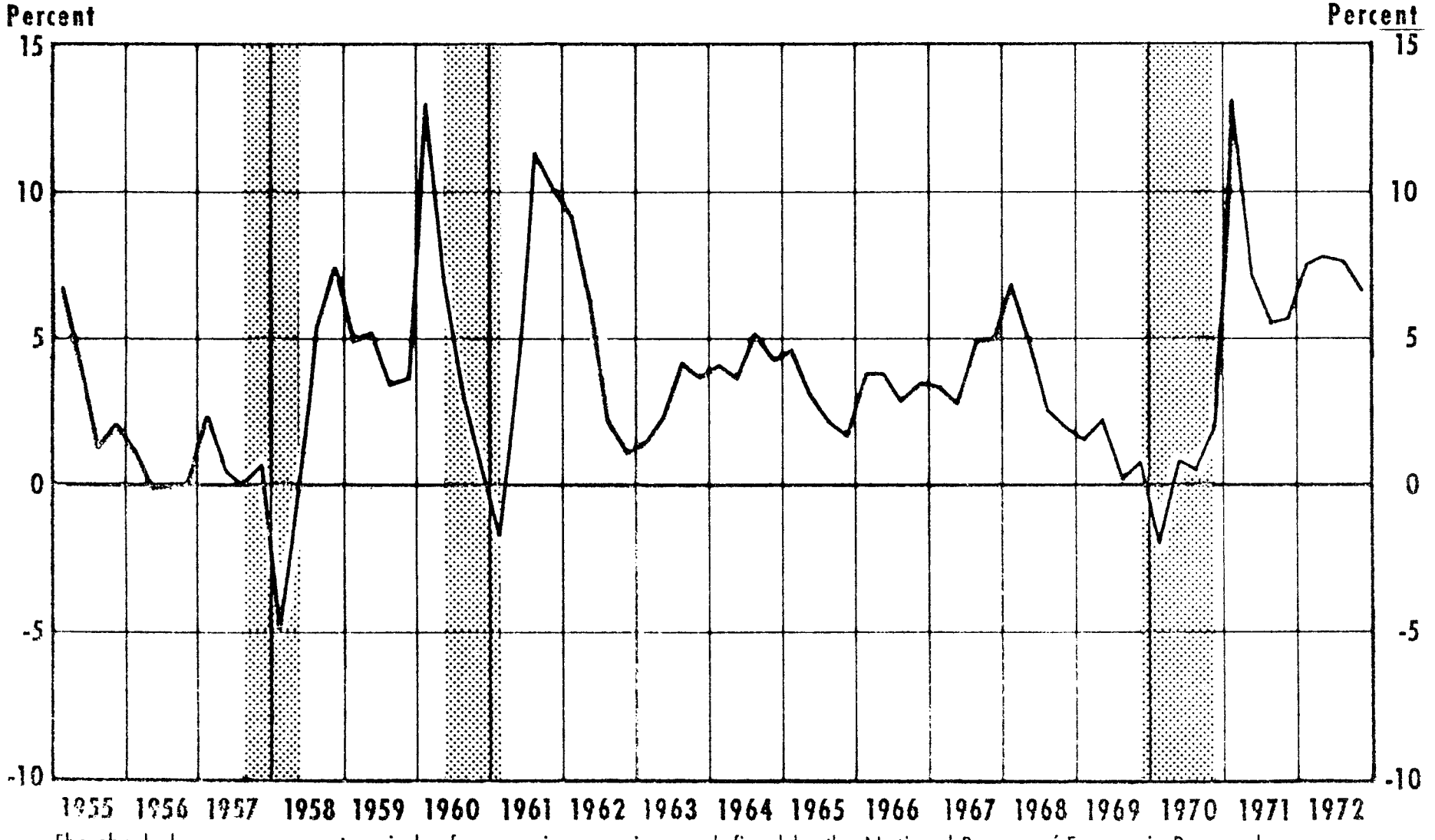
P^{ε}--index of expected implicit price deflator for private sector output, (1967=100).

rr--real rate of interest, $rr = r-\rho^{\varepsilon}$
r--yield on Moody's Aaa-rated corporate bonds.
Source: Federal Reserve Bank of St. Louis.

R--user cost of capital services, $R = P_k (r-\mu)$
P_k--implicit price deflator for business fixed ivestment.
Source: U.S. Department of Commerce, Survey of Current Business, National Income Issues (July), Tables 1.1 and 1.2.

Appendix C

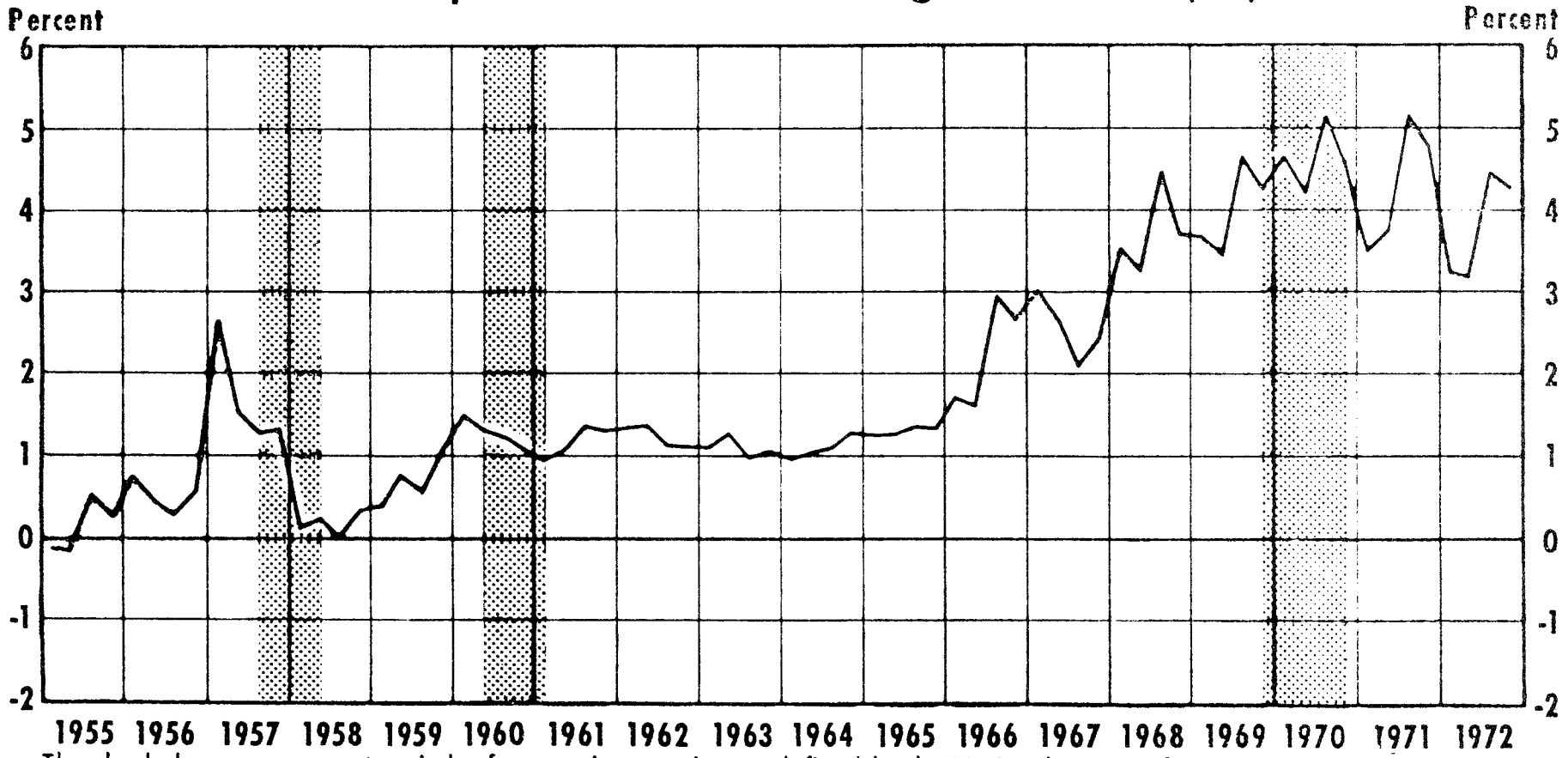
Expected Rate of Change of Demand ($\dot{Q}^{e}$)



The shaded areas represent periods of economic recession as defined by the National Bureau of Economic Research.

Appendix D

Expected Rate of Change of Prices ($\dot{P}^e$)



The shaded areas represent periods of economic recession as defined by the National Bureau of Economic Research.

APPENDIX E

ESTIMATES USING AN ALTERNATIVE MEASURE OF THE USER COST OF CAPITAL (R')[a]

Dependent Variable	Predetermined Variables									
	$\ln\bar{Q}^{\varepsilon}$[b]	$\ln P^{\varepsilon}$	$\ln R'$[c]	rr	$\ln w_{-1}$	t	Constant	$\bar{R}^2$	D.W.	h
lnN	.870 (13.259)	.528 (2.142)	-.008 (-.393)	.172 (.406)	-.177 (-.867)	-.007 (-6.382)	-.663 (-1.368)	.973	.730	
lnw	.152 (3.584)	.619 (3.875)	-.007 (-.525)	-.111 (-.403)	.496 (3.748)	.002 (2.550)	-1.297 (-4.134)	.999	1.748	2.593
lnP	.041 (2.328)	.948 (14.382)	-.007 (1.371)	.189 (1.663)	.071 (1.300)	-.001 (-3.816)	-.212 (-1.639)	.999	1.674	

[a]Values in parentheses below the estimated coefficients are t-scores. $\bar{R}^2$ is the coefficient of determination, adjusted for degrees of freedom. D.W. is the Durbin-Watson statistic, and h is Durbin statistic used to test for auto-correlation in the presence of lagged endogenous variables.

[b]The coefficient on $\ln\bar{Q}^{\varepsilon}$ is the sum coefficient generated by the Almon-lag estimator, with n=4. The Almon-constraints used were d=2, t+1=0, t-n-1=0.

[c]For the explanation of the construction of the series see Robert H. Rasche and Harold T. Shapiro, "The F.R.B.-M.I.T. Econometric Model: Its Special Features," American Economic Review, LVIII (May, 1968), 128-30.

The data series are the observations of the Quarterly Econometric Model (F.R.B.-M.I.T.-Penn) as defined in the Quarterly Econometric Model Data Directory (Board of Governors of the Federal Reserve System, January, 1973).

ESTIMATES USING AN ALTERNATIVE MEASURE OF THE USER COST OF CAPITAL (R')
(With Adjustment for Auto-correlation)

Dependent Variable	Predetermined Variables									
	$ln\bar{Q}^{\epsilon}-\hat{\rho}_i ln\bar{Q}^{\epsilon}_{-1}$	$lnP^{\epsilon}-\hat{\rho}_i lnP^{\epsilon}_{-1}$	$lnR'-\hat{\rho}_i lnR'_{-1}$	$rr-\hat{\rho}_i rr_{-1}$	$lnw_{-1}-\hat{\rho}_i lnw_{-2}$	t	Constant	$\hat{\rho}_i$	$\bar{R}^2$	D.W.
$lnN-\hat{\rho}_1 lnN_{-1}$	.774 (9.058)	.156 (.770)	.007 (.306)	.051 (.122)	.083 (.514)	-.007 (-5.241)	.301 (.475)	.706	.985	1.809
$lnw-\hat{\rho}_2 lnw_{-1}$	.199 (3.859)	.867 (4.791)	-.006 (-.384)	-.019 (-.060)	.263 (2.718)	.003 (3.437)	-1.649 (-4.476)	.273	.999	1.991
$lnP-\hat{\rho}_3 lnP_{-1}$	.028 (1.402)	.866 (11.924)	-.010 (-1.548)	.236 (1.884)	.145 (2.357)	-.001 (-4.387)	-.097 (-.666)	.224	.999	2.109

APPENDIX F

A. WEIGHTS OF THE DISTRIBUTION $\sum_{o}^{4} q_i \ln Q^{\varepsilon}_{-i}$

for Table 3.1*

i	Equation 3.2b	Equation 3.2c	Equation 3.2e
0	.461 (8.463)	.057 (1.625)	-.002 (-.106)
1	.261 (11.383)	.038 (2.559)	.007 (1.196)
2	.114 (6.882)	.023 (2.102)	.012 (2.686)
3	.022 (1.039)	.011 (.812)	.012 (2.160)
4	-.016 (-.966)	.004 (.334)	.008 (1.854)
Sum	.842 (11.753)	.133 (2.859)	.039 (1.994)

*Numbers in parentheses are t-values for the associated coefficients.

B. WEIGHTS OF THE DISTRIBUTION $\sum_{o}^{4} q_i \ln Q^{\varepsilon}_{-i}$

for Table 3.2*

i	Equation 3.2b	Equation 3.2c	Equation 3.2e
0	.328 (5.703)	.088 (2.089)	-.007 (-.396)
1	.205 (7.734)	.054 (3.086)	.005 (.670)
2	.111 (4.966)	.029 (2.082)	.011 (2.062)
3	.046 (1.777)	.011 (.634)	.012 (1.817)
4	.009 (.454)	.002 (.111)	.009 (1.634)
Sum	.699 (7.668)	.183 (3.270)	.030 (1.357)

*Numbers in parentheses are t-values for the associated coefficients.

C. WEIGHTS OF THE DISTRIBUTION $\sum_{o}^{4} q_i \ln Q^{\varepsilon}_{-i}$

for Table 3.3*

i	Equation 3.3b	Equation 3.3c	Equation 3.3e
0	.473 (9.615)	.074 (2.329)	-.005 (-.361)
1	.267 (14.963)	.048 (4.172)	.005 (.970)
2	.116 (8.030)	.027 (2.957)	.010 (2.529)
3	.022 (1.040)	.013 (.959)	.011 (1.940)
4	-.017 (-1.044)	.004 (.340)	.008 (1.696)
Sum	.860 (16.521)	.167 (4.938)	.029 (2.001)

*Numbers in parentheses are t-values for the associated coefficients.

D. WEIGHTS OF THE DISTRIBUTION $\sum_{o}^{4} q_i \ln Q_{-i}^{\varepsilon}$

for Table 3.4*

i	Equation 3.3b	Equation 3.3c	Equation 3.3e
0	.372 (7.389)	.101 (2.691)	-.012 (-.768)
1	.228 (10.462)	.062 (4.467)	.001 (.183)
2	.119 (5.476)	.032 (2.659)	.009 (1.800)
3	.044 (1.696)	.012 (.719)	.011 (1.652)
4	.005 (.236)	.001 (.095)	.008 (1.546)
Sum	.769 (9.950)	.207 (4.908)	.017 (.990)

*Numbers in parentheses are t-values for the associated coefficients.

BIBLIOGRAPHY

Ackley, Gardner. Macroeconomic Theory. New York: Macmillan Company, 1961.

_____. "A Third Approach to the Analysis and Control of Inflation." Inflation: Demand-Pull or Cost-Push? Edited with an Introduction by Richard Perlman. Studies in Economics. Boston: D.C. Heath and Company, 1965.

Alchian, Armen A. "Information Costs, Pricing, and Resource Unemployment." Western Economic Journal, VII (June, 1969), 109-28.

_____, and Allen, William R. University Economics: Elements of Inquiry. 3rd ed. Belmont, Calif.: Wadsworth Publishing Company, Inc., 1972.

_____, and Demsetz, Harold. "Production, Information Costs, and Economic Organization." American Economic Review, LXII (December, 1972), 777-95.

_____, and Klein, Benjamin. "On a Correct Measure of Inflation." Journal of Money, Credit and Banking, V (February, 1973, Part I), 173-91.

Almon, Shirley. "The Distributed Lag Between Capital Appropriations and Expenditures." Econometrica, XXXIII (January, 1965), 178-96.

Andersen, Leonall C., and Karnosky, Denis S. "The Appropriate Time Frame for Controlling Monetary Aggregates: The St. Louis Evidence." Controlling Monetary Aggregates II: The Implementation. Conference Series, No. 9. Boston: Federal Reserve Bank of Boston, September, 1972.

Ball, R. J., and Duffy, Martyn. "Price Formation in European Countries." The Econometrics of Price Determination: Conference. October 30-31, 1970. Edited by Otto Eckstein. Washington, D.C.: Board of Governors of the Federal Reserve System for itself and the Social Science Research Council, 1972.

Barro, Robert J., and Grossman, Herschel I. "A General Disequilibrium Model of Income and Employment." American Economic Review, LXI (March, 1971), 82-93.

Basmann, Robert L. "The Role of the Economic Historian in Predictive Testing of Proffered 'Economic Laws'." The New Economic History: Recent Papers on Methodology. Edited by Ralph L. Andreano. The Wiley Series in American Economic History. New York: John Wiley & Sons, Inc., 1970.

_____. On Predictive Testing of a Simultaneous Equations Model: The Retail Market for Food in the U.S. Paper for the Institute for Quantitative Research in Economics and Management, Institute Paper No. 78. Lafayette, Indiana: Purdue University, July, 1964.

Bodkin, Ronald G. The Wage-Price-Productivity Nexus. Philadelphia: University of Pennsylvania Press, 1966.

Brechling, Frank. "The Trade-off between Inflation and Unemployment." Journal of Political Economy, LXXVI (July-August, 1968), 712-37.

Bronfenbrenner, Martin, and Holzman, Franklyn D. "Survey of Inflation Theory." American Economic Review, LIII (September, 1963), 593-661.

Burns, Arthur F. "The Problem of Inflation." Address before the Joint Luncheon Meeting of the American Economic Association and the American Finance Association, Toronto, Ontario, Canada, December 29, 1972.

Clower, Robert W. "The Keynesian Counterrevolution: A Theoretical Appraisal." The Theory of Interest Rates; Proceedings of a Conference Held by the International Economic Association. Edited by F. H. Hahn and F.P.R. Brechling. London: Macmillan & Co., Ltd., 1965.

_____. "A Reconsideration of the Microfoundations of Monetary Theory." Western Economic Journal, VI (December, 1967), 1-8.

Cochrane, D., and Orcutt, G.H. "Application of Least Squares Regression to Relationships Containing Auto-correlated Error Terms." Journal of the American Statistical Association, XLIV (March, 1949), 32-61.

Cohen, Morris R., and Nagel, Ernest. An Introduction to Logic and Scientific Method. New York: Harcourt, Brace and Company, 1934.

Dicks-Mireaux, L. A., and Dow, J. C. R. "The Determinants of Wage Inflation: United Kingdom, 1946-1956." Journal of the Royal Statistical Society, CXXII (Series A, Part 2, 1959), 145-74.

Dolde, Walter C., and Tobin, James. "Wealth, Liquidity, and Consumption." Consumer Spending and Monetary Policy: The Linkages. Conference Series, No. 5. Boston: Federal Reserve Bank of Boston, June, 1971.

Dow, J. C. R. "Analysis of the Generation of Price Inflation." Oxford Economic Papers New Series, VIII (October, 1956), 252-99.

_____, and Dicks-Mireaux, L. A. "The Excess Demand for Labour. A Study of Conditions in Great Britain, 1946-1956." Oxford Economic Papers New Series, X (February, 1958), 1-33.

Durbin, J. "Testing for Serial Correlation in Least-Squares Regression When Some of the Regressors are Lagged Dependent Variables." Econometrica, XXXVIII (May, 1970), 410-21.

Eckstein, Otto, and Fromm, Gary. "The Price Equation." American Economic Review, LVIII (December, 1968), 1159-83.

_____, and Wilson, Thomas A. "Determination of Money Wages in American Industry." Quarterly Journal of Economics, LXXVI (August, 1962), 379-414.

Edwards, H. R. "Price Formation in Manufacturing Industry and Excess Capacity." Oxford Economic Papers New Series, VII (February, 1955), 94-118.

Evans, Michael K. Macroeconomic Activity: Theory, Forecasting, and Control; An Econometric Approach. With a Foreward by L.R. Klein. New York: Harper & Row, Publishers, 1969.

Fisher, Franklin. "Aggregate Production Functions and the Explanation of Wages: A Simulation Experiment." Review of Economics and Statistics, LIII (November, 1971), 305-25.

Friedman, Milton. "The Lag in Effect of Monetary Policy." Journal of Political Economy, LXIX (October, 1961), 447-66.

_____. "The Role of Monetary Policy." American Economic Review, LVIII (March, 1968), 1-17.

Gould, J. P. "Adjustment Costs in the Theory of Investment of the Firm." Review of Economic Studies, XXXV (January, 1968), 47-55.

Griliches, Zvi. "Distributed Lags: A Survey." Econometrica, XXXV (January, 1967), 16-49.

Grossman, Herschel I. "Was Keynes a 'Keynesian'? : A Review Article." Journal of Economic Literature, X (March, 1972), 26-30.

Hahn, F. H. "Some Adjustment Problems." Econometrica, XXXVIII (January, 1970), 1-17.

Hansen, Bent. "Excess Demand, Unemployment, Vacancies, and Wages." Quarterly Journal of Economics, LXXXIV (February, 1970), 1-23.

Hay, George A. "Production, Price, and Inventory Theory." American Economic Review, LX (September, 1970), 531-45.

Hotson, John H. International Comparisons of Money Velocity and Wage Mark-ups. New York: Augustus M. Kelley, Publishers, 1968.

Kessel, Reuben A., and Alchian, Armen A. "Effects of Inflation." Journal of Political Economy, LXX (December, 1962), 521-37.

Keynes, John Maynard. "The General Theory of Employment." Quarterly Journal of Economics, LI (February, 1937), 209-23.

_____. The General Theory of Employment, Interest, and Money. A Harbinger Book. New York: Harcourt, Brace & World, Inc., 1964.

Klein, L[awrence] R., and Ball, R[obert] J. "Some Econometrics of the Determination of Absolute Prices and Wages." Economic Journal, LXIX (September, 1959), 465-82.

Laidler, David. "On Wicksell's Theory of Price Level Dynamics." Manchester School, XL (June, 1972), 125-44.

Lancaster, Kelvin. "The Solution of Qualitative Comparative Static Problems." Quarterly Journal of Economics, LXXX (May, 1966), 278-95.

Leijonhufvud, Axel. On Keynesian Economics and the Economics of Keynes: A Study in Monetary Theory. New York: Oxford University Press, 1968.

Lucas, Robert E., Jr. "Adjustment Costs and the Theory of Supply." Journal of Political Economy, LXXV (August, 1967), 321-34.

_____, and Rapping, Leonard A. "Price Expectations and the Phillips Curve." American Economic Review, LIX (June, 1969), 342-50.

_____, and Rapping, Leonard A. "Real Wages, Employment, and Inflation." Journal of Political Economy, LXXVII (September-October, 1969), 721-54.

Lutz, Friedrich A. "On Neutral Money." Roads to Freedom; Essays in Honour of Friedrich A. von Hayek. Edited by Erich Streissler, Gottfried Haberler, Friedrich A. Lutz, and Fritz Machlup. London: Routledge & Kegan Paul, 1969.

Miller, Norman C. "Past Movements in Prices and Current Economic Activity: A Synthesis of Classical, Keynesian, and Neo-quantity Theory Macro-models." Unpublished study, Carnegie-Mellon University, Pittsburgh, October 1971.

Modigliani, Franco. "New Developments on the Oligopoly Front." Journal of Political Economy, LXVI (June, 1958), 215-32.

Nadiri, M. Ishag. "Some Approaches to the Theory and Measurement of Total Factor Productivity: A Survey." Journal of Economic Literature, VIII (December, 1970), 1137-77.

_____. "The Effects of Relative Prices and Capacity on the Demand for Labour in the U.S. Manufacturing Sector." Review of Economic Studies, XXXV (July, 1968), 273-88.

_____, and Rosen, Sherwin. "Interrelated Factor Demand Functions." American Economic Review, LIX (September, 1969), 457-71.

Nagel, Ernest. The Structure of Science: Problems in the Logic of Scientific Explanation. New York: Harcourt, Brace & World, Inc., 1961.

Nordhaus, William D. "Recent Developments in Price Dynamics." The Econometrics of Price Determination: Conference. October 30-31, 1970. Edited by Otto Eckstein. Washington, D.C.: Board of Governors of the Federal Reserve System for itself and the Social Science Research Council, 1972.

Oi, Walter Y. "Labor as a Quasi-fixed Factor." Journal of Political Economy, LXX (December, 1962), 538-55.

Okun, Arthur M. "The Mirage of Steady Inflation." Brookings Papers on Economic Activity, (No. 2, 1971), 485-98.

Patinkin, Don. Money, Interest, and Prices: An Integration of Monetary and Value Theory. 2nd ed. New York: Harper & Row, Publishers, 1965.

Perrakis, Stylianos, and Sahin, İzzet. "Resource Allocation and Scale of Operations in a Monopoly Firm: A Dynamic Analysis." International Economic Review, XIII (June, 1972), 399-407.

Perry, George L. Unemployment, Money Wage Rates, and Inflation. M.I.T. Monographs in Economics, No. 7. Cambridge, Mass.: M.I.T. Press, 1966.

_____. "The Determinants of Wage Rate Changes and the Inflation-Unemployment Trade-off for the United States." Review of Economic Studies, XXXI (October, 1964), 287-308.

Phelps, Edmund S. "The New Microeconomics in Inflation and Employment Theory." American Economic Review, LIX, papers and proceedings (May, 1969), 147-160.

_____. "A Note on Short-run Employment and Real Wage Rate under Competitive Commodity Markets." International Economic Review, X (June, 1969), 220-32.

_____; Alchian, Armen A.; Holt, Charles C.; Mortensen, Dale T.; Archibald, G. C.; Lucas, Robert E., Jr.; Rapping, Leonard A.; Winter, Sidney G., Jr.; Gould, John P.; Gordon, Donald F.; Hynes, Allan; Nichols, Donald A.; Taubman, Paul J.; and Wilkinson, Maurice. Microeconomic Foundations of Employment and Inflation Theory. New York: W.W. Norton & Company, Inc., 1970.

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

Rao, Potluri, and Miller, Roger LeRoy. Applied Econometrics. Belmont, Calif.: Wadsworth Publishing Company, Inc., 1971.

Rees, Albert, and Hamilton, Mary T. "The Wage-Price-Productivity Perplex." Journal of Political Economy, LXXV (February, 1967), 63-70.

Sargent, Thomas J. "Anticipated Inflation and the Nominal Rate of Interest." Quarterly Journal of Economics, LXXXVI (May, 1972), 212-25.

Saving, Thomas R. "Transaction Costs and the Demand for Money." American Economic Review, LXI (June, 1971), 407-20.

_____. "Transactions Costs and the Firm's Demand for Money." Journal of Money, Credit and Banking, IV (May, 1972), 245-59.

Schultze, Charles L. Recent Inflation in the United States. Study of Employment, Growth, and Price Levels, Study Paper No. 1. Washington, D.C.: United States Government Printing Office for Joint Economic Committee, September, 1959.

_____, and Tryon, Joseph L. "Prices and Wages." The Brookings Quarterly Econometric Model of the United States. Edited by James S. Duesenberry, Gary Fromm, Lawrence R. Klein, and Edwin Kuh. Chicago: Rand McNally & Company, 1965.

Shiller, Robert J. Estimation of the Investment and Price Equations of a Macroeconometric Model. Staff Economic Studies, No. 61. Washington, D.C.: Board of Governors of the Federal Reserve System [1971].

Soligo, Ronald. "The Short-run Relationship between Employment and Output." Yale Economic Essays, VI (Spring, 1966), 161-215.

Swan, Neil, and Wilton, David, eds. Inflation and the Canadian Experience; Proceedings of a Conference. Kingston, Ontario: Industrial Relations Centre, Queen's University, for the Institute for Economic Research, Queen's University, 1971.

Sylos-Labini, Paolo. Oligopoly and Technical Progress. Translated by Elizabeth Henderson. Harvard Economic Study, Vol. CXIX. Cambridge: Harvard University Press, 1962.

Theil, H[enri]. Linear Aggregation of Economic Relations. Contributions to Economic Analysis, Vol. VII. Amsterdam: North-Holland Publishing Company, 1954.

Tinsley, P. A. Optimal Factor Adjustment Paths: A Generalization of "Stock Adjustment" Decision Rules. Staff Economic Studies, No. 50. Washington, D.C.: Board of Governors of the Federal Reserve System [1969].

_____. "A Variable Adjustment Model of Labor Demand." International Economic Review, XII (October, 1971), 482-510.

Tobin, James. "Inflation and Unemployment." American Economic Review, LXII (March, 1972), 1-18.

Turnovsky, Stephen J. "Empirical Evidence on the Formation of Price Expectations." Journal of the American Statistical Association, LXV (December, 1970), 1441-54.

_____, and Wachter, Michael L. A Test of the 'Expectations Hypothesis' Using Directly Observed Wage and Price Expectations. Staff Economic Studies, No. 63. Washington, D.C.: Board of Governors of the Federal Reserve System [1971].

Waud, Roger N. "Man-hour Behavior in U.S. Manufacturing: A Neoclassical Interpretation." Journal of Political Economy, LXXVI (May-June, 1968), 407-27.

Weintraub, Sidney. An Approach to the Theory of Income Distribution. Philadelphia: Chilton Company, 1958.

_____, and Habibagahi, Hamid. "Money Supplies and Price-Output Indeterminateness: The Friedman Puzzle." Journal of Economic Issues, VI (September, 1972), 1-13.

Yohe, William P., and Karnosky, Denis S. "Interest Rates and Price Level Changes, 1952-69." Federal Reserve Bank of St. Louis Review, LI (December, 1969), 18-38.