A DYNAMIC MODEL OF U.S. UNEMPLOYMENT

by

M. Ishaq Nadiri

and

Florangela Arengo

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Introduction

The main purpose of this paper is to develop and test empirically a dynamic model of the labor market based on an intermarket disequilibrium framework. We shall argue that the unemployment rate experienced by the United States is the result of a multi-market adjustment process and not a purely labor market phenomenon. The model includes entrepreneurial decisions with respect to demand for factors of production, such as labor, capital, and energy, and household decisions regarding the supplying of labor services and the demand for goods and services. Both sets of decisions are assumed to be subject to short-run disequilibria due to market imperfections, lack of information, and other costs associated with changing the decision variables.

Using this framework, we trace the consequences of the sluggish growth of capital stock in the postwar period and the increase in energy prices in 1973-74, as well as the effects of recent increases in the supply of labor, on the rate of unemployment in the U.S. It is shown that difficulties in adjusting the decisions of firms and households had detrimental effects not only on the unemployment rate but also on its cyclical behavior. The spill-overs in adjustment from one market to another appear to exert their major influence on the turning points and levels of both economic activity and the unemployment rate.

The paper is organized as follows: Section 1 is devoted to the theoretical derivation of the model; in Section 2, the model is tested using aggregate data for the U.S. economy for the period 1957:1-1975:3; in Section 3 the model is used to perform a series of simulations under alternative hypothetical conditions, but especially to inquire into the
consequences of intermarket spill-overs as well as some exogenous influences (e.g., the energy crisis, investment tax credits) upon employment; finally, a short summary of the overall results and implications is presented in Section 4.

1. A Dynamic Model of Unemployment

The model is composed of three elements: a set of interrelated input demand functions, a set of intertemporal decision variables with respect to supply of labor and purchase of goods and services, and a price adjustment mechanism. The set of interrelated input demand functions is derived from a model of intertemporal profit maximization by the firm under adjustment costs. The analysis draws on the work of Lucas (1967), Tinsley (1969, 1971), and Treadway (1970, 1971). In a parallel fashion, the derivation of household decisions with respect to supply of labor and purchase of goods is based on a process of intertemporal utility maximization. This part of the analysis draws on the work of Clower (1965), Barro and Grossman (1971), and others. The price adjustment mechanism captures the non-tâtonnement process in which prices adjust to excess demands but, in the short run, do not necessarily clear the markets. These three theoretical elements are then put together to derive a dynamic model of unemployment.

1.1 Dynamic Demand Functions of the Firm

The firm is assumed to face perfectly competitive conditions such that the demand for its output and the supplies of inputs and funds are infinitely elastic. Also, we assume that expectations are stationary, i.e., current prices are expected to prevail during the planning period.
Let $X(t)$ be the $(n \times 1)$ vector of input stocks; $\dot{X}(t)$, the $(n \times 1)$ vector of time derivatives of $X(t)$; $Q(t)$, output; $P$, output price; $R$, the $(n \times 1)$ vector of rental prices for the services of the input stocks; $S$, the $(n \times 1)$ vector of market prices of the inputs, and $i$, the rate of interest.

The notion of adjustment costs is introduced by means of a generalization of the production function:

$$Q(t) = f(X(t), \dot{X}(t)), \text{ such that } f_x = \frac{\partial f}{\partial x} > 0 \text{ and } f_{xx} = \frac{\partial^2 f}{\partial x^2} < 0 \quad (1.1.1)$$

That is, changes in the levels of the inputs generate costs in terms of foregone output, $-f_x$.

It is assumed that $f$ has continuous first- and second-order partial derivatives and that the firm maximizes its present value:

$$V(t) = \int_0^\infty e^{-it}(P f(X(t), \dot{X}(t)) - R X(t) - S \dot{X}(t))dt, \quad (1.1.2)$$

subject to the $n$ initial conditions: $X(0) = X_0$. The problem reduces to one of standard maximization in the calculus of variations.\(^2\) For a maximum, the Euler\(^3\) (1.1.3), transversality (1.1.4), and Legendre\(^4\) (1.1.5) conditions are required:

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\(^1\)Although a depreciation rule for capital inputs could have been introduced, it was not for reasons of simplicity. The results are essentially the same if proportional depreciation rates are assumed.

\(^2\)For a summary of this technique, see Intriligator (1971), Ch. 12.

\(^3\)Non-separable adjustment costs are implied in the assumption of $\{f_{xx}\} \neq \{0\}$.

\(^4\)Although the condition required is negative semi-definite, it becomes negative definite when perfectly variable inputs are ruled out.
\[ f_{XX} \dot{X} + f_{XX}^{**} \ddot{X} = f_X + i f_X - (r + i s), \quad (1.1.3) \]

\[ \lim_{t \to \infty} e^{-it} (f_X^* - s) = 0, \quad \text{and} \]

\[ f_{XX}^{**} < 0, \quad (1.1.5) \]

where \( r = R/P, s = S/P, f_X = \partial f/\partial X, f_X^* = \partial f/\partial \dot{X}, \) and \( \ddot{X} = \partial \ddot{X}/\partial t \) are \((n \times 1)\) vectors, and \( \{ f_{XX}^* \} = \{ \partial f_X/\partial X \}, \{ f_{XX}^{**} \} = \{ \partial f_X/\partial \ddot{X} \} \) are \((n \times n)\) matrices.\(^5\)

Condition (1.1.3) is a system of \( n \) second-order differential equations, in general, nonlinear. It can be linearly approximated in a neighborhood of the equilibrium point \((X = X^*, \ddot{X} = 0)\) as:\(^6\)

\[ \{ f_{XX}^* \}\ddot{X} + \{ f_{XX}^{**} \}\dddot{X} = \{ f_{XX}^{*} \} (X - X^*) + i\{ f_{XX}^* \} (X - X^*) + \{ f_{XX}^{**} \}\dddot{X} + i\{ f_{XX}^{**} \}\dddot{X} \quad (1.1.6) \]

Evaluation of the solution to (1.1.6) at \( t = 0 \), application of the initial conditions \( X(0) = X_0 \), and differentiation with respect to time yields the adjustment mechanism known as the multivariate flexible accelerator:

\[ \dddot{X} = M(X^* - X), \quad (1.1.7) \]

\(^5\)A straight-forward interpretation of the Euler condition may be given by integrating (1.1.3) by parts and making use of (1.1.4) to yield

\[ (s - f_X^*) = \int_{-\infty}^{\infty} e^{-i(\tau-t)} (f_X - r) d\tau \]

which implies that investment in inputs should be undertaken until the discounted net marginal revenue equals the current total marginal cost. Condition (1.1.4) states that the optimal path must be such that the vector of state variables, \( X \), converges to its optimal value, while (1.1.5) is the analogue of the second-order condition of the classical maximization problem.

\(^6\)The system would be linear if the production function \( f \) were restricted to the second order. In this case, condition (1.1.6) would hold exactly, rather than as an approximation.
where the matrix \( M \) is, in general, non-diagonal and asymmetrical.\(^7\) The diagonal elements of \( M \) are the own-input adjustment coefficients, while the off-diagonal elements refer to the cross-adjustment coefficients of the inputs.

Expression (1.1.7) describes the optimal adjustment path toward the long-run equilibrium values of the inputs, \( X^* \). It indicates how the rate of investment in each input is dependent upon its own deviation from equilibrium as well as the deviations of all other inputs; the effects of disequilibria in the input stocks upon their rates of accumulation need not be symmetrical. According to the Euler condition, \( X^* \) is a function of \( r, s, \) and \( i \) so that (1.1.7) can be written as:

\[
\dot{X} = M(X^*(r,s,i) - X). \tag{1.1.8}
\]

1.2 Dynamic Utility Maximization of the Household

The household is assumed to face competitive conditions in the market for goods and services it buys as well as in that where it sells services, and its expectations about prices are stationary.

Let \( Y(t) \) be the \((k \times 1)\) vector of stock of goods bought or sold by the household; \( \dot{Y}(t) \), a \((k \times 1)\) vector of time derivatives of \( Y(t) \); \( n' \), the \((k \times 1)\) vector of prices, \( i(t) \), the rate of interest; and \( W \), the household stock of wealth.

Increases in the levels of goods from which the household derives utility are costly due to search and information costs, which can be measured in terms of foregone utility. The relevant utility function is:

\(^7\)For a detailed proof, see Lucas (1967).
\[ U = U(Y(t), \dot{Y}(t)) \quad (1.2.1) \]

\[ U_Y > 0 \text{ for goods and services purchased,} \]
\[ U_Y < 0 \text{ for provision of labor services,} \]
and \( U_{\dot{Y}} < 0, \]

where \( U \) is assumed to have continuous first- and second-order partial derivatives.

The household maximizes utility over time, subject to the constraint that the value of its terminal assets \((\mathcal{W})\) be equal to the discounted value of the excess of income over expenditures. Thus, the Lagrangian to be maximized becomes:

\[ L = \int_0^\infty e^{-it}(U(Y(t), \dot{Y}(t)) + \lambda(W - n'\dot{Y}(t))dt, \quad (1.2.2) \]

subject to the initial condition, \( Y(0) = Y_0 \).

Following a procedure similar to that employed in the case of the firm, a unique solution to the linear approximation of the Euler condition may be found that, when differentiated with respect to time, yields:

\[ \dot{Y} = N(Y^*(n, i, W) - Y) \quad (1.2.3) \]

Expression (1.2.3), therefore, defines the path of household activities toward equilibrium values in terms of a multivariate type of stock adjustment, each activity being adjusted according to its own and other decision variables' deviations from desired levels.
1.3 Price Adjustment

At the macro level, it can no longer be assumed that prices are exogenously given but rather that they are determined by the interaction of firms' and households' behavior. The dynamic nature of the model suggests a non-
étatonement process (i.e., where prices adjust to excess demands, but, in the short-run, do not necessarily clear the markets). The price mechanism can be characterized by:

\[ \Pi = D(\dot{X} - \dot{Y}), \]  

(1.3.1)

where \( \Pi \) is an \((s \times 1)\) vector of time derivatives of prices and \( D \) is a diagonal matrix of order \( s \) that contains the price adjustment coefficients.\(^8\)

Since \( \dot{X} \) and \( \dot{Y} \) are assumed to obey a multivariate stock adjustment process, (1.3.1) becomes:

\[ \Pi = D((\dot{M}Y^* - \dot{N}Y^*) + (\dot{N}Y - \dot{M}Y)), \]  

(1.3.2)

where the matrices \( \Pi \) and \( \Pi \) describe the adjustment pattern of the entrepreneurial and household sectors, respectively, and, as before, * stands for optimal levels.

Expression (1.3.2) shows how prices adjust to two conceptually separable forces, the first stemming from differences in the target levels of firms and households and the second from divergences in their actual paths toward equilibrium.

1.4 The Dynamics of Unemployment

The model of the labor market developed in this section is based on a theoretical specification of the behavioral relationships of the producing and consuming sectors and the price adjustment mechanism previously

\(^8\) The diagonality of \( D \) results from the fact that \( \dot{X} \) and \( \dot{Y} \) refer to effective rather than notional demands.
specified. Several qualifications are introduced. First, the continuous-
time assumption employed for ease of derivation is replaced by one of
discrete time in order to make the model suitable for empirical application.
Second, the assumption of fixed targets or optimal values of the two
sectors is substituted by moving targets. This implies that expectations
about prices are changing according to their actual behavior instead of
being completely static. Third, only a limited number of aggregate
decision variables whose interactions with the labor market are deemed
to be most relevant are considered. Such variables are labor, capital,
and energy inputs on the production side and demand for goods and labor
supply on the household side. Since it is only for the case of labor
that both supply and demand are being introduced simultaneously, the
wage rate is endogenously determined, while other prices are assumed
exogenous.\textsuperscript{9}

Further, due to the non-clearing nature of the labor market, a wage
adjustment mechanism is specified separately. Fourth, the output variable
is also taken as exogenous; the main reason for such modification being
that neither specification of a complete model of the economy nor identifi-
cation of the parameters of the implied aggregate production function
are intended in this study. Thus, aggregate output becomes an additional
argument in the input demand functions.\textsuperscript{10} This, in turn, implies that

\textsuperscript{9}This implies that the supply of capital and energy are exogenously
given.

\textsuperscript{10}At the micro level, the introduction of output in input demand
functions may be explained in terms of a cost minimization process which
is consistent with the output level of profit maximization or in terms of
short-run monopoly elements. For arguments related to this point as well
as to the implications of moving targets, see Nadiri and Rosen (1974),
pp. 27-28.
input demand functions are homogeneous of degree zero in prices.\textsuperscript{11}

Taking into account the above qualifications, the structure of the model in matrix form becomes:

\begin{align*}
X_t &= GAZ_t + (I - G)X_{t-1} \\
Y_t &= HBS_t + (I - H)Y_{t-1} \\
W_t &= RCV_t + (I - R)W_{t-1}
\end{align*} \tag{1.4.1, 1.4.2, 1.4.3}

where $X_t$ is the vector of input demands, labor, capital, and energy, 
\{L^d_t, K_t^d, E_t^d\}; $Y_t$, the vector of household activities, labor supply, and 
demand for goods, \{L^s, G^d\}; $AZ_t = X^*_t$ and $BS = Y^*_t$, their desired levels, 
$Z_t$ being the vector of expected real output and input prices,\textsuperscript{12} \{1, Q_t^e, 
(W/P)_t^e, (uc/P)_t^e, (pe/P)_t^e\}; and $S_t$, the vector of household net worth and 
real wage rate, \{1, NW_t, (W/P)_t^e\}. $W$ is the nominal wage rate, and $V_t$ the 
vector of long-run productivity, excess demand in the labor market, 
and prices, \{1, V_t, L^d_t - L^s_t, \sum p_{t-1}\}. $G$ and $A$ are the matrices of adjustment 
and long-run coefficients of the producing sector, and $H$ and $B$ those 
of the household sector; $R$ and $C$ are the adjustment coefficient and vector 
of long-run coefficients of the wage rate, respectively.\textsuperscript{13}

\textsuperscript{11} Such restriction is imposed upon the structural estimates of the 
model. Although, rigorously, restrictions upon the adjustment mechanism 
would also be necessary for similar reasons, this would require a priori 
knowledge of the underlying production function.

\textsuperscript{12} $W/P$, $uc/P$, and $pe/P$ are the real wage rate, user cost of capital, 
and price of energy, respectively.

\textsuperscript{13} The own-adjustment coefficients must lie within the range $0 < G_{ii}$, $H_{ii}$, $R < 1$, otherwise actual values would tend to diverge further and 
further from optimal levels rather than approach them. As for the $G_{ij}$ and $H_{ij}$, they could be positive, negative, or zero, depending 
on $\text{whether} i$ is a dynamic substitute, complement, or independent of $j$. 

...
Unemployment is defined as an excess supply in the labor market, but in the context of this model it is treated not only as a function of an excess of supply in the labor market but also as a function of all excess demands (supplied) in both the production and household sectors of the economy. This can be seen by expressing unemployment, \( U_t \), in terms of the determinants of labor demand and supply, as defined in (1.4.1) and (1.4.2):

\[
U_t = L_t^S - L_t^d = f(L_t^*, K_t^*, E_t^*, L_t^*, G_t^*, L_t^{d*,} K_t^{d*}, E_t^{d*}, L_{t-1}^S, K_{t-1}^d, E_{t-1})
\]

2. **Structural Estimation of the Model**

The structure of the model developed in the previous section is estimated below using aggregate quarterly data for the U.S. economy for the period 1957:1-1975:3. To overcome the simultaneity problem, a two-stage procedure was applied to those equations containing the wage rate in the current period and to the wage rate equation itself. For each of the equations, an h-test was performed in order to ascertain the presence of first-order auto-correlation. In those cases in which the hypothesis of a zero auto-correlation coefficient was rejected, the Cochrane-Orcutt iterative technique was applied.\(^{14}\)

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Note that the concept of dynamic substitutability does not necessarily coincide with the comparative static concept of substitution based on prices. For example, two inputs may display price substitutability and dynamic complementarity simultaneously.

\(^{14}\)The list of instruments employed in the first stage of each equation differs somewhat depending on whether a correction for serial correlation was introduced or not. In the latter case, all the predetermined variables of the model were used as instruments. In order to
It is assumed that expectations of future prices and output are periodically revised on the basis of recently acquired information. Depending on the nature of the market in question, a longer or shorter past history of the variable is assumed to be taken into account. Thus, Almon distributed lags are employed, their precise form being decided on both market characteristics and empirical grounds, according to the criteria of significance and minimization of the sum of squared residuals.

The following list provides definitions of the variables; their constructions and the sources of data are given in the Appendix.

$E^d$ is total gross energy input, seasonally adjusted at annual rates, in quadrillions of BTUs (see Appendix).

$G^d$ is the stock of consumer goods, seasonally adjusted, in billions of 1958 dollars (see Appendix).

$I$ is the population index, 1958 = 100 (see Appendix).

$K^d$ is capital stock, seasonally adjusted, in billions of 1958 dollars (see Appendix).

$L$ is the civilian labor force employed, seasonally adjusted, in thousands.

$L^s$ is the civilian labor force, seasonally adjusted, in thousands.

$NW$ is household net worth in billions of 1958 dollars (deflated by personal consumption deflator).

$P$ is the GNP deflator, 1958 = 100.

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ensure consistency, those equations that exhibited serial correlation in their error terms were estimated by the method suggested by Fair (1970). That meant adding to the previous list one-quarter lags of both the predetermined variables belonging to the specific equation and the dependent variable in the first stage. Additionally, in all cases, four outside instruments were used as a means of linking the model with the rest of the aggregate economic system; they are money supply, government expenditures, exports, and imports.
PC is the consumer price index, 1958 = 100.
pe is the wholesale price index of fuels and related products
and power, 1958 = 100.
Q is national income, all industries, seasonally adjusted at
annual rates, in billions of 1958 dollars.
\( \Phi \) is the long-run productivity trend in thousands of 1958
dollars per employee (see Appendix).
uc is the user cost of capital, by percent (see Appendix).
w is the hourly compensation in the non-agricultural sector,
seasonally adjusted, in dollars.

All the variables of the model, except the dummy variables, are defined
in logarithms.

The empirical results for the aggregate labor, capital, and energy
demand functions are presented in Table 1.\(^{15}\) The fit of the equations
is very good, judging by the conventional statistics \( R^2 \) and the standard
error of the regression. There is evidence of serial correlation in the
employment and capital stock equations, and a first-order serial corre-
lation adjustment was performed. The coefficient of the serial correlation
\( \beta \) is also shown in Table 1.

Short-run elasticities and adjustment coefficients are given in
Table 2. All output elasticities have the correct sign and are more
than twice their standard errors. Their magnitude indicates a relatively

\(^{15}\) A detailed definition of the variables and data sources is given
in the Appendix. The dummy variable, D, is intended to capture supply
restrictions arising from the oil embargo and, though the embargo went
into effect in 1973:3, its effect was felt with a lag. Then, D takes on
the value of one in 1973:4-1974:1 and of zero otherwise.
### Table 1

**Production Sector - Structural Estimates**

**Period 1957:1-1975:3**

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
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</thead>
<tbody>
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<td></td>
<td>$L_t^d$</td>
<td>$K_t^d$</td>
<td>$E_t^d$</td>
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<tr>
<td><strong>Constant</strong></td>
<td>4.1106</td>
<td>-0.2160</td>
<td>1.4460</td>
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<td></td>
<td>(8.1)</td>
<td>(1.5)</td>
<td>(0.8)</td>
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<tr>
<td></td>
<td>0.2083</td>
<td>0.0335</td>
<td>0.3166</td>
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<td></td>
<td>(8.8)</td>
<td>(2.6)</td>
<td>(2.8)</td>
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<tr>
<td>$Q_t^e$</td>
<td>-0.0347</td>
<td>0.0322</td>
<td>-0.0364</td>
</tr>
<tr>
<td></td>
<td>(5.3)</td>
<td>(3.5)</td>
<td>(0.5)</td>
</tr>
<tr>
<td>$(w/uc)_t^e$</td>
<td>-0.0214</td>
<td>0.0161</td>
<td>0.1392</td>
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<td></td>
<td>(3.1)</td>
<td>(2.6)</td>
<td>(2.3)</td>
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<tr>
<td>$(w/pe)_t^e$</td>
<td>0.4335</td>
<td>0.0549</td>
<td>-0.2132</td>
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<td></td>
<td>(6.4)</td>
<td>(3.9)</td>
<td>(0.8)</td>
</tr>
<tr>
<td>$(uc/pe)_t^e$</td>
<td>0.1340</td>
<td>0.9099</td>
<td>0.1048</td>
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<td></td>
<td>(5.1)</td>
<td>(61.2)</td>
<td>(1.1)</td>
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<tr>
<td>$L_{t-1}^d$</td>
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<td>0.0022</td>
<td>0.6711</td>
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<td></td>
<td>(0.6)</td>
<td>(0.6)</td>
<td>(7.6)</td>
</tr>
<tr>
<td>$K_{t-1}^d$</td>
<td>-0.0316</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(2.1)</td>
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<tr>
<td>$R^2$</td>
<td>0.999</td>
<td>0.999</td>
<td>0.991</td>
</tr>
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<td>$DW$</td>
<td>2.10</td>
<td>1.99</td>
<td>2.17</td>
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<td>$\text{SEE}$</td>
<td>0.0051</td>
<td>0.0006</td>
<td>0.0190</td>
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<tr>
<td>$\theta$</td>
<td>0.4913</td>
<td>0.8794</td>
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</tr>
</tbody>
</table>

**Note:** Expectational variables are defined as follows:

a) $X_t^e = x_t$

b) $X_t^e = \sum_{i=1}^{11} v_i \times x_{t-i}$ (first-degree polynomial, near-zero restriction)

$v_1 = 0.0152, v_2 = 0.0303, v_3 = 0.0455, v_4 = 0.0606, v_5 = 0.0758, v_6 = 0.0909, v_7 = 0.1061, v_8 = 0.1212, v_9 = 0.1364, v_{10} = 0.1515, v_{11} = 0.1667.$
Table 2
Production Sector - Short-Run Elasticities and Adjustment Coefficients

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Dependent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L^d</td>
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<tr>
<td>Short-run Elasticities:</td>
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<tr>
<td>Q^e</td>
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<td>(w/p)^e</td>
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<td>(uc/p)^e</td>
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<td>(pe/p)^e</td>
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<td>Adjustment Coefficients:</td>
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<td>L_{t-1}^d</td>
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<td>K_{t-1}^d</td>
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</tr>
<tr>
<td>E_{t-1}^d</td>
<td>-0.0100</td>
</tr>
</tbody>
</table>

Source: Table 1

c) X_t^e = \sum_{i=0}^{6} v_i X_{t-i} \text{ (first-degree polynomial, near-zero restriction)}

v_0 = 0.0357, v_1 = 0.0714, v_2 = 0.1072, v_3 = 0.1428,

v_4 = 0.1786, v_5 = 0.2143, v_6 = 0.2500.

Entries in parentheses are t-statistics.
short-run response, especially (as expected) in the case of capital input, though—as will be seen below—they become substantially larger in the long run.

The direction and magnitude of the employment response to changes in prices agree with a priori expectations—the own-price elasticity being negative and the cross-elasticities positive—implying mild substitutability with the other two inputs, that with capital being slightly greater. The estimates of short-run price elasticities from the capital stock equation, on the other hand, indicate substitutability with labor and complementarity with energy. Unfortunately, the results obtained for energy are not as satisfactory, as they suggest opposite relationships to those implied by the labor and capital equations.

As may be seen in Table 2, all the own-adjustment coefficients have the expected sign and are smaller than unity, as required, labor reacting faster to its own disequilibrium than the other two inputs. The dynamic spill-overs between capital and labor inputs appear to be highly significant and, though those with energy are not equally significant, their implications are fairly plausible. The cross-adjustment effects are not symmetrical, i.e., capital and labor and capital and energy are clearly identified as dynamic complements, while the dynamic relationship between labor and energy is not identifiable as either one of substitutability or complementarity.

Table 5 contains estimates of the aggregate household sector decision variables with respect to labor supply and demand-for-goods equations. 16 Short-run elasticities and adjustment coefficients are

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16 Given that population growth and shifts in its composition are taken as exogenous, the household decision variables are adjusted by an index, I, that reflects both effects. D1 and D2 are dummy variables
Table 3
Household Sector - Structural Estimates

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>((L^s/I)_t)</th>
<th>((G^d/I)_t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>5.2088</td>
<td>0.0528</td>
</tr>
<tr>
<td></td>
<td>(4.4)</td>
<td>(0.1)</td>
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<tr>
<td>((NN/I)_t)</td>
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<td>0.0609</td>
</tr>
<tr>
<td></td>
<td>(3.6)</td>
<td>(3.4)</td>
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<tr>
<td>((w/PC)^e_t)</td>
<td>0.0741</td>
<td>0.1004</td>
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<td></td>
<td>(1.9)</td>
<td>(1.9)</td>
</tr>
<tr>
<td>((L^s/I)_{t-1})</td>
<td>0.5270</td>
<td>0.0305</td>
</tr>
<tr>
<td></td>
<td>(5.1)</td>
<td>(6.4)</td>
</tr>
<tr>
<td>((G^d/I)_{t-1})</td>
<td>0.0546</td>
<td>0.8436</td>
</tr>
<tr>
<td></td>
<td>(1.8)</td>
<td>(18.2)</td>
</tr>
<tr>
<td>D1</td>
<td>-0.0088</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.4)</td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td>0.0024</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.5)</td>
<td></td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.991</td>
<td>0.999</td>
</tr>
<tr>
<td>DW</td>
<td>2.01</td>
<td>2.05</td>
</tr>
<tr>
<td>SEE</td>
<td>0.0029</td>
<td>0.0038</td>
</tr>
<tr>
<td>(\delta)</td>
<td></td>
<td>0.2098</td>
</tr>
</tbody>
</table>

Note: Expectational variables are defined as follows:

a) \[ x^e_t = x^{t-5}_t \]

b) \[ x^e_t = \sum_{i=1} v_i x_{t-i} \] (first-degree polynomial, near-zero restriction)

\[ v_1 = 0.0667, v_2 = 0.1313, v_3 = 0.20, v_4 = 0.2667, v_5 = 0.3333. \]
shown in Table 4. An increase in household net worth has an initial negative impact on supply of labor and a positive impact on consumption, both effects being relatively small. Upward movements in the level of expected real wages, on the other hand, have a positive and statistically significant effect on both supply of labor and demand for goods, the elasticity of the latter being somewhat larger.

As for the adjustment coefficients, the own-effects are within the required range, and their magnitudes indicate that labor supply adjusts somewhat faster to its own disequilibrium. The negative sign of cross-effects—non-significant in the goods equation—suggests a relation of dynamic complementarity between the two variables.

The empirical results obtained for the wage rate equation are given in Table 5. The magnitude of the $\bar{r}$ and $L_d/L_s$ coefficients suggest that, in the short-run, about 0.20 percent of a one percent increase in either productivity or excess demand in the labor market is reflected in wages. The latter result resembles the familiar Phillips curve analysis, though, in this case, relatively lower and higher rates of change in wages would be associated with slower and faster increases in employment rather than with low and high levels of employment, as the Phillips curve would imply. The initial effect of consumer prices is also low; however, its impact, as well as those of the remaining arguments, increases substantially in the long run as the slowly convergent wage rate approaches equilibrium values.

introduced to capture changes in the labor force series caused by revisions of the Household Survey resulting from the 1960 and 1970 population censuses. $D_1 = 1$ from 1962:2 on, and $D_2 = 1$ from 1972:2 on; $D_1 = D_2 = 0$ from the beginning of the sample up to those two quarters, respectively.
Table 4

Household Sector - Short-Run Elasticities and Adjustment Coefficients

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Dependent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( L^S )</td>
</tr>
<tr>
<td>Short-run Elasticities:</td>
<td></td>
</tr>
<tr>
<td>NW</td>
<td>-0.0466</td>
</tr>
<tr>
<td>((W/PC)^e)</td>
<td>0.0741</td>
</tr>
<tr>
<td>Adjustment Coefficients:</td>
<td></td>
</tr>
<tr>
<td>( L^S_{t-1} )</td>
<td>0.4730</td>
</tr>
<tr>
<td>( G^d_{t-1} )</td>
<td>-0.0546</td>
</tr>
</tbody>
</table>

Source: Table 2.3

Table 5

Wage Rate - Structural Estimates

Period 1957:1-1975:3

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Dependent Variable</th>
<th>( w_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td></td>
<td>-1.0348</td>
</tr>
<tr>
<td>( \Pi_t )</td>
<td></td>
<td>0.2424 (2.3)</td>
</tr>
<tr>
<td>((L^d/L^S)_t)</td>
<td></td>
<td>0.2400 (3.6)</td>
</tr>
<tr>
<td>PC(_{t-1})</td>
<td></td>
<td>0.1690 (3.3)</td>
</tr>
<tr>
<td>( w_{t-1} )</td>
<td></td>
<td>0.8297 (12.9)</td>
</tr>
<tr>
<td>( R^2 )</td>
<td></td>
<td>0.999</td>
</tr>
<tr>
<td>DW</td>
<td></td>
<td>2.07</td>
</tr>
<tr>
<td>SEE</td>
<td></td>
<td>0.0046</td>
</tr>
<tr>
<td>Adjustment coefficient:</td>
<td></td>
<td>0.1702</td>
</tr>
</tbody>
</table>
As for the dynamic properties of the system, it is important to note that the structure of the model gives rise to an adjustment process more complex than that for univariate stock, as low speeds of convergence in one variable are translated to variables with which it interacts (even if they can be adjusted relatively easily). Computation of the successive one-period responses from quarter t to t + 40 to a shock occurring in t indicate that labor and energy inputs react quickly to a change in expected output and prices and that household decision variables are also relatively quick to adjust.\(^\text{17}\) Actually, employment and, to some extent, energy and labor supply initially over-react, over-shooting their long-run levels, and then smoothly approach their equilibrium values.\(^\text{18}\) Though the system converges,\(^\text{19}\) it does so rather slowly, especially because of the sluggishness of the capital input adjustment process.

By cumulating one-period responses, or, equivalently, by finding the stationary solution to the system (1.4.1) through (1.4.3), long-run elasticities were calculated and are presented in Table 2.6. In the production sector, the own long-run price elasticities have the expected negative sign; those of capital and energy increase in magnitude, while that of employment decreases. Similar to initial impacts, long-run cross-elasticities of labor and capital display symmetry in their signs, but

---

\(^{17}\) While the mean adjustment lag of all decision variables but capital is around two to five quarters, that of capital is about ten quarters.

\(^{18}\) A severe and/or long-lasting over-shooting may cause the long-run value of an elasticity to be of a smaller magnitude than its short-run counterpart, or even to reverse its sign.

\(^{19}\) The largest characteristic roots of the estimated matrices \((I-\hat{G})\) and \((I-\hat{H})\) for the adjustment coefficients given in (1.4.1) and (1.4.2) are both less than unity.
Table 6
Long-Run Elasticities

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Dependent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production Sector</td>
</tr>
<tr>
<td></td>
<td>( L^d ) ( \kappa^d ) ( E^d )</td>
</tr>
<tr>
<td>( Q_t^e )</td>
<td>0.5554 0.7308 0.8353</td>
</tr>
<tr>
<td>( (w/p)_t^e )</td>
<td>-0.0164 0.3482 0.0109</td>
</tr>
<tr>
<td>( (uc/p)_t^e )</td>
<td>0.0318 -0.1507 0.3545</td>
</tr>
<tr>
<td>( (pe/p)_t^e )</td>
<td>-0.0155 -0.1975 -0.3654</td>
</tr>
<tr>
<td></td>
<td>Household Sector</td>
</tr>
<tr>
<td></td>
<td>( L^s ) ( \gamma^d )</td>
</tr>
<tr>
<td>( NW_t )</td>
<td>-0.0547 0.3789</td>
</tr>
<tr>
<td>( (w/PC)_t^e )</td>
<td>0.2361 0.6876</td>
</tr>
<tr>
<td></td>
<td>Wage Rate</td>
</tr>
<tr>
<td>( \Pi_t )</td>
<td>1.4238</td>
</tr>
<tr>
<td>( (L^d/L^s)_t )</td>
<td>1.4097</td>
</tr>
<tr>
<td>( PC_{t-1} )</td>
<td>0.9929</td>
</tr>
</tbody>
</table>

Source: Tables 2, 4, and 5.
those related to energy remain asymmetric.\textsuperscript{20}

As for the household sector, none of the elasticities change sign and all of them increase in absolute value. They suggest a positive long-run response of the supply of labor to the real wage rate, which agrees with cross-section evidence on labor force participation. The wage rate elasticities imply that, while a rise in the price level is fully reflected in higher nominal wages, productivity increases result in more than proportional increments, and that the trade-off between unemployment and the level of wages is considerably lower in the long run.

Finally, a very important test of the model lies in the ability of its various components to simultaneously interact and generate meaningful predictions of the unemployment rate. For this purpose, the system was solved for its reduced form,\textsuperscript{21} and the dependent variables were dynamically simulated.\textsuperscript{22}

Actual and simulated values of the unemployment rate for the period 1957:2-1975:3 are presented in Chart 1. Compared to standards for unemployment predictions, the model does remarkably well. The largest error, 1.1 percentage points, occurs in 1962:1 and to a large extent can

\textsuperscript{20}The limited amount of empirical evidence in this area is contradictory. See Berndt and Wood (1975) and Griffin and Gregory (1976).

\textsuperscript{21}The simultaneous nature of the model prevents the use of the structural form for simulation purposes.

\textsuperscript{22}Historical values were used for the exogenous variables and for the initial conditions of the endogenous variables. At $t = 0$, the vector of disturbance terms was set at its expected value of zero; thereafter, predicted values of the endogenous variables and the error term in each period were used to feed the next period's lagged values of the same variables.
Chart 1

Unemployment Rate - Actual and Simulated Values
1957:2 - 1975:3

Correlation coefficient = 0.9667
Regression coefficient of actual on predicted = 0.9440
Root-mean-squared error = 0.0080
Mean absolute error = 0.2410
Thiel's inequality coefficient = 0.0265
Fraction of error due to bias = 0.0027
Different variation = 0.0144
Different co-variation = 0.0054
be explained by an over-prediction of labor supply.\textsuperscript{23} The root-mean-squared error (RMSE) is 0.3 percent, and there is no perceptible prediction bias.\textsuperscript{24} From a total of eighteen turning points in the actual unemployment rate series during the sample period, the model misses three altogether and predicts three with a one-quarter lag. It incorrectly predicts seven.

3. Simulations of the Model

To probe further into the dynamics of intermarket disequilibrium and the resulting unemployment, we simulated the time path of unemployment under several hypothetical conditions, using the estimates of the model presented in the previous section. Three broad sets of issues are considered, namely, the sensitivity of unemployment to market interrelations, policy actions, and exogenous shocks to the economy.

3.1 Unemployment and Intermarket Spill-overs

The structural estimates presented in Section 2 yielded short-run parameters and adjustment coefficients of the system, i.e., the matrices $\hat{G}$, $\hat{H}$, $\hat{G}$, and $\hat{H}$, the vector $\hat{C}$, and the coefficient $\hat{r}$, and, based on them, long-run elasticities were derived. For the purpose of simulation

\textsuperscript{23} This may be partially attributed to a substantial build-up of the armed forces (around 13 percent) during the period 1961:4-1962:1.

\textsuperscript{24} Comparable simulation statistics supplied by Black and Kelejian (1970) and Roach (1974) for the periods 1950:1-1965:2 and 1957:1-1971:4 are: $\text{RMSE} = 0.53$ and 0.57, respectively; $R^2 = 0.82$ and 0.82; and $\text{RMSE/mean} = 0.11$ and 0.11. For this model, those statistics are: $\text{RMSE} = 0.31$, $R^2 = 0.96$, and $\text{RMSE/mean} = 0.06$. 
runs in this section, the process is reversed; long-run coefficients are taken as given and short-run ones are expressed as functions of them and adjustment coefficients.\textsuperscript{25} The alternative hypotheses are then introduced by changing the elements of the matrices of adjustment coefficients $\hat{G}$, $\hat{H}$, and $\hat{K}$. The rationale for this procedure is the assumption that, while long-run behavior is invariant, short-run behavior is influenced by the specific characteristics of the intermarket adjustment process.

Then, to test the sensitivity of unemployment to market interactions, labor market behavior, and, therefore, the unemployment path, can be simulated under the assumption of independence from the remaining input and household markets. For example, to simulate the unemployment path under the assumption that the labor market is not influenced by constraints of capital market adjustments, the capital cross-adjustment coefficients of the labor demand and energy functions, $G_{12}$ and $G_{32}$, should be set to zero and the model solved for the endogenous variables.

These experiments were run for each market separately as well as cumulatively. However, only the results for the case in which the labor market is assumed to behave independently of all the remaining markets are presented in Chart 2.\textsuperscript{26} In the chart, the simulated path (ASS.1) is plotted against the historically simulated one (H.S.) and the difference between them, plotted in the lower part, indicates the unemployment that

\textsuperscript{25} Further, as in the historical simulation case, for simultaneity reasons, it is necessary to use the reduced rather than the structural form.

\textsuperscript{26} That is, all cross-adjustment coefficients related directly or indirectly to the labor demand and labor supply functions are set equal to zero, i.e., $G_{12} = G_{32} = G_{13} = G_{23} = H_{12} = 0$. 
CHART 2

UNEMPLOYMENT RATE - HISTORICAL SIMULATION VS ASSUMPTION I

1957:2 - 1976:3
can be attributed to the presence of intermarket spill-overs. Vertical lines refer to the business cycle, broken lines to peaks, and solid lines to troughs.

As shown in the chart, during most of the simulation period, the unemployment levels obtained under this assumption are lower than historical ones. However, the difference between the two paths depends on the phase of the business cycle; it increases in the expansionary phase and decreases in the downturn. It is clear that actual levels of employment can be more easily adjusted upwards if constraints faced in adjusting other inputs were not transmitted to the labor market. Because intermarket disequilibria appear to have a larger impact upon entrepreneurial than household decisions, their removal results in labor demand increasing more than labor supply and, therefore, in lower unemployment rates during economic expansions. Conversely, during contractions, they check the downward trend in labor demand more than they do labor supply and, thus, the no-cross-effects assumption results in higher unemployment levels than those actually experienced. In periods of stability or even mild contractions, the constraints do not play a major role, and, therefore, the paths do not differ significantly.

The conclusion is, then, that the presence of intermarket cross-effects tends to smooth out the cyclical behavior of unemployment. Since expansion periods are generally longer than contraction periods on average for a time span, they are more likely to result in higher unemployment rates. For the period studied, 1957:2-1976:3, an average of 1.7 percentage points in the unemployment rate can be attributed to such effects.
Table 7 gives average contributions for subperiods corresponding to the business cycle phases. Each subperiod includes the quarter immediately following a turning point (peak or trough) up to the next turning point, i.e., subperiod 1957:4-1958:2 includes the quarter following the 1957:3 peak through the 1958:2 trough. The second column gives the average unemployment rate for each subperiod. The next four columns present the average contribution in percentage points and as a percent of the average unemployment rate of the cross-effects stemming from capital, energy, capital and energy jointly, and goods. The last column indicates the total contribution of intermarket disequilibria, that is, how much of the unemployment rate can be attributed to the effects originating in the markets considered.

Some general features are apparent from an analysis of the table. First, the joint contribution of the market spill-overs to unemployment is quite large during economic expansions and decreases during contractions; during severe recessions, it becomes negative. Thus, for example, while 59.5 percent of the average unemployment rate experienced during the 1961:2-1969:4 period can be attributed to adjustment constraints in the markets, such constraints did prevent the average unemployment rate of the 1957:4-1958:2 recession period from increasing in 0.53 additional percentage points, that is, 8.4 percent. Second, while constraints in the adjustment of the demand side of the labor market (capital and energy) tend to smooth out the cyclical behavior of unemployment, those on the supply side (goods) work in the opposite direction. Thirdly, the role played by the demand side, and especially by capital input, is far more important than that of the supply side.
### TABLE 7

**AVERAGE CONTRIBUTION OF INTERMARKET DISEQUILIBRIUM TO THE UNEMPLOYMENT RATE**

<table>
<thead>
<tr>
<th>Period</th>
<th>H.S. UR</th>
<th>$k^d$</th>
<th>$x^d$</th>
<th>$e^d$</th>
<th>$x^d$ &amp; $e^d$</th>
<th>$g^d$</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>points</td>
<td>percent</td>
<td>points</td>
<td>percent</td>
<td>points</td>
<td>percent</td>
<td>points</td>
</tr>
<tr>
<td>1957:4-58:2 (T)</td>
<td>6.35</td>
<td>-0.69</td>
<td>-10.9</td>
<td>0.06</td>
<td>0.9</td>
<td>-0.63</td>
<td>-10.0</td>
</tr>
<tr>
<td>1958:3-60:2 (P)</td>
<td>5.47</td>
<td>0.16</td>
<td>2.9</td>
<td>0.12</td>
<td>2.2</td>
<td>0.28</td>
<td>5.1</td>
</tr>
<tr>
<td>1960:3-61:1 (T)</td>
<td>6.16</td>
<td>0.62</td>
<td>10.1</td>
<td>0.04</td>
<td>0.6</td>
<td>0.66</td>
<td>10.7</td>
</tr>
<tr>
<td>1961:2-69:4 (P)</td>
<td>4.74</td>
<td>3.11</td>
<td>65.6</td>
<td>0.03</td>
<td>0.6</td>
<td>3.14</td>
<td>66.2</td>
</tr>
<tr>
<td>1970:1-70:4 (T)</td>
<td>4.76</td>
<td>2.12</td>
<td>44.5</td>
<td>0.07</td>
<td>1.5</td>
<td>2.19</td>
<td>46.0</td>
</tr>
<tr>
<td>1971:1-73:4 (P)</td>
<td>5.39</td>
<td>2.31</td>
<td>42.9</td>
<td>0.00</td>
<td>0.0</td>
<td>2.31</td>
<td>42.9</td>
</tr>
<tr>
<td>1974:1-75:1 (T)</td>
<td>6.20</td>
<td>0.09</td>
<td>1.5</td>
<td>-0.22</td>
<td>-3.6</td>
<td>-0.13</td>
<td>-2.1</td>
</tr>
<tr>
<td>1975:2-76:3</td>
<td>7.86</td>
<td>-0.62</td>
<td>-7.9</td>
<td>-0.12</td>
<td>-1.5</td>
<td>-0.74</td>
<td>-9.4</td>
</tr>
</tbody>
</table>

**NOTE:** (P) or (T) indicate that either a peak or a trough took place at the end of each subperiod.
3.2 Unemployment, the Investment Tax Credit, and the Employment Tax Credit

It has been recently suggested by Kesselman, Williamson, and Berndt (1977) that employment rather than investment tax incentives may be much more effective in dealing with the unemployment problem.

Although it would have been desirable to introduce a labor incentive in our model and, taking account of the interactions of markets, analyze its implications for the behavior of unemployment, the fact that the wage rate is being treated endogenously prevents the use of the model, as presently specified, for those purposes. However, in order to get some notion of the magnitude of the employment effect of such a measure, the structural form of the labor demand function is used to carry out a simulation under the hypothesis of a labor subsidy equivalent in cost to the investment tax credit, beginning in 1962.\(^{27}\)

Imposition of employment incentives during the period 1962:1-1975:3 would have resulted in aggregate levels of employment higher than those actually experienced by about 0.17 percent on the average. If labor subsidies rather than investment tax credits had been instituted, additions to employment ranging from 0.45 to 0.53 percent would have been induced. These findings are of the same order of magnitude as those of Kesselman, Williamson, and Berndt (1977) for manufacturing employment.

\(^{27}\)The labor subsidy rate was approximated as: 
\[ r_{Kt} = \left( \frac{S_K}{S_L} \right) r_{Kt} \]

where \( S_K \) and \( S_L \) are the average shares of capital and labor in national income for the period under consideration and \( r_{Kt} \) is the rate of subsidy on capital in period \( t \). The latter variable was calculated as the percentage difference between the user-cost of capital excluding and including the investment tax credit. Then the wage rate was adjusted by the factor \((1 - r_{Lt})\).
3.3 Unemployment and the Energy Crisis

Since the occurrence of the energy crisis in late 1973, a heated controversy has arisen regarding its impact on domestic economic activity, employment, and prices. In an attempt to gain some insight as to the extent to which unemployment was driven above the levels that the severe economic downturn would have normally generated if experienced alone, the model was used to simulate two related hypothetical situations.

As documented evidence points out, there is an important by-product of the oil embargo and the price explosion that cannot be overlooked—the concomitant drop in potential output of the economy—which clearly points to the inadequacy of the ceteris paribus assumption for this specific case. To overcome this limitation, estimates obtained from Rasche and Tatom (1977), who calculated that the energy crisis reduced economic capacity by 4 to 5 percent, were used. Then, starting in 1973:4, real output was adjusted upwards in those proportions and the revised series fed into the model.

As for the supply and price effects, these were removed by setting the dummy variable intended to capture the oil embargo equal to zero throughout and by assuming since 1973:3 a constant quarterly rate of increase in the overall energy price of 2.04 percent—which corresponds to the average for the preceding four years, 1970:1-1973:3—instead of the actual increase.

Chart 3 gives the results of assumption II that correspond to a four percent output drop, while Chart 4 refers to the five percent case.

See Rasche and Tatom (1977) and the references therein.
CHART 3
HISTORICAL SIMULATION VS ASSUMPTION II

Labor Demand

Labor Supply

Unemployment Rate

H.S.  
ASS. II

PERIOD

Q12

DIFFERENCE

8-
7-
6-
5-
4-
3-
2-
1-
0-
-1-
-2-
-3-
73Q1
73Q2
73Q3
74Q1
74Q2
74Q3
75Q1
75Q2
75Q3
76Q1
76Q2
76Q3

0.013

-0.013

0.014

-0.014

Millions of Persons

Millions of Persons

Per cent
CHART 4.

HISTORICAL SIMULATION VS ASSUMPTION III

Labor Demand

H.S.  
ASS. III

Millions of Persons

PERIOD

73Q1  73Q2  73Q3  73Q4  74Q1  74Q2  74Q3  75Q1  75Q2  75Q3  76Q1  76Q2  76Q3

0.3

DIFERENCE:

-0.3

Labor Supply

Millions of Persons

73Q1  73Q2  73Q3  74Q1  74Q2  74Q3  75Q1  75Q2  75Q3  76Q1  76Q2  76Q3

0.23

Unemployment Rate

8-
7-
6-
5-
4-

0.22

33
These results suggest that, while the energy crisis prevented the unemployment rate from falling further during 1973:4-1974:1 and contributed to maintaining it higher during the next three quarters, it did not have any major impact from 1974:4 on, that is, the high unemployment levels of the year 1975 were not related to the oil price increase.

If the estimates of output loss are accurate and the true impact lies somewhere in between the two assumptions considered, it can be inferred that though the energy crisis did in fact contribute to the unemployment rate experienced during the years 1973-1976, the source of the unprecedented levels of the period cannot be found in that event. At most, the energy crisis could be blamed for increasing the unemployment rate by 0.2 to 0.5 percent on the average during the period. The remainder must have been the result of the economic recession that simultaneously took place.

4. Concluding Remarks

The main results obtained from our set of empirical findings can be summarized as follows:

i. The structural estimates clearly confirm the relevance of the model as short-run intermarket disequilibria appear to play a major role in the adjustment process of firm and household decisions. Both firm and household decision variables are characterized for the most part by a relationship of dynamic complementarity.

ii. The distributed-lag response patterns indicate that labor and energy inputs play a flexible role relative to capital; actually, labor and, to some extent, energy over-adjust initially to input price changes.
In the household sector, the supply of work appears as the most easily adjustable variable; it over-reacts to changes in net worth. When the two sectors act simultaneously, the convergence of the whole system is dominated by the production sector--specifically, by the adjustment process of the capital input.

iii. Difficulties in adjusting the decision variables of firms and households have a substantial impact on unemployment behavior. By preventing it from falling further during economic expansions and from rising further during contractions, they substantially temper its cyclical behavior. Furthermore, they appear to exert their major influence at both turning points and high levels in economic activity. For the period as a whole, spill-overs from one market to another had a detrimental effect on the unemployment rate.

iv. As for the effects of the energy crisis upon unemployment, it is tentatively concluded that, though the event did in fact contribute to the unemployment rate experienced during the years 1973 to 1976, it did not have a substantial impact from 1974:4 on; thus, it does not appear to be the major source of the unprecedented unemployment rates recently registered.

v. The results obtained point to several policy implications. The fact that some markets are extremely sluggish in their adjustment while others even over-adjust in the short-run makes the implementation, as well as the assessment of their effectiveness, extremely difficult. Furthermore, policies designed to foster one particular market may cause unexpected adverse effects on some other market. Finally, the characteristics of the adjustment pattern of the labor input suggests that employment rather than investment incentives may be a more effective way of addressing the problem of cyclical unemployment.
Construction of Variables

\( E^d \) - Total Gross Energy Input

Two series were used to generate \( E^d \): 1) "Sales of Electric Power and Gas to Ultimate Customers" (\( E^d_1 \)) from the Survey of Current Business, seasonally adjusted at annual rates, in millions of dollars deflated by \( p_e \), quarterly observations; and 2) "Gross Energy Input" (\( E^d_2 \)) from the Federal Energy Administration, in quadrillions of BTUs, annual observations for 1957:1-1972:4, quarterly observations for 1973:1-1976:3, seasonally adjusted at annual rates.

Annual observations of \( E^d_2 \) were regressed on annual observations of \( E^d_1 \) for the period 1957:1-1972:4. The regression coefficients were then used to generate quarterly values of \( E^d_2 \) based on quarterly observations of \( E^d_1 \), for the period 1957:1-1973:1. The ratio of the predicted to the actual value of \( E^d \) in 1973:1 was used to adjust the level of the predicted series. \( E^d \) is composed of the actual values of \( E^d_2 \) for 1973:1 on and adjusted predicted values for 1957:1-1972:4.

\( G^d \) - Stock of Consumer Goods

This variables is defined as the "Stock of Consumer Durables" (Federal Reserve Board) plus personal consumption expenditures in non-durables and services.

I - Population Index

Its definition is given by:

\[
I_t = \frac{L_0^P}{L_0^P} \frac{P_t^P}{P_0^P} + \frac{L_0^S}{L_0^P} \frac{P_t^S}{P_0^S} \]
where L refers to civilian labor force, P to population, the superscripts p and s to primary and secondary labor force, and the subscripts indicate time. The base period is 1958.

\[ K^d - \text{Capital Stock} \]

The series was generated by using the relation:

\[ K_t = I_t + (1 - \delta)K_{t-1}, \]


\[ \bar{\mu} - \text{Long-run Productivity Trend} \]

Defined as the predicted values of the regression of the following exponential function:

\[ (Q/L^d) = a e^{bt}, \]

where a and b are constants and t is time.

\( uc - \text{User Cost of Capital} \)

Its definition is given by:

\[ uc = P_k \frac{r + \delta}{1 - v} (1 - k - vz + vz',) \]

where \( P_k \) is the implicit deflator for fixed gross private domestic
investment; $\delta$, the quarterly depreciation rate; $v$, the corporate income tax rate; $\tilde{k}$, the effective rate of the investment tax credit; $k'$ the tax credit allowance under the Long Amendment (equal to $\tilde{k}$, when it was in effect); and $z$, the present value of the depreciation deduction. $r$, the real interest rate, is calculated as the Moody's AAA industrial bond rate minus a fourteen quarter-lag of the rate of change in $P_k$. The series was taken from Sheldon Cheng, then adjusted and updated.

NOTE: With the exception of the net worth series that was obtained from the Federal Reserve Board and those variables for which the source is explicitly indicated, the data was obtained from the National Bureau of Economic Research Data Bank.
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