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ABSTRACT

Volume 2 contains supporting appendixes of a three-volume study designed to evaluate the need for new labor market information. The study also sought to improve methods for making better use of currently collected statistical and administrative data. The appendixes support Volume 1, chapter 4 "Local Labor Market Models" and contain: (1) a model of unemployment insurance, (2) a description of data used for the economic model of labor supply and demand, (3) a short guide to the use of the SOLAMI simulation program (simulation of labor market information), and (4) a discussion of the relative earning effect of geographical mobility. (WCM)

Report DLMA 71-24-70-02-2

ON THE FEASIBILITY OF A LABOR MARKET INFORMATION SYSTEM

Volume II

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Ann Arbor, Michigan 48104

June 1974

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APPENDIX A

THE LMIS MODEL: AN ECONOMETRIC MODEL OF LOCAL URBAN LABOR MARKETS

Malcolm S. Cohen, C. Russell Hill and Harold T. Shapiro*

1.0 Regional Analysis And Econometric Models

Overall economic welfare differs significantly from one region of the country to another. It is quite clear that not all regions have shared equally in the growth of the U. S. economy.[1] Further, even those regions that exhibit the same average rate of growth as the national economy do not always share the same pattern of growth. Thus, although the secular and cyclical forces that determine the level of national economic activity are often the most dominant factors in the determination of regional economic activity, other forces are at work which must be analyzed and understood. The study of regional economic growth, therefore, requires an understanding of the forces governing national economic activity, the relation of a region's development to such activity and the systematic factors which cause the region to deviate from the national norm. The careful study of the development of regional economic activity should help us to better understand the nature of the process and thus provide some of the information necessary for the planning of regional economic policy.

The notion of a region, or a geographic subsector of the national economy is not easily or uniquely defined. There are many alternative criteria for dividing a large area into regions, depending on the nature

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1 Even in long run equilibrium (where no factor of production has any incentive to change the level or location of its activity and where no shifts in resources will increase national product), per capita incomes will not be the same in all regions. Differences will persist because of the differences in the skill composition of the labor force, differences in labor force participation rates and differences in the extent of ownership of non-human capital.

and objectives of the study. Generally, however, we confine our search to contiguous geographic areas that have certain common characteristics and, when planning quantitative studies, they must also be areas for which the required data are available or can be conveniently produced. The construction of regional econometric models is one of a number of methodologies available that promise to yield some new insights into the economic development of the national economy. The principal objective of these models, therefore, is to provide a useful tool of analysis for those concerned with the regional economic planning. A summary and analysis of some of the most recent work in this area can be found in Milliman [24] and Meyer [23].

1.1 The LMIS Model - An Introduction

The LMIS model represents the initial result of an experiment to build an econometric model primarily designed to "model" the response of employment and unemployment in local urban labor markets to cyclical economic forces. The geographical unit of analysis is the Standard Metropolitan Statistical Area (SMSA). Thus, although the model belongs to the growing class of attempts to use econometric models to improve our understanding of both the cyclical and secular development of various aspects of "Regional Economies," it is the first attempt we are aware of to model in some detail the cyclical forces determining labor demand and supply within an SMSA. Most previous studies of regional labor markets have concentrated either on determining the labor requirements for a particular configuration of output (through input-output studies), or on the relationship between "export" induced employment and the total employment of a region (community economic base studies). The studies of Hirsch [15] and Thompson [32] provide early examples of the "requirements" approach and the "export-base" approach, respectively. Both of these approaches are concerned with the estimation of the effects on local employment of shifts in "export" demand (aggregate demand generated outside the region). In a recent study, Baschler [3] provides an interesting discussion of the possible equivalences of these two procedures, while Humphrey [18] has contributed a useful article setting forth a suggested methodological framework for future investigations of this type. A study by Dockson and Shreiner [7] is a good example of a more recent empirical study on local employment patterns, but this work confronts a somewhat different topic -- the effect of private investment on the pattern of state employment. Another class of studies on local employment has been generated out of the broad literature on location theory. These studies deal with local employment as part of the dynamic movement of populations between urban and rural regions and/or between various growth centers. The study by Lewis and Prescott [20] is a good example of this approach. There are only a few studies on the determination of local labor force participation rates (e.g., Parker and Shaw [27]) and all of these are developed on the basis of cross section data and, therefore, contain no dynamic elements.

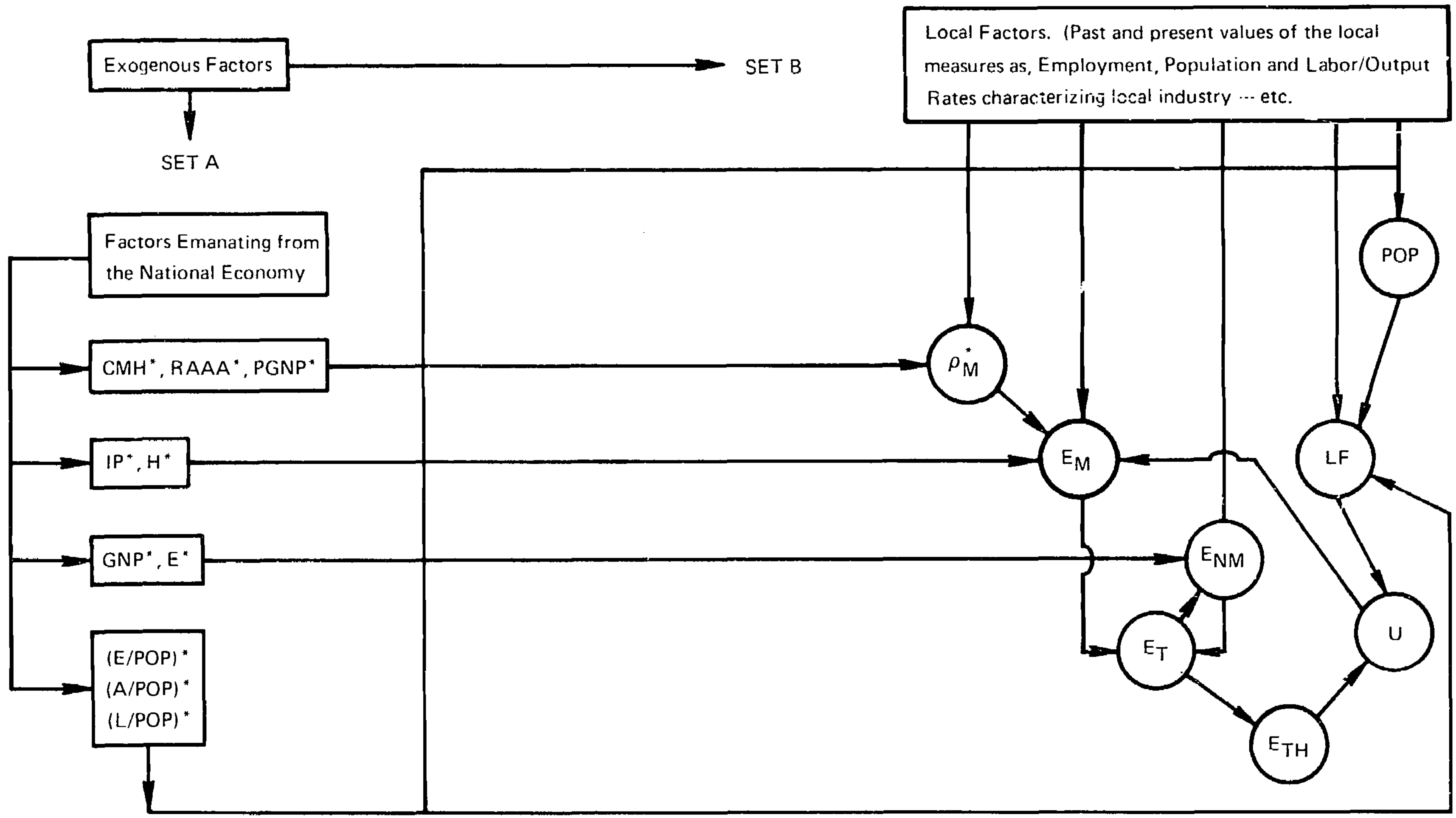
None of the above studies, however, deals adequately with the mechanism by which supply and demand adjusts over time to changes in various stimuli. Perhaps the study that is closest in spirit to the current investigation is the work by Glickman [8] on an econometric forecasting model of the Philadelphia region. Glickman's model contains an employment-wage-labor output for three industries and income. The LMIS model has a considerably more complex articulation of the labor market, but contains no mechanism for the determination of local output. The particular objective of the present model is to produce a mechanism capable of assisting in policy analysis, estimation of current labor force estimates, forecasting and other aspects of decision making relating to local (SMSA) labor markets.

The model is primarily concerned with isolating, from quarterly time series data generated over the period 1956 through 1972, equations which predict SMSA employment by industry, labor force participation rates and population by age/sex groups as well as the aggregate levels of both local unemployment and the local labor force. The current investigation studies the labor markets of Detroit, Milwaukee and Denver, each of which is represented by a separate set of relationships attempting to describe certain key aspects of the operation of labor markets in these areas. Thus the LMIS model is really three separate models (one for each of the above SMSAs) which operate independently of each other. All three models, however, are built around the same conceptual framework and attempt to pattern the same aspects of the local labor market in each case. This general framework could, in principle, also be applied to other SMSAs. The flow diagram presented below (Figure 1) summarizes the basic outlines of the model used. The diagram represents a substantial simplification of the acutal model and should, therfore, be interpreted with some care. It does, however, reflect some of the principal forces at work.

The following summary features of the model should be noted:

1) Local employment is heavily influenced by both the level and composition of national aggregate demand. Indeed, these are the most important forces determining the variation in local employment levels. However, as one would also expect, non-manufacturing employment is relatively less dependent on changes at the national level than employment in the manufacturing sector.
2) The model is primarily focused on short run cyclical changes in local employment. It does not deal directly with the issues of long term (secular) shifts in employment patterns.
3) The design of the model calls for a uni-directional flow of causality from the national economy to the local labor market. There is no provision for any feedback into national economic activity caused by the evolution of economic events in the local labor market. Although this feedback undoubtedly exists, it is assumed to be of minor importance.
4) Wage rates and interest rates are assumed to be governed by forces at the national level. While wage rates are not governed by national forces in all industries, this exception is of minor importance to our model.
5) The "demand sector" of the model generates total establishment employment (number of jobs). Total employment on a household basis is then derived in order to generate estimates of the level of unemployment.
6) Although net migration and commuting are important channels of adjustment in local labor markets, the current model does not have data on projections of these flows for the post 1970 Census period. The principal difficulty in isolating these

Figure 1 Principal Forces Determining Local Employment And Unemployment In The LMIS Model.[a]



[a]Items with asterisks are national variables.

FIGURE 1 Variable List

a) National Variables (designated by an asterisk on FIGURE 1)

A	Employment in Armed Forces
CMH	Compensation per Manhour -- Private Nonfarm Sector (Current Dollars)
E	Total Employment (Establishment)
GNP	Gross National Product (Constant Dollars)
H	Average Hours Worked
IP	Industrial Production (Manufacturing)
L	National Labor Force
PGNP	GNP Price Deflator
RAAA	Triple A Corporate Bond Rate

b) Local (SMSA) Variables

E_M	Employment in Manufacturing
E_{NM}	Employment in Non-Manufacturing
E_T	Total Establishment Employment
E_{TH}	Total Employment (Household Basis)
LF	Labor Force
POP	Population
U	Unemployment
ρ_M	Desired Labor/Output Ratio for Local Manufacturing Industries

mechanisms is the lack of appropriate time series data. The model does allow, however, for independent projections of these flows to interact with other elements determining the size of the labor force. Thus, a researcher or analyst could use the current model to investigate the effects of shifts in these flows. In the sample period, the population estimates are generated by compound population growth rates derived from the 1960 and 1970 Censuses of Population. For predictions beyond the sample period account is taken of changes in birth cohorts during the sixties.

7) The lack of time series data on the local labor force by age/sex groups necessitated the extensive use of parameters estimated from national data in that part of the model determining labor force participation rates by age/sex groups. These parameters were then adjusted to reflect local conditions through information available on the composition of the local labor force at Census dates. Thus, in each of the separate models the parameters reflect the influence of local conditions, although somewhat imperfectly. The resulting sets of parameters were then used together with variables reflecting local labor market conditions to generate local labor force participation rates over time.

8) The model underlying the demand equations for employment in manufacturing is quite distinct from that used in the non-manufacturing sector. In the manufacturing sector the desired mix of labor and capital (toward which the firm is moving) is determined by relative prices, and short run employment decisions are centered around expected demand for output and the existence of a surplus (deficit) of workers in a firm. Thus, "labor hoarding" is allowed a significant role. In the non-manufacturing sector a somewhat simpler model is employed.

Each of the models contains a mechanism to determine the following labor market variables:

Employment

1) Manufacturing Employment (Establishment Basis)

a) Durables

b) Non-Durables

2) Non-Manufacturing Employment (Establishment Basis)

a) Construction

b) Financial Institutions, Real Estate, Services and Mining

c) Transportation and Public Utilities

d) Wholesale and Retail Trade

e) Government

3) Total Employment (Establishment Basis)

4) Total Employment (Household Basis)

Labor Force and Population[2]

5) Labor Force by 10 age/sex groups

6) Population by 10 age/sex groups

7) Total Labor Force and Population

Unemployment

8) Total Unemployment

Miscellaneous

9) Desired capital/output ratios in durable and non-durable manufacturing.

In principle, the model can be disaggregated to more industry groups. In preliminary versions of the model, disaggregated estimates were made successfully. Similarly, additional disaggregation was attempted on the supply side.

The remainder of this paper is divided into two principal sections. Section 1.2 deals with the derivation and estimation of the relationships governing the demand for employment (supply of jobs). This section also includes a discussion of the procedures used to model the desired output-labor ratio for each industry. Section 1.3 describes in detail the mechanism used in the LMIS model to generate quarterly estimates

---

2, The model differs from the Employment Service procedures for construction of labor force estimates because the LMIS model predicts the number of persons in the labor force while the Manpower Administration procedures predict the work force by inflating the number of jobs in the area by an unemployment rate [5, 39]. Since other Employment Service procedures measure "persons" who need manpower programs, a technique for generating labor force as opposed to work force estimates has something to offer.

of SMSA labor force and population. We should note that the model is still in an experimental stage, and a significant amount of further testing is necessary before an adequate amount of confidence can be placed in its output. Preliminary results are encouraging, however, and they are presented in a working paper rather than published at this time. In future papers we also hope to present forecasts for the three SMSAs.

1.2 The Demand For Labor

This section of the study is concerned with the mechanism determining the demand by firms for labor inputs in a given SMSA. Our aim is to isolate from the appropriate data base the relationship governing the quarter to quarter changes in employment, by various industry groupings, within each area studied. This section discusses the general nature of the models used to help specify the labor demand equations of our model and then derives the basic regression models for both the manufacturing and non-manufacturing industries. This section also discusses the determination of optimal output-labor ratios -- an important variable -- in determining the demand for labor.

The demand for labor inputs is, of course, but one of a whole host of interrelated decisions which every firm must make and it is important that any proposed mechanism for "modeling" this aspect of firm behavior give adequate recognition to these interrelationships. Of particular concern to us is the nature and relationship of the firm's production, pricing, and factor demand decisions. These decisions are related not only because of the common decision unit involved, but because they are constrained by the technological possibilities currently available to the firm and the speed with which adjustments from the status quo can be made. Economic theory, however, does offer us some guidance in developing a model for firm decision making in this context. The "neoclassical" model of interrelated factor demands provides the basic starting point for the specification of labor demand equations, particularly for manufacturing firms. It is important to note, however, that the theory can be taken only as a preliminary guide since it applies directly only to a world of perfect competition, perfect knowledge, and profit maximization. Further, most of the results concern the equilibrium position of the firm.

The neoclassical theory of the firm envisions firms as attempting to maximize profits subject to the technological constraints with the following framework:

$$\text{Maximize } \Pi = pQ - wL - rK \quad (1)$$

$$\text{Subject to } Q = f(K,L) \quad (2)$$

where

Π = profits

p = price of output

w = price of labor services

r = price of capital services

Q = output

L = labor inputs

K = capital inputs

Under these conditions, in equilibrium the firm's decision regarding its level of output and its consumption of labor and capital services are functions of output prices (p), capital prices (r), labor prices (w) and the parameters of its production function (equation (2) above). In particular, the demand for labor will depend on the capital stock and relative input prices. This static model has been extended to a dynamic context where the present value of future profits are maximized and the cost of adjustment implied by shifting technologies is incorporated. These extensions have the effect of introducing additional variables into the firm's decision process, particularly expected values of _future_ prices, _future_ wages, and _future_ demand conditions. Relative prices (or expected relative prices), however, remain the important determinant of factor demands.

The approach taken in this study is to use some of the basic insights provided by the neoclassical model within a framework that reflects the particular objectives of the study and allows adequate allowances for the "imperfections" of the market being analyzed. Our primary interest is in the short run demand for employment. In this context it seems reasonable, at least as a first approximation, to take the existing capital stock and the state of technology as given and to analyze how the firm develops plans for the overall level of operation (output) and derives its demand for labor. There have been a number of studies of the demand for labor at the national level which have taken this approach ([2], [14], [17]), but the study by Fair [9] is perhaps closest to the basic underlying model which we employ, especially with regard to the labor demand model we use for the manufacturing industries. We have approached the manufacturing and non-manufacturing sectors somewhat differently for the following reasons. First, it seemed to us that many of the developments in economic theory that deal with the demand for labor were more directly applicable to manufacturing industries than to non-manufacturing industries. This is especially so with respect to the "neoclassical" theory of factor demands which places great emphasis on the substitutibility of capital, employment, and average hours worked in the cyclical evolution of employment. Second, for the particular SMSAs under investigation in this study (and for many, though not all, urbanized areas), the manufacturing industries represent the primary "export-base" sector in the region. Relatively speaking, output in manufacturing (and, therefore, the derived demand for labor) is much more directly dependent on national demand factors than output in the non-manufacturing sector. For the non-manufacturing industries it is the level of local activity that is the primary direct stimulus to output. There are, of course, important interrelationships between these sectors, but we felt these differences were adequate to justify a somewhat different treatment of these two industry groupings. We turn now to a detailed description of our models. We begin by outlining our model for the manufacturing industries and follow this with a description of the mechanism used in the case of non-manufacturing firms.

Manufacturing Industries: We begin by assuming the following production function to provide the framework for the firm's decision making in the short run:

$$Q^*_t = \alpha(t)L^*_t \qquad (3)$$

where

Q^*_t = desired output

L^*_t = desired labor inputs

Labor inputs, of course, can be adjusted by changing the number of employees, by changing the number of hours worked per employee or by some combination of these two alternative policies. We can express the desired labor inputs, therefore, in terms of its basic components as follows,

$$L_t^* = E_t^* H_t^* \tag{4}$$

where

E_t^* = desired level of employment

H_t^* = desired level of average hours per employee

Substituting (4) into (3) yields

$$Q_t^* = \alpha(t) E_t^* H_t^* \tag{5}$$

Equation (5) may be solved for $\alpha(t)$, a variable which will play an important role in the development of our model.

$$\alpha(t) = \frac{Q_t^*}{E_t^* H_t^*} \equiv \rho_t^* \tag{6}$$

It is now clear that $\alpha(t)$ is simply the inverse of the desired labor-output ratio or the "equilibrium" value of output per manhour. This is a critical variable in our analysis since it determines a firm's desired level of labor inputs once a level of production, or output, is decided. It is the movement of this variable over time that allows for changes in the relation of labor inputs to total output. A model governing the determination of this variable is outlined below.

Subject to the constraints implied by equation (5) above, we adopt the following model for the demand for employees by the firm,

$$\frac{E_t}{E_{t-1}} = A\left(\frac{E_t^*}{E_{t-1}}\right)^{\lambda_1} \left(\frac{E_{t-1}}{E_{t-1}^*}\right)^{\lambda_2} \qquad \lambda_1 > 0,\ \lambda_2 < 0; \tag{7}$$

That is, changes in employment reflect the "cascading" of the adjustment processes, represented by the two principal variables on the right hand side of equation (7). Let us examine each of these separately. The first term (E_t^*/E_{t-1}) simply reflects the discrepancy between the actual number of employees at the beginning of the period (E_{t-1}) and the firm's desired level of employment (E_t^*). Our hypothesis is that firms will adjust gradually towards their preferred state. The parameter λ_1 is a measure of the speed by which they will adjust. That is, if the actual level of employment is below the desired level there will be an increase in employment $(\lambda_1 > 0)$ and the larger λ_1, the quicker the gap will be closed. The second term, (E_{t-1}/E_{t-1}^*), is a measure of the "excess stock" of labor on hand (employed in the firm) at the beginning of the current period. We assume that only at peak rates of output will firms not be investing in (hoarding) excess labor. There are many reasons why a firm would find it to its advantage to hold (hoard) excess labor. Some of the primary ones are: 1) Contractual commitments or seniority provisions where younger and often more efficient workers must be laid off first, 2) Transaction costs - costs of hiring and laying off workers, 3) Retraining costs and loss of acquired skills by laid off workers, 4) Other reasons such as morale problems or higher re-organization costs. Our hypothesis is that the greater the excess stock, the smaller will be the necessary and actual changes in employment $(\lambda_2 < 0)$.

In order to derive a regression model to test the above mechanism, it is necessary to express each of the above expressions in terms of variables other than E_t^* which is not directly observable. From (6) we can write,

$$E_t^* = \frac{Q_t^*}{\rho_t^* H_t^*} \tag{8}$$

Dividing both sides of (8) by E_{t-1} yields the desired expression for the gap between desired and actual employment (E_t^*/E_{t-1}),

$$\frac{E_t^*}{E_{t-1}} = \frac{Q_t^*}{\rho_t^* H_t^* E_{t-1}} \tag{9}$$

To obtain the appropriate expression for our "excess employment" term (E_{t-1}/E^*_{t-1}), consider the reciprocal of equation (9),

$$\frac{E_{t-1}}{E^*_t} = \frac{\rho^*_t H^*_t E_{t-1}}{Q^*_t}$$

$$\therefore E_{t-1} = \frac{\rho^*_t H^*_t E^*_t}{Q^*_t} \cdot E_{t-1} \qquad (10)$$

Now, from equation (8)

$$E^*_{t-1} = \frac{Q^*_{t-1}}{\rho^*_{t-1} H^*_{t-1}} \qquad (11)$$

Dividing (10) by (11) and using (6), yields

$$\frac{E_{t-1}}{E^*_{t-1}} = \frac{\rho^*_{t-1} H^*_{t-1} E_{t-1}}{Q^*_{t-1}} \qquad (12)$$

We now have appropriate expressions for each of the principal "driving" variables in our model.

Given the multiplicative form of our principal hypothesis (equation (7)), it is convenient to express our estimating equations in logarithmic form. We begin our derivation of the regression equations, therefore, by transforming (7) as follows:

$$\ell n \frac{E_t}{E_{t-1}} = \lambda_0 + \lambda_1 \ell n \frac{E^*_t}{E_{t-1}} + \lambda_2 \ell n \frac{E_{t-1}}{E^*_{t-1}} \qquad (13)$$

Substituting (9) and (12) for (E^*_t/E_{t-1}) and (E_{t-1}/E^*_{t-1}), respectively, and rearranging terms, yields the following basic initial regression model

$$\ell n \frac{E_t}{E_{t-1}} = \lambda_0 + \lambda_1 \ell n \frac{Q^*_t}{Q^*_{t-1}} + (\lambda_2 - \lambda_1) \ell n \frac{\rho^*_{t-1} H^*_{t-1} E^*_{t-1}}{Q^*_{t-1}}$$

$$- \lambda_1 \Delta \ell n \rho^*_t - \lambda_1 \Delta \ell n H^*_t + \mu_1 \qquad (14)$$

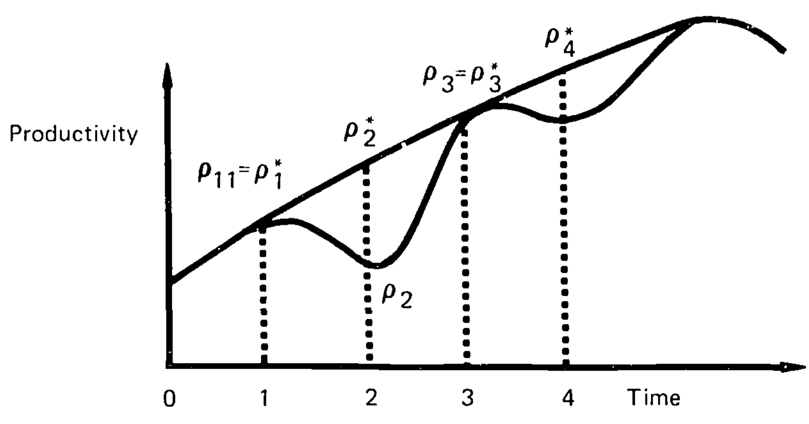
where μ_1 is a stochastic error term added to the model

A number of issues remain, however, before the model represented by equation (14) can be implemented. These involve the measurement of Q^* (desired output), the measuremnt of ρ^* (desired output-labor ratio), and the measurement of H^* (desired level of average hours worked per employee). We now deal with each of these issues in turn.

Regarding the desired level of production or output (Q^*) we make the simple assumption that production targets are achieved on a period by period basis. That is, we assume $Q^*_t = Q_t$, that actual output is equal to the desired target. We did experiment with a number of more "sophisticated" mechanisms for determining Q^*_t (including most of the usual "expectational mechanisms"), but these alternative procedures yielded no net benefits as far as we could judge. We retained, therefore, the above "naive" hypothesis.

Estimates of ρ^* were derived in two steps. First, for each industry involved the Federal Reserve Board's index of industrial production was combined with an index of aggregate manhours worked (from BLS 790) to derive quarterly estimates of the actual output-labor ratio in each industry. By plotting these actual ratios over time and connecting the peaks, we derived estimates of the desired output-labor ratio -- ρ^*_t. Figure (2) illustrates the relationship between the actual output-labor ratio (ρ_t) and the desired ratio (ρ^*_t).

Figure 2 Deriving Desired Productivity



Although the data underlying the calculation of ρ are all industry-specific, they are based on national aggregates and do not, therefore, reflect possible differences in either the actual or desired combinations of capital and labor in the different regions studied. In general, the national data were consistent with Fair's [6] hypothesis that employers adjust their work force to a near optimal situation once a year, since there was usually one peak per year in each industry, often in the same quarter.

With respect to a measure for H* (average hours worked per employee), we experimented with a number of alternatives, each one of which implied a somewhat different estimating equation for our model. Our first procedure was simply to assume that the desired level of average hours worked per employee (H_t^*) was a constant over our sample period (1956-1972). This we refer to as Model A. Our second approach was to adopt the "naive" model employed in the case of Q_t^* and simply assume that the desired and actual level of average hours worked were the same, i.e., $H_t^* = H_t$. This we refer to as Model B. Finally, in our third model (Model C) we allowed for the possibility both of a long run trend in H* as well as the possibility that the desired or optimal level of this variable might also have a cyclical component. Allowance for these factors required the incorporation of the following additional relationships into our basic model.

$$H_t^* = a_0 e^{\gamma t} . e^{f(u)}; \ \gamma<0, \ f'(u)<0; \qquad (15)$$

where u = unemployment rate

t = time trend

To incorporate this relationship into our model it is somewhat more convenient to deal with the logarithmic form of this expression. Taking natural logarithms of both sides of equation (15) yields

$$\ell n H_t^* = A_0 + \gamma t + f(u) \qquad (16)$$

Incorporating these various assumptions along with the basic model presented above (equation (14)) yields the following alternative models and estimating equations.

$$\ell n\left(\frac{E_t}{E_{t-1}}\right) = \lambda_0 + \lambda_1 \ \ell n \left(\frac{Q^*}{Q^*_{t-1}}\right) + (\lambda_2 - \lambda_1)\ell n \left(\frac{\rho^*_{t-1}H^*_{t-1}E_{t-1}}{Q^*_{t-1}}\right)$$

$$- \lambda_1 \Delta \ell n \rho^*_t - \lambda_1 \Delta \ell n H^*_t + \mu_1 \qquad (14)$$

$$Q^*_t = Q_t \qquad (17)$$

$$H^*_t = \overline{H} \qquad (18)$$

$$H^*_t = H_t \qquad (19)$$

$$H^*_t = a_0 e^{\gamma t} \cdot e^{f(u)} \qquad (20)$$

To derive the appropriate estimating equations for each of these models, equation (17) and either equation (18), (19), or (20) are substituted into equation (14). This procedure generates the following regression equations. Seasonal dummy variables were then added.

Model A:

$$\ell n \left(\frac{E_t}{E_{t-1}}\right) = \lambda_A + \delta_1 S_1 + \delta_2 S_2 + \delta_3 S_3 + \lambda_1 \left(\frac{Q_t}{Q_{t-1}}\right)$$

$$+ (\lambda_2 - \lambda_1)\ell n\left(\frac{\rho^*_{t-1}E_{t-1}}{Q_{t-1}}\right) - \lambda_1 \Delta \ell n \rho^*_t + \mu_A \qquad (21)$$

Model B:

$$\ell n \left(\frac{E_t}{E_{t-1}}\right) = \lambda_B + \delta_1 S_1 + \delta_2 S_2 + \delta_3 S_3 + \lambda_1 \left(\frac{Q_t}{Q_{t-1}}\right)$$

$$+ (\lambda_2 - \lambda_1)\ell n \left(\frac{\rho^*_{t-1}H_{t-1}E_{t-1}}{Q_{t-1}}\right) - \lambda_1 \Delta \ell n \rho^*_t - \lambda_1 \Delta \ell n H_t + \mu_B \qquad (22)$$

Model C:

$$\ell n\left(\frac{E_t}{E_{t-1}}\right) = \lambda_C + \lambda_1 S_1 + \lambda_2 S_2 + \lambda_3 S_3 + \lambda_1 \ell n\left(\frac{Q_t}{Q_{t-1}}\right)$$

$$+ (\lambda_2 - \lambda_1)\ell n\left(\frac{\rho^*_{t-1}E_{t-1}}{Q_{t-1}}\right) - \lambda_1 \Delta \ell n \rho^*_t + (\lambda_2 - \lambda_1)\gamma(t-1)$$

$$+ (\lambda_2 - \lambda_1)f(u)_{t-1} - \lambda_1 \Delta f(u)_t + \mu_C \qquad (23)$$

where

E_t = total SMSA employment (not seasonally adjusted) in period t for the particular industry (establishment basis) - hundreds of people.

Q_t = Federal Reserve Board Index of Industrial Production for a particular industry for period t (1967 = 100). This is an index of national output for the industry. (Not seasonally adjusted.)

H_t = average number of hours worked per employee per quarter for a particular industry. Figures used are national average weekly hours paid for production, construction, and non-supervisory workers. (Not seasonally adjusted.)

u_t = unemployment rate in a particular SMSA for a particular quarter; estimation based on the number unemployed as a percent of the area work force, derived from the Manpower Administration labor force estimation technique [5].

S_1, S_2, S_3 = seasonal dummies which measure seasonal variation.

t = a time trend.

Before turning to the demand for employment in the non-manufacturing sector we will outline that part of our model concerned with the determination of the desired output-labor ratio (ρ^*_t) which plays such an important role in the above employment demand equations. The actual measurement of the variable was described above; here we will describe the mechanism used to model the evolution of this variable over time.

In the framework of the "neoclassicial" theory of interrelated factor demands the desired or optimal output-labor ratio depends on the parameters describing the technological possibilities open to the firm (production function parameters) and the relative prices of capital and labor inputs. The more expensive capital inputs are relative to labor inputs, the higher will be the desired output-labor ratio and vice-versa. In a dynamic context we must think in terms of expected prices of inputs rather than actual prices, but other than that the general rationale remains the same. In each of the manufacturing industries, therefore, we developed a model of the desired output-labor ratio of the following general form.

$$\ell n\rho^*_{tj} = \alpha + \beta\ell nW^*_t + \gamma\ell nRAAA^*_t + \delta\ell nPGNP^*_t + E\ell nt \quad (24)$$

$$\ell nW^*_t = \sum_{i=0}^{n} a_i \ell nW_{t-i} \quad (25)$$

$$\ell nRAAA^*_t = \sum_{i=0}^{m} b_i \ell nRAAA_{t-i} \quad (26)$$

$$\ell nPGNP^*_t = \sum_{i=0}^{k} c_i \ell nPGNP_{t-i} \quad (27)$$

$(\beta < 0, \gamma > 0)$

where

ρ^*_{tj} = desired output-labor ratio for manufacturing industry j

W^*_t = expected wages

$RAAA^*_t$ = expected interest rates

$PGNP^*_t$ = expected output price (GNP prices)

t = time trend reflecting shifts in the parameters of the production function

W_t = Index of Compensation per manhour (national) 1967 = 100

$RAAA_t$ = Moody's triple A corporate bond rate (percent)

PGNP = Implicit Deflator for Gross National Product (1967 = 100)

All of the explanatory variables in this model are economy-wide measures and do not, therefore, reflect any inter-regional differences in input prices (wages, interest rates, etc.). This is not to suggest that inter-regional differences in wage rates do not exist, but only that the dependent variable, or the variable being explained in this instance, is itself an economy-wide measure.

This model is implemented for each of the manufacturing industries studied. The actual estimating equation employed allows for the differential weights on each of the explanatory variables, as indicated in equations (25) - (27), and has the following form.

$$\ln \rho^*_{tj} = \alpha + \beta \sum_{i=0}^{3} \frac{1}{4} \ln W_{t-i} + \gamma \sum_{i=0}^{3} \frac{1}{4} \ln RAAA_{t-1} + \delta \ln PGNP$$

$$+ \varepsilon \ln t + \theta_1 \ln \rho^*_{t-1j} + \theta_2 \ln \rho^*_{t-2j} + \mu_4 \qquad (28)$$

<u>Non-Manufacturing Industries</u>: Our basic model of employment in the non-manufacturing sector is a simple partial adjustment model which can be expressed as follows:

$$\left(\frac{E_{ti}}{E_{t-1i}}\right) = \beta \left(\frac{E^*_{ti}}{E_{t-1i}}\right)^{\lambda_3} e^{\mu_5}, \quad 0 < \lambda_3 < 1 \qquad (29)$$

$$E^*_{ti} = c_i \qquad (30)$$

$$E^*_{ti} = (c_i ET_t)^{Z_{ti}} \qquad (31)$$

where

E_{ti} = employment in the i^{th} industry (establishment basis).

E^*_{ti} = desired employment in i^{th} industry.

Z_{ti} = set of factors that help determine the ratio of employment in industry i to total employment in the SMSA.

ET_t = total employment in the SMSA (establishment basis).

μ_5 = stochastic error term.

Equations (31) and (32) represent alternative hypotheses regarding the relationship of total SMSA employment to employment in a particular non-manufacturing industry.

Combining equations (29), (30), and (31) and expressing the result in logarithmic form yields the following regression model, (Model D).

$$\ell nE_{ti} = a_0 + a_1\ell nET_t + a_2Z_{ti}\ \ell nET_t + a_3\ell nE_{t-1i} + \mu_5 \qquad (33)$$

If equation (32) is used rather than (31) a somewhat different model (Model E) is derived.

$$\ell nE_{ti} = a_0 + b_1\ell nZ_{ti} + b_2\ell nET_i + a_3\ell nE_{t-1i} + \mu_5 \qquad (34)$$

We experimented with both of these models as well as with some minor variations of these mechanisms. In each case (for each industry and each SMSA studied) we selected that model which seemed most strongly confirmed by the data. The details regarding the final models selected we presented in the results section below.

1.3 A Labor Supply Model

In this section a labor supply model is described which provides a framework for the determination of local labor force participation rates and population for ten age-sex groups as well as a mechanism whereby these variables together with establishment employment are combined to produce estimates of the gross unemployment rate for the SMSA. The ten age-sex groups for which population and labor force are predicted are:

Males	Females
16-17	16-17
18-19	18-19
20-54	20-44
55-64	45-64
65+	65+

The age groups are not identical for males and females in the prime ages 20-64. For males ages 55-64 are broken out to permit analysis of possible trends in early retirement. For females ages 20-44 and 45-64 are separated to permit an analysis of participation in child bearing versus non-child bearing ages.

Unfortunately, quarterly time series on local SMSA labor force participation rates are not available. In general these rates are available only every ten years for most SMSAs. Thus we must begin by using what information is available to generate a synthetic data base for these local labor force participation rates. In some large SMSAs data from the Current Population Survey can be used to verify the procedures employed, but in many cases actual verification of the synthetic time series is possible only every ten years. Calculations that use this synthetic data, such as our estimate of the gross unemploymet rate, must, therefore, be examined very critically. Our labor supply model is composed of two separate modules, a population sector and a labor force sector. We will discuss each module in turn, beginning with the population section.

Population Sector: The nature of the mechanism used to generate quarterly estimates of population during the sample period (1960's) is sharply different from that which we propose for the 1970's (the post sample period). During the sample period we simply assume that the SMSA population is growing at a constant percentage rate each quarter. The rate of growth itself is computed from the population estimates available from the 1960 and 1970 Census of Population. From these ten year growth rates for each of the age-sex groups the implied quarterly rates of change are derived under the assumption of constant rates of growth. Table 1 shows the civilian population for each of the three SMSAs for 1970 and Table 2 presents the ten year percentage change for each of the ten different age groups involved.

To predict population growth in the 1970's on the basis of the 1960-1970 rates would clearly be foolish. Known changes in the age distribution of the population in the 1960's imply a substantially different pattern of growth in the 1970's for certain age groups. For example, the post World War II baby boom led to dramatic increases in teenage population in the 1960's. This will be reflected in the

TABLE 1

CIVILIAN POPULATION BY SMSA BY SEX BY AGE, 1970

	Denver	Detroit	Milwaukee
Males			
16-17	23541	86528	27227
18-19	20973	65017	22697
20-54	260783	875001	285887
55-64	42901	174350	60974
65+	38109	148782	55859
Females			
16-17	23010	82304	26111
18-19	22482	70363	24269
20-44	221281	686667	227027
45-64	115840	450384	149232
65+	57126	193023	79417

Source: U.S. Bureau of the Census, 1970
Census of Population, Detailed Characteristics, PC(1)-D, Table 164.

TABLE 2

PERCENT GROWTH IN TOTAL POPULATION AGE BY SMSA 1960-1970

Age	Denver	Detroit	Milwaukee
16-17	80.0%	47.9%	48.7%
18-19	73.7	69.1	55.1
20-54	34.6	8.8	5.2
55-64	30.3	11.5	9.5
65+	24.4	26.4	20.4
20-44	33.5	5.0	4.6
45-64	35.0	16.3	8.1

Source: 1970 Census of Population, General Population Characteristics, PC(1)-B, Table 24.

population growth rates among young adults in the 1970's. Correspondingly, a decrease in the population growth rate among teenagers will be noticed. These patterns have already become apparent. Table 3 compares national population growth during the sixties with the projected 1970-1980 growth rates by age-sex groups.

The procedure followed for the post sample period is to compute the rate of growth of population by aging cohorts of persons of the same race and sex born in a single year in each SMSA. These cohorts are aged by assuming the number of persons in the SMSA in an age-sex-race group equals the number in the previous year in the (Age-1)-sex-race groups adjusted for mortality and mobility. Table 4 gives mortality rates by age-race-sex for the U.S. Some studies have been made of differential mortality by SMSA. However, the differences are very small and adjustments are made for differences in race-sex-age.[3]

Table 5 illustrates the rate of growth of population in the absence of migration into or out of the SMSA. Account should, of course, be taken of net migration. Net migration rates for the three SMSAs are given in Table 6. Once account is taken of net migration the rate of growth of population can be predicted for the three SMSAs as can be seen in Table 7.

<u>Labor Force Sector</u>. Even a cursory look at data on national labor force participation rates by demographic groups will indicate that over time, for any given demographic group, there exist pronounced variations in these rates. Our labor supply model is based on the major premise that SMSA-specific labor force participation rates adjust to changing job opportunities and long-run trend factors in the same manner as do national participation rates, and have the same seasonal variations. The assumption, then, is to the extent that national and local rates differ, they differ in their level -- not their responsiveness to cyclical, secular and seasonal stimuli. Consequently, our method of analysis consists of estimating national labor force participation rate equations for ten demographic groups and then adjusting these relationships to reflect level differences within the three SMSAs of interest.

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[3] See for example Duffy, E. A. and Carrol, R. E. [8].

TABLE 3

NATIONAL POPULATION GROWTH 1960-1970 and PROJECTED 1980

	1960-1970	1970-1980
Males		
16-17	36.7%	4.4%
18-19	47.4	13.9
20-54	12.7	19.6
55-64	15.6	11.8
65+	11.5	15.7
Females		
16-17	36.6	3.7
18-19	45.8	13.4
20-44	11.8	26.5
45-64	18.2	4.9
65+	25.4	25.4

Source: U.S. Bureau of Labor Statistics, Special Labor Force Report #156.

TABLE 4

U.S. MORTALITY RATES BY AGE, RACE AND SEX

Age (years)	Mortality Rate Per 1,000 Living at Specified Age: Total	White		Negro and Other	
		Male	Female	Male	Female
Under 1	21.08	21.33	16.08	35.18	28.58
1	1.30	1.18	1.07	2.32	1.88
2	0.85	0.81	0.66	1.54	1.22
3	0.68	0.70	0.55	0.94	0.88
4	0.58	0.58	0.49	0.87	0.67
5	0.63	0.80	0.41	1.15	0.59
6	0.51	0.59	0.37	0.80	0.51
7	0.40	0.43	0.33	0.56	0.45
8	0.32	0.31	0.29	0.41	0.39
9	0.27	0.25	0.26	0.35	0.35
10	0.26	0.24	0.24	0.38	0.33
11	0.29	0.30	0.24	0.49	0.34
12	0.37	0.42	0.27	0.68	0.38
13	0.50	0.60	0.32	0.94	0.47
14	0.66	0.84	0.39	1.25	0.58
15	0.85	1.11	0.48	1.61	0.72
16	1.04	1.37	0.56	2.00	0.86
17	1.19	1.60	0.62	2.38	0.98
18	1.30	1.75	0.64	2.73	1.06
19	1.36	1.86	0.65	3.07	1.12
20	1.41	1.96	0.65	3.43	1.19
21	1.47	2.05	0.65	3.78	1.27
22	1.50	2.09	0.66	4.05	1.35
23	1.50	2.05	0.66	4.19	1.44
24	1.48	1.96	0.66	4.26	1.54
25	1.45	1.85	0.67	4.29	1.64
26	1.42	1.76	0.68	4.35	1.75
27	1.42	1.69	0.70	4.47	1.89
28	1.44	1.66	0.73	4.67	2.06
29	1.50	1.67	0.78	4.95	2.25
30	1.56	1.70	0.84	5.24	2.47
31	1.64	1.74	0.90	5.55	2.69
32	1.73	1.81	0.98	5.87	2.92
33	1.85	1.91	1.06	6.20	3.18
34	1.99	2.05	1.16	6.56	3.44
35	2.15	2.21	1.26	6.94	3.73
36	2.32	2.40	1.38	7.35	4.03
37	2.52	2.62	1.51	7.81	4.34
38	2.74	2.87	1.66	8.33	4.66
39	2.97	3.15	1.82	8.90	4.99
40	2.24	3.47	2.00	9.53	5.34
41	3.52	3.82	2.20	10.18	5.71
42	3.83	4.21	2.40	10.81	6.10
43	4.15	4.63	2.61	11.39	6.51
44	4.50	5.08	2.83	11.96	6.95
45	4.88	5.59	3.07	12.54	7.42

Table 4 (cont.)

Age (years)	Total	White		Negro and Other	
		Mortality Rate Per 1,000 Living at Specified Age			
		Male	Female	Male	Female
46	5.29	6.14	3.34	13.19	7.92
47	5.75	6.76	3.62	13.98	8.44
48	6.26	7.45	3.94	14.94	8.98
49	6.83	8.21	4.28	16.06	9.55
50	7.44	9.04	4.65	17.27	10.17
51	8.10	9.93	5.05	18.52	10.84
52	8.82	10.93	5.47	19.84	11.59
53	9.62	12.04	5.92	21.22	12.44
54	10.48	13.26	6.40	22.66	13.37
55	11.42	14.55	6.93	24.21	14.42
56	12.41	15.94	7.51	25.86	15.55
57	13.49	17.47	8.13	27.57	16.76
58	14.66	19.18	8.78	29.33	18.04
59	15.91	21.04	9.48	31.17	19.42
60	17.26	23.06	10.26	33.11	20.77
61	18.71	25.18	11.13	35.22	22.29
62	20.26	27.33	12.12	37.59	24.34
63	21.92	29.46	13.25	40.32	27.12
64	23.72	31.61	14.54	43.40	30.47
65	25.60	33.80	15.92	46.52	34.17
66	27.61	36.19	17.45	49.82	37.85
67	29.91	39.00	19.23	53.84	41.27
68	32.56	42.41	21.34	58.88	44.15
69	35.53	46.36	23.74	64.79	46.52
70	-	50.70	26.30	71.90	49.00
71	-	55.40	29.20	79.40	51.50
72	-	59.90	32.20	85.40	53.20
73	-	64.30	35.40	87.90	53.60
74	-	68.50	38.90	86.90	52.80
75	-	72.70	42.70	83.50	51.50
76	-	77.30	46.90	79.30	50.20
77	-	82.50	51.60	76.00	49.60
78	-	88.30	56.80	74.70	50.10
79	-	94.90	62.70	75.70	51.80
80	-	102.20	69.40	78.90	55.10
81	-	109.90	77.00	83.60	60.00
82	-	117.60	85.80	88.70	66.60
83	-	124.70	96.00	92.60	75.20
84	-	129.90	108.10	92.90	86.30
85+ *	-	190.00	190.00	190.00	190.00

* Assumed rate

Source: U.S. Public Health Service, Vital Statistics of the United States, annual.

TABLE 5

RATE OF GROWTH OF CIVILIAN POPULATION BASED ON COHORT AGING AND DYING

(ASSUMING ZERO NET MIGRATION)

	Denver		Detroit		Milwaukee	
	70-73	73-76	70-73	73-76	70-73	73-76
Males						
16-17	8.37%	7.52%	9.50%	1.56%	8.77%	6.00%
18-19	15.04	6.64	33.41	7.17	22.76	5.35
20-54	4.89	4.97	3.26	5.76	3.61	5.50
55-64	4.95	11.10	9.85	7.74	3.79	5.26
65+	3.19	7.66	3.20	5.14	6.35	4.64
Females						
16-17	8.08	4.44	9.34	0.33	8.06	5.15
18-19	4.47	7.71	21.69	7.01	8.50	7.65
20-44	6.59	3.90	2.92	7.03	5.26	5.44
45-64	5.01	5.91	7.41	2.60	2.06	3.15
65+	6.09	6.42	7.76	8.88	8.15	7.89

SOURCE: Table 4, U.S. Bureau of Census 1970, census of population detailed characteristics, PC(1)-D, Table 164 and the two one percent public use samples 1970 census for the three SMSA's.

TABLE 6

NET MIGRATION RATES 1965-1970 (PER 100 POPULATION 1970)
SMSA BY SEX BY AGE

	Denver	Detroit	Milwaukee
Males			
15-19	4.06	-7.60	-7.26
20-54	6.96	-1.04	-2.83
55-64	-.44	-4.47	-2.87
65+	.17	-7.46	-3.51
Females			
15-19	3.79	-4.64	-3.06
20-44	9.48	.33	-2.05
45-64	.66	-3.31	-2.43
65+	1.27	-4.19	-1.66

Source: U.S. Bureau of Census, 1970 Census of Population, Mobility of Metropolitan Areas, PC(2)-2C, Table 15.

TABLE 7

PROJECTED POPULATION GROWTH 1970-73, 1973-76 BY SMSA BY SEX BY RACE
(ADJUSTING FOR MIGRATION, MORTALITY AND AGING)

	Denver		Detroit		Milwaukee	
Male	1970-73	1973-76	1970-73	1973-76	1970-73	1973-76
16-17	10.81%	9.96%	[illegible].94%	-3.00%	4.41%	1.64%
18-19	17.48	9.08	28.85	2.61	18.40	0.99
20-54	9.07	9.15	2.64	5.14	1.91	3.80
55-64	4.64	10.84	7.17	5.06	2.07	3.54
65+	3.09	7.56	-1.28	0.66	4.24	2.53
Female						
16-17	10.35	6.71	6.56	-2.45	6.22	3.31
18-19	6.74	9.98	18.91	4.23	6.66	5.81
20-44	12.28	9.59	3.12	7.23	4.03	4.21
45-64	5.41	6.31	5.42	0.61	0.60	1.69
65+	6.85	7.18	5.25	6.37	7.15	6.89

SOURCES: Tables 5, 6. The computations were made adding 3/5 of the rate in Table 6 for each age group to the rate in Table 5. This is only an approximation. The correct computation is $g = M^{3/5}P + M^{3/5} + P$ where M is the rate in Table 6 and P is the rate in Table 5. However, the corrections affect the second or third decimal place and are small relative to the underlying errors in assuming the same mobility patterns in 1965-1970 and 1970-1976. Keeping the simpler form makes it easier for persons to change assumptions in either table and recompute Table 7.

Our point of departure was the time series analysis of labor-force participation rates undertaken by Alfred Tella [30, 31] at the national level. Tella's prime concern, as is ours, was to determine the effect of short-run variations in employment demand on the size of the labor force after controlling for trend and seasonal influences. This type of investigation has a long history in empirical and theoretical economic analysis but enjoyed an upsurge of interest during the 1960's. Tella's work, in common with several others, attempted to determine the relative strengths of what have become known as the "discouraged worker" and "additional worker" hypotheses. These hypotheses suggest that in an economic down-swing some unemployed workers may give up the apparently hopeless job search and withdraw from the labor force and/or potential labor-force entrants or re-entrants may be inhibited from ever starting to look for work; on the other hand, additional workers may enter the labor market to bolster declining family incomes. Both of these effects are likely to coexist; therefore, the question is not which tendency is the true one but which is the stronger.

At this point it may be useful to review a few of Tella's results, as they will be useful in our subsequent discussion of the LMIS model: Tella employed national time series quarterly data on the labor-force participation rates of several age-sex groupings as the dependent variable and group-specific employment ratios (number of persons employed/number of persons in the relevant population) as the prime independent variable. His regression results indicate a net positive sensitivity to employment conditions in all groups with females as a group exhibiting a greater sensitivity than the males. The extreme age groups are more sensitive than the middle-age groups. The single most important conslusion is that, in time series, labor-force sensitivity to employment conditions is primarily a characteristic of the"secondary" labor force (usually defined to include women of all ages and males 16-24 and 55+).

More formally, we expect a demographic group's participation rate to respond to changing job opportunities through a distributed lag. That is to say, the participation rate at any period t responds to a measure of job opportunities in all previous periods of time. It is convenient to express this hypothesis in the following form as a first step:

$$\left(\frac{L_{ij}}{P_{ij}}\right)_t = a + b_o\left(\frac{E}{P}\right)_{t-1} + b_1\left(\frac{E}{P}\right)_{t-2} + b_2\left(\frac{E}{P}\right)_{t-3} + \dots + e_t. \quad (34)$$

The variables in equation (1) are defined as follows:

$\left(\frac{L_{ij}}{P_{ij}}\right)$ = national civilian labor force participation rate of the i^{th} age group (i = 1, ..., 5) and j^{th} sex (j = 1, 2),

$\frac{E}{P}$ = total establishment employment divided by total civilian noninstitutional population,

e = error term

Since our sample is finite in size, the infinite set of lagged values of E/P must be cut off at some point. A convenient method to accomplish this is to specify a priori that the coefficients of the successive E/P's decline systematically as we go further back in time. In particular, we will assume that the coefficients of E/P in (34) decline geometrically in the following manner:

$$b_k = b\lambda^k \qquad (k = 0, 1, 2, \dots) \quad (35)$$

where $0<\lambda<1$. Equation (34) may now be written as:

$$\left(\frac{L_{ij}}{P_{ij}}\right)_t = a + b\left[\left(\frac{E}{P}\right)_{t-1} + \lambda\left(\frac{E}{P}\right)_{t-2} + \lambda^2\left(\frac{E}{P}\right)_{t-3} + \dots\right] + e_t \quad (36)$$

However, if we lag (36) by one period and multiply through by λ we obtain

$$\lambda\left(\frac{L_{ij}}{P_{ij}}\right)_{t-1} = \lambda a + b\left[\lambda\left(\frac{E}{P}\right)_{t-2} + \lambda^2\left(\frac{E}{P}\right)_{t-3} \dots\right] + \lambda e_{t-1} \quad (37)$$

and subtracting (37) from (36) we obtain

$$\left(\frac{L_{ij}}{P_{ij}}\right)_t = a(1-\lambda) + b\left(\frac{E}{P}\right)_{t-1} + \lambda\left(\frac{L_{ij}}{P_{ij}}\right)_{t-1} \quad (38)$$

where $u_t = e_t - \lambda e_{t-1}$. The assumption of geometrically declining coefficients on E/P, then, achieves a substantial simplification of (34), for instead of having to estimate a string of b_k coefficients, one now has only to estimate the two parameters b and λ. Finally, then, the basic labor supply model, which will be initially estimated using national data for ten age-sex groups, has the following form:

$$(5) \quad \left(\frac{L_{ij}}{P_{ij}}\right)_t = a^1 + b\left(\frac{E}{P}\right)_{t-1} + c\left(\frac{L_{ij}}{P_{ij}}\right)_{t-1} + d[\log_{10}T] + e_1 S_1 + e_2 S_2 + e_3 S_3 + f\left(\frac{AF}{P}\right)_t + u_t \qquad (39)$$

where $a^1 = a(1 - \lambda)$ (k = 1, 5) (j = 1, 2)

$c = \lambda$

T = trend (time) variable which equals one in the first quarter of 1954,

S_1 = 1 if the observation occurs in the first quarter of the year,
= 0, otherwise,

S_2 = 1 if the observation occurs in the second quarter of the year,
= 0, otherwise,

S_3 = 1 if the observation occurs in the third quarter of the year,
= 0, otherwise,

AF/P = ratio of armed forces to total civilian noninstitutional population.

However, estimation of (40) by ordinary least squares leads to inconsistent estimates because of the lagged dependent variable. Exploration of instrumental variable estimation of (40) failed however to produce coefficients or standard errors which were sufficiently different to warrant the use of the technique.

APPENDIX B

DESCRIPTION OF DATA USED FOR THE ECONOMIC MODEL OF LABOR SUPPLY AND DEMAND

Shirish C.R. Sanghvi*

2.0 Introduction

An econometric model of labor supply and demand is being developed for the labor markets of Detroit, Denver and Milwaukee SMSA's. This model would permit manpower planners and administrators to forecast employment by industry in the three areas as well as unemployment and supply of labor force by demographic group.[1] It would also help them to study the effects of alternative public policy measures on the labor supply and demand in these areas. For generating the various equations that are incorporated into this model a considerable amount of data was collected. This paper describes the various data sets that were obtained.

The principal source of the various data sets is the Bureau of Labor Statistics, U.S. Department of Labor. Other sources include the Federal Reserve System, the various government statistical publications, and the National Bureau of Economic Research[2] (NBER) machine-readable data bank. This NBER data bank has hundreds of time series and for more details one should refer to their publication "Time Series Data Bank" which is a directory of all the time series that they maintain.

All of our data sets are either monthly and/or quarterly time series and unless otherwise stated they are all Seasonally Unadjusted.

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* The Labor Market Information Systems Project is sponsored by the Manpower Adminstration, Office of Research and Development, United States Department of Labor, under contract no. 71-24-70-02. The views represented in this paper are the sole responsibility of the author and do not necessarily reflect the views of the Department of Labor.

1 See Appendix A.

2 National Bureau of Economic Research, 261 Madison Avenue, New York, N.Y., 10016 [25]

The years that they cover could be different for different series. The seasonally adjusted time series (national) that we may have used for data analyses purposes have come mostly from the NBER data bank. Only the time series on those variables which are used directly in the model regression equations at present (or are envisaged to be used in the near future) are described in this paper.

The time series are either for the whole U.S. (national) or for any or each of the three SMSA's, Detroit, Denver or Milwaukee. Unless otherwise stated the time series that refer to industries are for those industries listed in Appendix B-1.

The time series that are described are quite reliable and error free as they have all gone through a rigorous checking process. They will be updated, up to 1972 (and if possible 1973) as and when the data become available.

2.1 Index of Industrial Production (National), 1967 Base

The Index of Industrial Production[3] is monthly and "relative" for individual production of manufactures and minerals. The present index is designed such that we can study the economic growth and cyclical fluctuations along with seasonal and irregular fluctuations. The time series for national production are published by the Board of Governors of the Federal Reserve System [4].

For our model we use the index of industrial production for the manufacturing industries described in Appendix B-1. All the time series are for national production, from 1949 to 1971 and with 1967 as the base. We have the monthly and the quarterly, not seasonally adjusted, time series.

2.2 Average Weekly Hours (National)

The information on average weekly hours (national) for production, construction, or nonsupervisory workers in various industries relates to the average hours during the work week, including the 12th of the

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3 The above 1971 publication should be consulted for more technical detail

from standard or scheduled hours. Average hours also include the overtime hours. More overtime hours cause the average weekly hours to be higher than scheduled hours of work and factors such as absenteeism, labor turnover, part-time work, and work stoppages cause them to be lower than the scheduled hours of work for an establishment.

The data we use consist of monthly and quarterly time series from 1955 to 1971. All the observations are in thousands of employees and are not seasonally adjusted. Besides the industries listed in Appendix B-1, we have the average weekly hours time series for the following industries also.

LIST 1

SIC Code	Name
21	Tobacco Manufactures
22	Textile mill products
23	Apparel and other finished products made from fabric and similar materials
24	Lumber and wood products except furniture
25	Furniture and fixtures
26	Paper and allied products
27	Printing publishing and allied industries
28	Chemicals and allied industries
29	Petroleum refining and related industries
30	Rubber and miscellaneous plastic products
31	Leather and Leather products
32	Stone, clay, glass, and concrete products
3	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks
39	Miscellaneous manufacturing industries

SOURCE: Employment and Earnings, United States 1909-1971. Bulletin 1312-8, Bureau of Labor Statistics, U.S. Department of Labor. The average weekly hours data can also be obtained from the various monthly issues of the Bureau of Labor Statistics publication Employment and Earnings.

2.3 Employment (National)

The data on national employment of production, construction, or nonsupervisory workers in various industries consist of monthly time series from 1955 to 1971. Included in these data are full and part-time workers on establishment payrolls who received pay for any part of pay period which includes the 12th of the month. Also included are workers who are on paid sick leave (when pay is received directly from the firm), on paid holidays or vacation, or who work during a part of the pay period and are unemployed or on strike during the rest of the period. Not counted as employed are workers who are laid off, on leave without pay or on strike for the entire period or who are hired but have not reported to work during the period.

All the observations are in thousands of employees and are not seasonally adjusted.

The monthly time series were converted into quarterly time series for our use.

Besides the industries listed in Appendix B-1, we have the employment time series for the following industries also.

LIST 2

SIC Code	Name
21	Tobacco manufactures
22	Textile mill products
23	Apparel and other finished products made from fabric and similar materials
24	Lumber and wood products except furniture
25	Furniture and fixtures
26	Paper and allied products
27	Printing publishing and allied industries
28	Chemicals and allied products
29	Petroleum refining and related industries
30	Rubber and miscellaneous plastic products
31	Leather and leather products

LIST 2 (Cont.)

SIC Code	Name
32	Stone, clay, glass, and concrete products
38	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks
39	Miscellaneous manufacturing industries

SOURCE: Employment and Earnings, United States 1909-1971. Bulletin 1312-8, Bureau of Labor Statistics, U.S. Department of Labor. The employment data can also be obtained from the various monthly issues of the Bureau of Labor Statistics' publication Employment and Earnings and Monthly Report on the Labor Force.

2.4 Man-Hours (National)

The quarterly time series for average weekly man-hours (national) of production, construction, or nonsupervisory workers are obtained as follows:[4]

Let $AWH_{i,y,q}$ = quarterly averages of average weekly hours[5] (national and not seasonally adjusted) for production, construction, or nonsupervisory workers in industry i, year y and quarter, q.

$EPW_{i,y,q}$ = quarterly averages of production, construction or nonsupervisory workers' employment in thousands[6] (national and not seasonally adjusted) in industry i, year y and quarter q.

and $MHP_{i,y,q}$ = quarterly man-hours of production, construction, or nonsupervisory workers (national and not seasonally adjusted) in thousands of man-hours for industry i, year y and quarter q.

then $MHP_{i,y,q} = AWH_{i,y,q} * EPW_{i,y,q}$

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4 Source: Average weekly hours and employment of production, construction, or nonsupervisory workers' time series [35].

5 See Average Weekly Hours (National). Heading 2.2.

6 See Employment (National). Heading 2.3.

2.5 Man-Hour Index (National), 1967 Base

The quarterly time series for average weekly man-hour index (national) of production, construction, or nonsupervisory workers are obtained in the following manner.

The man-hour index time series, national and not seasonally adjusted, are derived from the corresponding time series of man-hours in thousands of man-hours.[7] To be consistent with the Index of Industrial Production[8] base, we have used 1967 as the base year for converting man-hours series into man-hour index series. Further, all our series are quarterly and not seasonally adjusted.

Let $MHP_{i,67,1}$, $MHP_{i,67,2}$, $MHP_{i,67,3}$, and $MHP_{i,67,4}$, be the four quarterly values of man-hours of production, construction, or nonsupervisory workers (national and not seasonally adjusted) in thousands of man-hours for industry i and the year 1967.

Then

$$\left(\sum_{q=1}^{4} MHP_{i,67,q} \right) \Big/ 4 \qquad (40)$$

is equal to the annual average for 1967 of weekly man-hours in thousands for industry i. Call this BASE.

We now use such a BASE, one for each industry, to convert the quarterly man-hours time series into quarterly man-hour index series. The four quarterly values of man-hour index, MHI, time series for industry i and year y (with 1967 as the base year) will be given by:

$$MHI_{i,y,1} = \left(MHP_{i,y,1} \Big/ BASE \right) * 100.0 \% \qquad (41)$$

$$MHI_{i,y,2} = \left(MHP_{i,y,2} \Big/ BASE \right) * 100.0 \% \qquad (42)$$

$$MHI_{i,y,3} = \left(MHI_{i,y,3} \Big/ BASE \right) * 100.0 \% \text{ and} \qquad (43)$$

$$MHI_{i,y,4} = \left(MHI_{i,y,4} \Big/ BASE \right) * 100.0 \% \qquad (44)$$

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7 See Man-Hours (National). Heading 2.4.

8 See Index of Industrial Production (National), 1967 Base, Output per Man-Hour (National), 1967 Base, and Potential Output per Man-Hour (National), 1967 Base.

We have prepared the quarterly man-hour index with 1967 as the base for national and seasonally unadjusted time series from 1955 to 1971 for the industries listed in Appendix B-1.[9]

2.6 Output Per Man-Hour (National), 1967 Base

The quarterly time series for output per man-hour index, national, seasonally unadjusted and with 1967 as the base are also derived time series. The computation is done in the following manner:

Let $MHI_{i,y,q}$ = man-hour index (national)[10] with 1967 as the base and seasonally unadjusted for industry i, year y, and quarter q,

and $IP_{i,y,q}$ = index of industrial production (national)[11] with 1967 as the base and seasonally unadjusted for industry i, year y and quarter q,

then $QMH_{i,y,q}$ = the index of output per man-hour, national and seasonally unadjusted, for the industry i, year y and quarter q is given by:

$$QMH_{i,y,q} = \left(IP_{i,y,q} \Big/ MHI_{i,y,q} \right) * 100.0 \ \% \qquad (45)$$

We have prepared the quarterly output per man-hour index time series with 1967 as the base for national and seasonally unadjusted data from 1955 to 1971 for the industries listed in Appendix B-1.[12]

2.7 Potential Output Per Man-Hour (National), 1967 Base

Potential output per man-hour is an important index and its time series is a derived one. The index is obtained by plotting the output

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[9] Same as for Man-Hours (National). Heading 2.4.

[10] See Man-Hour Index (National), 1967 Base. Heading 2.5.

[11] See Index of Industrial Production (National), 1967 Base. Heading 2.1.

[12] Man-Hour Index (National), 1967 Base and Index of Industrial Production (National), 1967 Base. Headings 2.1 and 2.5.

per man-hour index series[13] over time and then connecting the resultant peaks. This peak to peak graph over time is then the graph of the potential output per man-hour index.

We have prepared the quarterly potential output per man-hour index with 1967 base for national and seasonally unadjusted time series from 1955 to 1971 for the industries listed in Appendix B-1.[14]

2.8 Unemployment Rates

The unemployment rate represents the number unemployed as a percent of civilian labor force.[15]

The data we have consist of national as well as local (for Detroit, Denver, and Milwaukee SMSA's) seasonally unadjusted monthly time series.

The national series are for the years 1948 to 1971. Series for the SMSA's are for the following years.

LIST 3

SMSA	From	To
Detroit	1956	1971
Denver	1958	1971
Milwaukee	1960	1971

SOURCE: The national unemployment rate time series can be obtained from various sources and also directly from the Bureau of Labor Statistics, U.S. Department of Labor. The local series were obtained from the respective state's employment agencies.

The national series are based on monthly household surveys (CPS) and the SMSA series are based, among other things, on the establishment data.

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13 See Man-Hour Index (National), 1967 Base Time Series. Heading 2.5.

14 Same as for Man-Hours (National).

15 For concepts and definitions on employed persons, unemployed persons, civilian labor force, not in labor force, etc., see the Technical Note at the end of any recent issue of Employment and Earnings and Monthly Report on the Labor Force, Bureau of Labor Statistics, U.S. Department of Labor.

The monthly series were converted into quarterly time series for our use.

2.9 Employment (SMSA)

The data on SMSA employment[16] (for Detroit, Denver and Milwaukee SMSAs) in various industries consist of monthly time series roughly from 1956 to 1971. The SMSA employment data, except for the Department of Defense, refer to persons on establishment payrolls who receive pay for any part of the pay period which includes the 12th of the month.[17] For civilian employees of the Department of Defense establishments, the figures represent the number of persons who occupied positions on the last day of the calendar month and intermittent workers are counted if they performed any service during the month.

The data exclude proprietors, self-employed, unpaid family workers, farm workers and domestic workers in the households. Salaried officers of corporations are included. Government employment covers only civilian employees. Federal military personnel are excluded from the estimates of total nonagricultural employment.

Persons on an establishment payroll who are on paid sick leave (when pay is received directly from the firm), on paid holiday or paid vacation, or who work during any part of the pay period and are unemployed or on strike during the rest of the period are counted as employed. Not counted as employed are persons who are laid off, on leave without pay or who are hired but do not report to work during the period.[18]

We have the monthly and the quarterly, seasonally unadjusted time series[19] for the SMSAs' employment for the industries listed in Appendix B-1.

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[16] The SMSA Employment data that we have is for all employees not just for production workers.

[17] This is also true for national employment data.

[18] This definition is taken from the Technical Note at the end of an Employment and Earnings and Monthly Report on the Labor Force.

[19] The time series that we needed were extracted from a magnetic tape (No. 18627-SA 07/71, 3 areas) supplied to us by the Bureau of Labor Statistics, U.S. Department of Labor. (790 aggregate data.) These time series were updated to include the latest year (1971) by using the data supplied by the respective state's employment agency [37]. Also see Employment and Earnings, States and Areas, 1939-1970, Bulletin 1370-8 [34].

The series are for the following years:

LIST 4

SMSA	From	To
Detroit	1956	1971
Denver	1958	1971
Milwaukee	1956	1971

2.10 Labor Turnover[20]

Labor turnover consists of New Hires, Quits and Layoffs and is the gross movement of wage and salary workers into and out of employed status with respect to individual establishments. Each type of action, new hiring, quitting or layoff, is cumulated for a calendar month and expressed as a rate per 100 employees. The data relate to all employees, whether full or part-time, permanent personnel and production workers. Transfers to another establishment of the company are included beginning with January 1959.

The data consist of monthly time series converted into quarterly ones from the year 1955 to 1969 for the national and for different years for different industries for the SMSA's.[21]

All the series are in percent of total establishment employment payroll and are not seasonally adjusted.

2.11 Average Hourly Earnings (National)[22]

The data on average hourly earnings for production, construction or nonsupervisory workers consist of quarterly time series for the years

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20 For manufacturing industries only.

21 The national and the SMSA time series will have to be updated to include the years 1970 and 1971. For national data - Bulletin 1317-7 [35]. For SMSA data - same as SMSA employment.

22 From various series given to us by L. Taylor, Department of Economics, University of Michigan, Ann Arbor, Michigan.

1949 to 1969.[23] Average hourly earnings are on a "gross" basis and are therefore different from wage rates.[24] Earnings are the actual return to the workers for a stated period of time and include the basic hourly and incentive wage rates, premium pay for overtime and late shift work and also the pay for paid sick leave, holidays and vacations. Not included are irregular bonuses, retroactive items, payments of various welfare benefits, payroll taxes paid by employers.

All the series are in dollars per hour per person and are not seasonally adjusted. Average hourly earnings are establishment data.

2.12 Civilian Labor Force (National)

Monthly and quarterly time series for civilian labor force are available for the following race, sex and age groups for the years 1954 to 1972.

LIST 5

Race	White and Non-White.
Sex	Male and Female.
Age	14 years and above, (16 years and above from 1967).
	14 years and 15 years.
	16 years and 17 years.
	18 years and 19 years.
	20 years to 24 years.
	25 years to 34 years.
	35 years to 44 years.
	45 years to 54 years.
	55 years to years, and
	65 years and above.

SOURCE: All the civilian labor force monthly time series were obtained from the Bureau of Labor Statistics, U.S. Department of Labor (Current Population Survey data).

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23 The average hourly earnings time series are to be updated for the years 1970 to 1971.

24 Straight-time average hourly earnings time series are also available from the above source.

The data for 14 years and 15 years age group were not obtained from 1967 to 1972.

All the time series are in thousands of persons and are seasonally unadjusted.

2.13 Civilian Noninstitutional Population (National)

Monthly and quarterly time series for the civilian noninstitutional population are available for the following race, sex and age groups for the years 1954 to 1972.

LIST 6

Race	White and Non-white.
Sex	Male and Female
Age	14 years and above, (16 years and above from 1967)
	14 years and 15 years.
	16 years and 17 years.
	18 years and 19 years.
	20 years to 24 years.
	25 years to 34 years.
	35 years to 44 years.
	45 years to 54 years.
	55 years to 64 years, and
	65 years and above.

SOURCE: All civilian noninstitutional population monthly time series were obtained from the Bureau of Labor Statistics, U.S. Department of Labor (Current Population Survey data).

2.14 Participation Rates (National)[25]

The civilian noninstitutional population participation rate represents the number in civilian labor force as a percent of civilian noninstitutional population. The participation rate is computed in the following manner.

Let CLF_m = the civilian labor force in thousands of persons for a

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25 Civilian Labor Force (National) and Civilian Noninstitutional Population (National).

particular race, sex and age group during the month m,

CNP_m = the civilian noninstitutional population in thousands of persons for the same race, sex and age group during the same month m, and

PRT_m = the participation rate for the same race, sex and age group during the month m,

Then $$PRT_m = \left(CLF_m \Big/ CNP_m \right) * 100.0 \ \% \qquad (46)$$

Monthly and quarterly time series for participation rates for the same race, sex and age groups as civilian labor force or civilian noninstitutional population are available for years 1954 to 1972. All the time series are seasonally unadjusted.

2.15 Miscellaneous Time Series on Labor Force (National)

Monthly and quarterly time series are available for the following data sets. All the time series are seasonally unadjusted and cover the period from 1948, first quarter to 1972, fourth quarter.

LIST 7

1. Total labor force, 16 years and above.
2. Civilian labor force, total, 16 years and above.
3. Civilian labor force, males, 16 years and above.
4. Civilian labor force, females, 16 years and above.
5. Armed forces, total, 16 years and above. (Armed forces, total = Total labor force - Civilian labor force, total).
6. Civilian employment, total, 16 years and above.
7. Total employees in nonagricultural establishments.

SOURCE: All the above time series, except No. 7, were obtained from the Bureau of Labor Statistics, U.S. Department of Labor. Series No. 7 was obtained from Employment and Earnings, United States 1909-70, Bulletin 1312-7 [35].

2.16 Other Variables (From MQEM-Line File)

As mentioned in the introduction, the National Bureau of Economic Research Inc. maintains a huge time series data bank containing hundreds of time series in machine readable form. From this data bank the

Research Seminar in Quantitative Economics (RSQE)[26] have created their own data bank called RSQE-Line File containing the time series required for their use. The following time series that we use in our Econometric model were picked out from this RSQE-Line File. All these time series, unless otherwise stated, are national, quarterly, seasonally adjusted and available from 1954 first quarter to 1972 second quarter. The source for each series is the same as mentioned in the NBER or the RSQE-Line File data bank.

LIST 8

Time Series

1. Gross national product in billions of 1958 dollars.
   SOURCE: Survey of Current Business (CB), Table 1.2.
2. Fixed investment, nonresidential structures in billions of 1958 dollars.
   SOURCE: SCB Table 1.2.
3. Fixed investment, residential structures in billions of 1958 dollars.
   SOURCE: SCB Table 1.2.
4. Government purchases of goods and services in billions of 1958 dollars.
   SOURCE: SCB Table 1.2.
5. Gross national product by major type of product - structures; in billions of dollars.
   SOURCE: SCB Table 1.3.
6. Gross national product by major type of product - goods output; in billions of 1958 dollars.
   SOURCE: SCB Table 1.5.
7. Gross national product by major type of product - services; in billions of 1958 dollars.
   SOURCE: SCB Table 1.5.
8. Gross national product by sector - general government; in billions of 1958 dollars.
   SOURCE: SCB Table 1.8.

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26 Research Seminar in Quantitative Economics, Department of Economics, University of Michigan [40].

Time Series

9. Implicit price deflator for gross national product; 1958 = 100.
   SOURCE: SCB Table 8.1.

10. Implicit price deflator for gross national product by sector - private (business) non-farm; 1958 = 100.
    SOURCE: SCB Table 8.4.

11. Corporate AAA interest rate in per cent.
    SOURCE: Federal Reserve Board (FRB) Bulletin, Bond and Stock Yields.

12. Number of employees on nonagricultural pay rolls, establishment survey; in thousands of persons.
    SOURCE: Business Conditions Digest (BCD), series No. 41.

13. Private non-farm sector - compensation per man-hour; 1967 = 100.
    SOURCE: Employment and Earnings, Table C-10.

14. Private non-farm sector - output per man-hour; 1967 = 100.
    SOURCE: Employment and Earnings, Table C-10.

15. Nonagricultural establishment employment - government (includes government and government enterprise, excludes armed forces); in thousands of persons.
    SOURCE: SCB Blue Pages.

16. Nonagricultural establishment employment, "Regulated"; in thousands of persons. (This series is from 1954, first quarter to 1972, fourth quarter.)
    SOURCE: SCB Blue Pages.
    Note: "Regulated" = Transportation + Communication + Electric, Gas and Sanitary.

17. Nonagricultural establishment employment, trade. (Wholesale and Retail); in thousands of persons. (This series is from 1954, first quarter to 1972, fourth quarter.)
    SOURCE: SCB Blue Pages.

18. Nonagricultural establishment employment, "Service" industries; in thousands of persons. (This series is from 1954, first quarter to 1972, fourth quarter.)

SOURCE: SCB Blue Pages.

Note: "Service" Industries = Services + Finance, Insurance and Real Estate.

APPENDIX B-1

INDUSTRIAL CLASSIFICATION CODES

This Appendix lists the various industries for which we have some of the time series. We have tried to use, as far as we could, the standard two digit SIC Code [26] for industrial classification; but where this was not possible other two digit codes are used. The industries are divided into two groups, 1) Manufacturing and 2) Non-manufacturing. We have the various time series only for those industries listed on page numbers 51 and 52. The other pages are added only to give a more detailed explanation of those non-manufacturing industries that are grouped together under one code.

This is an explanation of industrial classification codes for manufacturing industries.

LIST 9

MANUFACTURING INDUSTRIES	SIC OR OTHER CODE
ALL DURABLES	01*
ALL NON-DURABLES	02*
FOOD & KINDRED PRODUCTS	20
PRIMARY METAL INDUSTRIES	33
FABRICATED METAL PRODUCTS EXCEPT ORDNANCE, MACHINERY, & TRANSPORTATION EQUIPMENT	34
MACHINERY EXCEPT ELECTRICAL	35
ELECTRICAL MACHINERY, EQUIPMENT & SUPPLIES	36
TRANSPORTATION EQUIPMENT	37

*NOTE: These are NOT SIC codes, all others ARE.

Explanation of industrial classification codes for non-manufacturing industries.

LIST 10

NON-MANUFACTURING INDUSTRIES	SIC OR OTHER CODES
MINING & SERVICES	03
CONTRACT CONSTRUCTION	04
TRANSPORTATION, COMMUNICATION, ELECTRIC, GAS & SANITARY SERVICES	05
WHOLESALE TRADE	50*
RETAIL TRADE	06
FINANCE INSURANCE & REAL ESTATE	07
FEDERAL GOVERNMENT	91*
STATE & LOCAL GOVERNMENT	08
WHOLESALE & RETAIL TRADE	95
FEDERAL, STATE & LOCAL GOVERNMENT	96

*NOTE: These are SIC codes, all others ARE NOT.

A more detailed explanation of the non-manufacturing industries is again on the following list.

LIST 11

NON-MANUFACTURING INDUSTRIES		SIC OR OTHER CODE
CONTRACT CONSTRUCTION (DIVISION G) WHICH INCLUDES:		04
BUILDING CONSTRUCTION-GENERAL CONTRACTORS	SIC 15	
CONSTRUCTION OTHER THAN BUILDING CONSTRUCTION-GENERAL CONTRACTORS	SIC 16	
CONSTRUCTION-SPECIAL TRADE CONTRACTORS	SIC 17	
TRANSPORTATION, COMMUNICATION, ELECTRIC, GAS AND SANITARY SERVICES (DIVISION E) WHICH INCLUDES:		05
RAILROAD TRANSPORTATION	SIC 40	
LOCAL & SUBURBAN TRANSIT & INTERURBAN PASSENGER TRANSPORTATION	SIC 41	
MOTOR FREIGHT TRANSPORTATION & WAREHOUSING	SIC 42	

LIST 11 (Cont.)

NON-MANUFACTURING INDUSTRIES		SIC OR OTHER CODE
WATER TRANSPORTATION	SIC 44	
TRANSPORTATION BY AIR	SIC 45	
PIPE-LINE TRANSPORTATION	SIC 46	
TRANSPORTATION SERVICES	SIC 47	
COMMUNICATION	SIC 48	
ELECTRIC, GAS & SANITARY SERVICES	SIC 49	
WHOLESALE TRADE		50
RETAIL TRADE (PARTIAL DIVISION F) WHICH INCLUDES:		06
BUILDING MATERIALS, HARDWARE & FARM EQUIPMENT DEALERS	SIC 52	
RETAIL TRADE-GENERAL MERCHANDISE	SIC 53	
FOOD STORES	SIC 54	
AUTOMOTIVE DEALERS & GASOLINE SERVICE STATIONS	SIC 55	
APPAREL & ACCESSORY STORES	SIC 56	
MINING AND SERVICES		03
MINING (DIVISION B) INCLUDES:		
METAL MINING	SIC 10	
ANTHRACITE MINING	SIC 11	
BITUMINOUS COAL AND LIGNITE MINING	SIC 12	
CRUDE PETROLEUM AND NATURAL GAS	SIC 13	
MINING AND QUARRYING OF NONMETALLIC MINERALS, EXCEPT FUELS	SIC 14	
SERVICE (DIVISION H) INCLUDES:		
HOTELS, ROOMING HOUSES, CAMPS & OTHER LODGING PLACES	SIC 70	
PERSONAL SERVICES	SIC 72	
MISCELLANEOUS BUSINESS SERVICES	SIC 73	
AUTOMOBILE REPAIR, AUTOMOBILE SERVICES, AND GARAGES	SIC 75	
MISCELLANEOUS REPAIR SERVICES	SIC 76	
MOTION PICTURES	SIC 78	

LIST 11 (Cont.)

NON-MANUFACTURING INDUSTRIES		SIC OR OTHER CODE
AMUSEMENT AND RECREATION SERVICES EXCEPT MOTION PICTURES	SIC 79	
MEDICAL & OTHER HEALTH SERVICES	SIC 80	
LEGAL SERVICES	SIC 81	
EDUCATIONAL SERVICES	SIC 82	
MUSEUMS, ART GALLERIES, BOTANICAL & ZOOLOGICAL GARDENS	SIC 84	
NONPROFIT MEMBERSHIP ORGANIZATIONS	SIC 86	
PRIVATE HOUSEHOLDS	SIC 88	
MISCELLANEOUS SERVICES	SIC 89	
FURNITURE, HOME FURNISHINGS & EQUIPMENT STORES	SIC 57	
EATING & DRINKING PLACES	SIC 58	
MISCELLANEOUS RETAIL STORES	SIC 59	
FINANCE, INSURANCE & REAL ESTATE (DIVISION G) WHICH INCLUDES:		07
BANKING	SIC 60	
CREDIT AGENCIES OTHER THAN BANKS	SIC 61	
SECURITY & COMMODITY BROKERS, DEALERS, EXCHANGES & SERVICES	SIC 62	
INSURANCE CARRIERS	SIC 63	
INSURANCE AGENTS, BROKERS & SERVICE	SIC 64	
REAL ESTATE	SIC 65	
COMBINATIONS OF REAL ESTATE, INSURANCE LOANS & LAW OFFICES	SIC 66	
HOLDING AND OTHER INVESTMENT COMPANIES	SIC 67	
FEDERAL GOVERNMENT		91
STATE & LOCAL GOVERNMENT (PARTIAL DIVISION I) WHICH INCLUDES:		08
STATE GOVERNMENT	SIC 92	
LOCAL GOVERNMENT	SIC 93	
WHOLESALE & RETAIL TRADE (DIVISION F)		95
FEDERAL, STATE & LOCAL GOVERNMENT (DIVISION I)		96

APPENDIX C

A Short Guide to the Use of the SOLAMI Simulation Program (Simulation of Labor Market Information)

Shirish C. R. Sanghvi*

3.0 Introduction

The simulation of labor market information is essentially composed of three parts; namely, the data base, the theoretical model together with estimated parameters, and the simulation procedure or the simulation program. In this manual only the simulation program will be described.[1]

The Simulation of Labor Market Information Program (SOLAMI Program) is a highly interactive computer program. It is designed to allow the user to solve a system of equations for the purpose of generating forecasts, policy simulations and performing various other tasks. The system of equations could be an econometric model representing a labor market. In fact, the program allows the user to simulate the behavior of three local labor markets covering the Detroit, Denver, and the Milwaukee Standard Metropolitan Statistical Areas (SMSA). The program, however, is not restricted to these three SMSA's only. It can be used to simulate other labor markets as well, provided that the necessary data base and the theoretical model together with estimated parameters for the system of equations to be solved exist.

The interaction between the user and the program is achieved through a basic set of commands. The user, sitting at a terminal, can enter any one of these commands and have the program perform a specific task. For example, he can specify the SMSA he wishes to simulate, choose the type of simulation he wants to perform - dynamic or quarterly, select the initiating year and quarter from where to begin the simulation, etc.

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1 Appendix B describes the data base used for the model. Volume 1, Chapter IV, Section 4.1 and Appendix A describe the model.

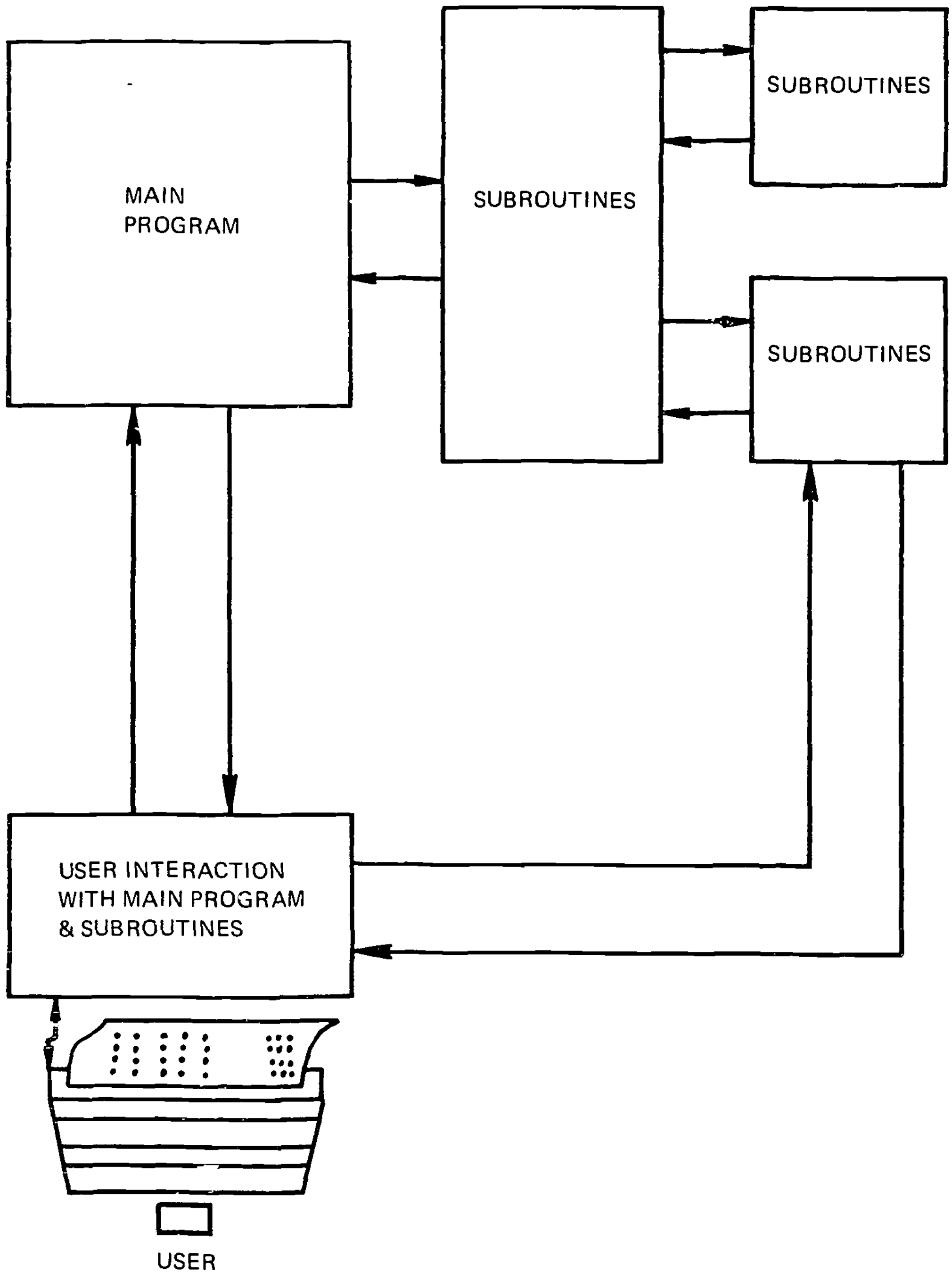
Later, after performing the simulation, he can print the results selectively using the selective printing commands. The program can also be run in batch by putting the appropriate command cards together in the form of a deck. However, it is the highly interactive nature of the program which makes it a very useful tool in studying the various factors and the effects of the changes in these factors on the labor supply and demand in any of the above SMSA's.

The SOLAMI program is written in FORTRAN-IV but uses many Michigan Terminal System (MTS) routines. Hence, at present, it is implementable only under MTS. However, the modification of the program for use under different systems could be made at a modest cost.

Basically the whole program consists of a main program and several subroutines. In general the main program receives a command, calls upon a subroutine to analyze the command, and then depending upon the results of this analysis, calls upon the appropriate subroutine to handle the specific task, like reading the data, printing a variable, doing the computations, etc. Very often a subroutine may also call upon another subroutine to handle some repetitive task. After the specific task is performed by a subroutine the control is returned to the calling program from where it may return back to the user. The operation of the subroutine and the interaction between them is such that to the user it always appears that he is interacting with just one routine, that is, the whole SOLAMI program.

The basic structure of the SOLAMI program is illustrated by the block figure on the following page.

Figure 3 Basic Structure Of The SOLAMI Program



3.1 The Solution Procedure

As mentioned in the introduction, one of the primary functions the SOLAMI program performs is to solve a system of equations representing an econometric model. The econometric model can be one for a local labor market, as it is in our case. The system of equations consists of dependent and independent variables, estimated parameters, and constants. The dependent variables are always endogenous and the independent variables can be either exogenous or endogenous. In order to simplify the solution procedure the program distinguishes two types of endogenous variables; namely, recursive and simultaneous. The recursive endogenous variables depend on their own lagged values, the lagged values of other similar endogenous variables, lagged values of simultaneous variables, exogenous variables, constants and estimated parameters. They can also be dependent on the current values of other recursive variables provided the latter ones are already computed prior to the computation of the variable in question. The simultaneous endogenous variables intrinsically depend on the current values of other similar variables, their own and other similar variables' lagged values, the current and lagged values of recursive variables, exogenous variables and constants and estimated parameters. The exogenous variables and constants are each handled as an individual class. The estimated parameters are classified into labor supply (or simply supply) parameters and labor demand (or simply demand) parameters.

In order to facilitate the solution of the system of equations they must be arranged in an order to confirm the "natural flow". That is to say, the recursive variables which do not depend on the current values of other recursive variables must be solved first. Then those recursive variables which depend on the current values of already computed ones must be solved. Lastly the simultaneous variables are solved. To achieve this purpose the system of equations may often have to be rearranged.

For example, a system of equations, after rearranging, may be as follows:

$$R_1 = C_1 + P_1 + P_2 E_1 + P_3 E_{1_{-1}} + P_4 R_{1_{-2}} + P_5 S_{1_{-1}} \quad \ldots\ldots\ldots\ldots (47)$$

$$R_2 = C_2 + P_6 + P_7 R_1 + P_8 E_2 + P_9 E_{2_{-3}} + P_{10} R_{2_{-3}} \quad \ldots\ldots\ldots\ldots (48)$$

$$R_3 = C_3 + P_{11}E_3 + P_{12}E_4 + P_{13}R_1 + P_{14}R_2 + P_{15}S_{2_{-1}} + P_{16}S_{3_{-2}} \quad \ldots\ldots (49)$$

$$R_4 = C_4 + P_{17}R_1 + P_{18}R_2 + P_{19}R_3 + P_{20}R_{4_{-5}} \quad \ldots\ldots (50)$$

$$S_1 = C_5 + P_{21} + P_{22}S_2 + P_{22}S_{2_{-1}} + P_{23}R_4 + P_{24}E_{4_{-1}} + P_{25}E_5 \quad \ldots\ldots (51)$$

$$S_2 = C_6 + P_{26} + P_{27}S_1 + P_{28}S_{1_{-1}} + P_{29}S_{3_{-2}} + P_{30}E_6 + P_{31}R_3 \quad \ldots\ldots (52)$$

$$S_3 = C_7 + P_{32} + P_{33}S_1 + P_{34}S_2 + P_{35}S_{3_{-1}} + P_{36}E_1 + P_{37}E_{5_{-1}} \quad \ldots\ldots (53)$$

In this system of equations there are:

1) Seven endogenous variables;

   a) four recursive R_1, R_2, R_3, and R_4, and

   b) three simultaneous S_1, S_2, and S_3.

2) Five exogenous variables; namely E_1, E_2, E_3, E_4, and E_5.

3) Thirty-seven estimated parameters P_1 to P_{37}.

4) Seven constants C_1, C_2, C_3, C_4, C_5, C_6, and C_7.

NOTE: The second suffix with a negative sign on recursive, simultaneous and exogenous variables indicates the number of lag periods for those variables. The constants can be used as adjustment constants.

The solution procedure for the system of equations, like the one above, is iterative and proceeds as follows.

Solution of the recursive equations is a two-step procedure.

The first step is to solve those recursive variables which do not depend on the current values of other recursive variables, in terms of C's, P's, and E's and the lagged values of R's and S's. In the example above R_1 would be solved first.

The second step is to solve all the other recursive variables which depend on C's, P's, E's and the lagged values of R's and S's, and also on the current values of other recursive variables solved in the first step. In our example, R_2, R_3, and R_4 would be solved in the second step.

Thus, at the end of the second step all the recursive variables would have been solved.

The simultaneous equations are solved en bloc[2] and iteration may have to be performed on the whole block before a solution can be reached.

The simultaneous variables depend on C's, P's, R's, E's, the lagged values of any of the S's and also on the current values of other S's. Now, if for the current values of the other S's on the right hand side we use their values from the previous period then we have a system of simultaneous equations which can be easily solved. This is exactly what is done in the program. After this first solution set is obtained, the program compares the new value of each of the dependent simultaneous variables with its corresponding old value. If none of the S's has changed by more than a prespecified small amount, the simultaneous block is considered solved. If, however, one or more of the S's is found to have changed by more than the specified small amount, the whole process is repeated and new values for the set of dependent simultaneous variables are obtained. The process continues until no simultaneous variable changes in value from one iteration to the next by more than the specified amount. It should be clear that during the solution of the simultaneous block the recursive block remains unaffected.

The iterative procedure for the solution of the simultaneous block is simple, but is does not guarantee a solution. However, the method seems to work well for realistically formulated models. If no solution is reached within a reasonable number of iterations then the following step can be taken: the equations of the model can be reordered, moving some of the more volatile relationships to the end of the iterative cycle. In this way the values for those S's that are least sensitive to initial conditions are calculated first and then the values for those that are more sensitive. The problem is, therefore, equivalent to whether or not a particular "cobweb" model is convergent or not. For non-linear models the initial starting point can also affect the ability to reach a solution.

In the next section we will discuss how to code the equations properly for use in the SOLAMI program.

3.2 Coding the Equations

The entire model is divided into two parts, the recursive equations part and the simultaneous equations part. Both parts must be coded in FORTRAN IV. The recursive equations are stored in a file called RECUR-CODE and the simultaneous equations are stored in a file called SIMUL-

CODE. The coding procedures and the conventions are as follows.

3.3 Constants

There can be a maximum of 999 different CONSTANTS in the entire model. These CONSTANTS appear on the right hand side of the equations are are coded as CONSTS(j), where j is the CONSTANT number (1 to 999).

3.4 Estimated Parameters

The SOLAMI program differentiates between two different kinds of estimated parameters, namely SUPPLY PARAMETERS and DEMAND PARAMETERS. There can be a maximum of 999 different parameters of each kind in the entire model. The SUPPLY PARAMETERS are coded as SP(j), where j is the SUPPLY PARAMETER number (1 to 999).

3.5 Exogenous Variables

The coding of EXOGENOUS variables is done in a manner different from the above. A lagged EXOGENOUS variable needs two specifications, namely, the number of lag periods for the variable and the variable number. The SOLAMI program allows a maximum of 15 lag periods. The maximum number of different EXOGENOUS variables allowed in the entire model is 99.

When the lag period is between 1 and 15, the EXOGENOUS variables are coded as LE(i,j) where i refers to the length of the lag (between 1 and 15) and j refers to the variable number (1 to 99).

For the current value of the EXOGENOUS VARIABLE no specification for the number of lags is required. The current values of EXOGENOUS variables are therefore coded as CE(j), where j is the variable number (1 to 99).

3.6 Recursive Variables

The program allows a maximum of 99 RECURSIVE variables.

The RECURSIVE variables are computed sequentially in the order in which their coding is arranged. Therefore, those which do not depend on the current value of any other ones (RECURSIVE VARIABLES) must be coded first. After these, those RECURSIVE variables which depend on the current values of already computed ones can be coded. This arrangement must be maintained very strictly, otherwise computed results will be erroneous. Computations for the block of RECURSIVE equations are performed only once for each period of simulation.

The RECURSIVE variables which are to be computed appear on the left hand side of the equation and they denote the current value of the variable. These variables are coded as R(j), where j is the variable number (1 to 99). The current values of RECURSIVE variables which appear on the right-hand side of an equation are similarly coded. (This situation arises when the current value of a RECURSIVE or SIMULTANEOUS variable depends on the current values of other RECURSIVE variables which are already computed).

NOTE: A RECURSIVE variable which is being computed cannot depend on its own current value.

Lagged RECURSIVE variables (like EXOGENOUS ones) need two specifications, one for the number of lag periods for the variable and the other for the variable number. Lagged RECURSIVE variables are, therefore, coded as LR(i,j), where i refers to the length of the lag (between 1 and 15) and j refers to the variable number (1 to 99).

3.7 Simultaneous Variables

A SIMULTANEOUS variable can depend on the current values of other SIMULTANEOUS variables for which the values are not yet computed. Hence, the SIMULTANEOUS variables are computed en bloc. Computations for the whole block are iterated a number of times until the values of the SIMULTANEOUS variables during two successive iterations differ by a certain preset small number (like 0.01 etc.).

The SIMULTANEOUS variables (like EXOGENOUS and RECURSIVE ones) also need two specification; one for the number of lag periods for the variable and the other for the variable number. The lagged simultaneous variables, therefore, are coded as LS(i,j), where i refers to the length of the lag (between 1 and 15) and j refers to the variable number (1 to 99).

The coding procedure for the current value of SIMULTANEOUS variables which appear on the right hand side of a SIMULTANEOUS equation is slightly different than the corresponding procedure for RECURSIVE variables. The current SIMULTANEOUS variables on the right hand side are coded as CS(j), where j is the variable number (1 to 99).

Standard FORTRAN functions (like EXP, ALOG, SQRT, etc.) can be used anywhere in the coding of equations following the FORTRAN procedures.

A summary of the coding indices and procedure follows.

3.8 Summary of Coding Indices

CONSTS(j)	for coding CONSTANTS. j is the CONSTANT number (1 to 999).
SP(j)	for coding SUPPLY PARAMETERS. j is the SUPPLY PARAMETER number (1 to 999).
DP(j)	for coding DEMAND PARAMETERS. j is the DEMAND PARAMETER number (1 to 999)
CE(j)	for coding current value of EXOGENOUS variables. j refers to the variable number (1 to 99).
LE(i,j)	for coding lagged EXOGENOUS variables. i refers to the number of lag periods (1 to 15) and j refers to the variable number (1 to 99)
R(j)	for coding the current value of a RECURSIVE variable to be computed and appearing on the left hand side of an equation. j is the variable number (1 to 99).
R(j)	for coding the current value of a RECURSIVE variable on the right hand side of an equation. j is the variable number (1 to 99). R(j) must have already been computed somewhere in the block of RECURSIVE equations before it can be used in the right hand side of an equation.
LR(i,j)	for coding a lagged RECURSIVE variable. i refers to the number of lag periods (1 to 15) and j refers to the variable number (1 to 99).
S(j)	for coding the current value of a SIMULTANEOUS variable to be computed and appearing on the left hand side of an equation. j is the variable number (1 to 99).
CS(j)	for coding current value of a SIMULTANEOUS variable appearing on the right hand side of an equation. j is the variable number (1 to 99).
LS(i,j)	for coding a lagged SIMULTANEOUS variable. i refers to the number of lag periods (1 to 15) and j refers to the variable number (1 to 99).

3.9 Examples of Coding the Equations

Let us now look at examples of coding the equations for use in the SOLAMI program.

In the system of seven equations in section 3.1 there are:

i. four recursive variables R_1 to R_4,

ii. three simultaneous variables S_1 to S_3,

iii. five exogenous variables E_1 to E_5,

iv. thirty-seven estimated parameters P_1 to P_{37}, and,

v. se[illegible] constants C_1 to C_7.

Of the thirty-seven estimated parameters let us assume that the first fifteen (P_1 to P_{15}) are demand parameters and the remaining twenty-two (P_{16} to P_{37}) are supply parameters. Then the seven equations should be coded as:

```
R(1) = CONSTS(1) + DP(1) + DP(2) * CE(1) + DP(3) * LE(1,1) + DP(4)
     * LR(2,1) + DP(5) * LS(1,1). . . . . . . . . . . . . . . . . . . (54)

R(2) = CONSTS(2) + DP(6) + DP(7) * R(1) + DP(8) * CE(2) + DP(9)
     * LE(3,2) + DP(10) * LR(3,2) . . . . . . . . . . . . . . . . . . (55)

R(3) = CONSTS(3) + DP(11) * CE(3) + DP(12) * CE(4) + DP(13) * R(1)
     + DP(14) * R(2) + DP(15) * LS(1,2) + SP(1) * LS(2,3) . . . . . (56)

R(4) = CONSTS(4) + SP(2) * R(1) + SP(3) * R(2) + SP(4) * R(3)
     + SP(5) * LR(5,4) . . . . . . . . . . . . . . . . . . . . . . . .(57)

S(1) = CONSTS(5) + SP(6) + SP(7) * CS(2) + SP(7) * LS(1,2) + SP(8)
     * R(4) + SP(9) * LE(1,4) + SP(10) * CE(5) . . . . . . . . . . .(58)

S(2) = CONSTS(6) + SP(11) + SP(12) * CS(1) + SP(13) * LS(1,1)
     + SP(14) * LS(2,3) + SP(15) * CE(6) + SP(16) * R(3) . . . . . .(59)

S(3) = CONSTS(7) + SP(17) + SP(18) * CS(1) + SP(19) * CS(2)
     + SP(20) * LS(1,3) + SP(21) * CE(1) + SP(22) * LE(1,5) . . . . (60)
```

In the SOLAMI program since the econometric model deals with labor supply and demand we have differeniated between the parameters estimated for labor supply equations (SP's) and those estimated for labor demand equations (DP's). The user, however, has to have his own conventions as regards to what the recursive variables (R's and LR's), the simultaneous variables (S's, CS's, and LS's), the exogenous variables (CE's and LE's) and the constants (C's) represent in his econometric model.

A listing of the coded equations used for the sample run (see the section on SIMULATION for this) is given in Appendix C-1.

3.10 File Organization

The SOLAMI program reads the data it needs for simulation from one of three files stored in the computer. The data for the DETROIT SMSA are stored in the file DT, and those for DENVER and MILWAUKEE SMSA's are stored in the files DN and ML respectively. The organization of these files is an important aspect of the use of SOLAMI program. They must be set up correctly in a certain sequence.

All the three files DT, DN, and ML are MTS line files and are similarly organized as explained below.

(NOTE: In the explanation given below x is any digit. All the lines in the file start from column number one. All the formats refer to standard FORTRAN formats).

All the files must be organized in the following sequence.

1. xxx the first line in the file should be line number (in I3 format from where the main body of data starts.
2. xx the second line in the file should be the number of maximum lag periods in (I2 format) in the model. Maximum number of lag periods allowed in the model is 15.
3. xx the third line in the file is the number of industries (in I2 format) being simulated. In the present version we do not use this information, hence it must be set to 00.
4. xxx the fourth line in the file is the number of different constants (in I3 format) in the model. Maximum number of constants allowed in the model is 999.
5. The next several lines in the file should contain values of the various constants used (in 10 (F8.0) format). If there are no constants

then these lines need not be present and the preceding line must be 0 (zero).

6. xxx this line (the one after the lines containing the values of the constants, if there are any) is the number of demand parameters (in I3 format) in the model. The model allows a maximum number of 999 demand parameters.

7. The next several lines should contain the values of the various demand parameters used (in 10 (F8.0)[3] format). If there are no demand parameters then these lines should be omitted and the preceding line must be 0 (zero).

8. xxx this line (the one after the lines containing the values of the demand parameters, if there are any) is the number of supply parameters in the model. A maximum of 999 supply parameters can be used in the model.

9. The next several lines again should contain the values of the various supply parameters used (in 10 (F8.0)[3] format). If there are no supply parameters then these lines must be omitted and the preceding line must be 0 (zero).

10. xxxx.x this line contains the value of last year (in F6.1 format) of recursive and simultaneous data that will be stored in the file.

11. xx,xx,xx,xx this line contains the values of four variables (in 4(I2,1X) format).

i. The first value is the number of exogenous variables in the model. There can be a maximum of 99 exogenous variables.

ii. The second value is the number of recursive variables in the model. Maximum number of recursive variables allowed is 99.

iii. The third value is the number of simultaneous variables in the model. The model can handle a maximum of 99 simultaneous variables.

iv. The fourth value is the total number of lines (or data cards) in each segment (see below) which contain the period specification and the values of exogenous, recursive and simultaneous variables for that period.

From the next line starts the main body of data. It is this line number which should be entered in the first line in the file (see 1 above).

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3 See the footnote on page 67.

The main body of data is organized in segments, each segment containing the values of exogenous, recursive and simultaneous variables for one period. Further, the segments are organized backwards, that is, the latest period first, the second latest period next and so on. These segments are organized as follows.

12. xxxx.x the first line in the segment is the period (in F6.1 format) for which the values of exogenous, recursive and simultaneous variables are stored in the segment.

13. The lines after this contain the values of exogenous variables (in 10(F8.0)[4] format) for the above period.

14. After these are stored values of recursive variables (again in 10 (F8.0)[4] format) for the same period.

15. Lastly are the lines for the values of simultaneous variables (in 10 (F8.0)[4] format again) for the same period.

NOTE: Any line in the segment should contain values for variables of one type only.

The organization of all the segments is done in the same manner until the end of the file is reached.

NOTE: The file must not contain any fractional or negative line numbers.

The total number of lines for 12, 13, 14, and 15 is the figure which is entered for the total number of lines for each segment in (11,iv) above.

A complete listing of the data file for the Detroit SMSA used for the sample run (see the section on SIMULATION for this) is given in Appendix C-2.

3.11 Description of Commands

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[4] In spite of the format specification being 10(F8.0), each of the ten (or less) data items in a line can be entered in a different F format. The only requirement is that each entry must be within fields of 8 and must contain a decimal point and a sign if required. That is, the first entry in a line must be within the first eight columns and must contain a decimal point somewhere within those columns and a sign at the beginning if required. Similarly the second entry with its decimal point (and sign, if required) can be in the next eight columns and so on.

The SOLAMI program permits considerable interaction between the user and the simulation program through a set of commands. Each command performs a specific task. In the interaction mode, a command should be entered only after the probe character, a question mark (?), is printed on the terminal. This means that the simulation program is ready to receive a command. Many of the commands operate in two stages. That is, after a particular command is entered it may be necessary to supply further information to complete its execution. The operation of such commands will become clear when they are fully explained later on. In many cases, after a command is entered, instructions on how to proceed from there will be automatically printed. In other cases the command HELP can be entered to obtain further information.

Basically there are two sets of commands. First of all, there are commands which can be entered any time after the SMSA to be simulated and the period from which the simulation is to be begun are defined, but before performing any simulation of the model. These commands primarily permit the user to print and/or change the values of various constants, parameters and variables used, and it initiate the simulation. Secondly, there are commands which permit the user, after a simulation for at least one period is done, to obtain a selective printing of the results and error statistics, to obtain a status on the number of periods simulated and to terminate the simulation. However, if the user enters a command incorrectly a message to that effect will be printed and he can then enter the correct command.

All the presently available commands are described below.

In the commands the parenthesized letter(s) can be used as an abbreviation of the corresponding word. The other words must be used as they are. There must not be any blank(s) embedded in a command word. Unless otherwise stated, the maximum length of the total command can be up to 80 characters and there can be one or more blanks at the beginning or at the end of a command word or in between two command words. Commands which must be entered in a specified format must follow that format otherwise error will result.

COMMANDS WHICH CAN BE USED BEFORE THE MODEL IS SIMULATED FOR AT LEAST ONE PERIOD BUT AFTER THE SMSA TO BE SIMULATED AND THE PERIOD FROM WHICH THE SIMULATION IS TO BE BEGUN ARE DEFINED.

1. (P)RINT (COM)MANDS - This command is used to print a list of the commands presently available in SOLAMI.
2. (P)RINT (EXP)LANATION - This command is used to obtain a print-out of a short explanation of the SOLAMI model.
3. (P)RINT (IND)USTRIES - This command is used to print a list of the industries simulated.
4. (P)RINT NITER - This command prints the Number of ITERations for which computations of simultaneous equations are carried out to achieve convergence.
5. (P)RINT CONCRI - This prints the CONvergence CRIterion for simultaneous equations.
6. (P)RINT EVAR or (P)RINT EXOGENOUS - This command allows the user to print the values of Exogenous VARiables. (Also see the NOTE at the end of (P)RINT SVAR command).
7. (P)RINT RVAR or (P)RINT RECURSIVE - This command is similar to the above command and allows the user to print the values of Recursive VARiables. (Also see the NOTE at the end of (P)RINT SVAR command).
8. (P)RINT SVAR or (P)RINT SIMULTANEOUS - This command is similar to the above two commands and allows the user to print the values of Simultaneous VARiables. (See the NOTE below).

<u>NOTE:</u> The above three commands, nos. 6, 7 and 8, operate in two stages. After any one of these commands is entered, the SOLAMI program asks the user to enter further information on the number of the variable to be printed and the periods for which it is to be printed. This information is entered in the form VARNO, YRQU1, YRQU2 where:

VARNO = the variable number whose values are to be printed, in I2 format.

YQ1 = the year and quarter, in F6.1 format, beginning which the values are to be printed.

YQ2 = the year and quarter, in F6.1 format, up to and including which the values are to be printed.

VARNO, YQ1 and YQ2 must be separated by a comma (,) or a dash (-).

After the values of the variables are printed, a new specification for VARNO,YQ1,YQ2 can be entered. When no more variables are to be printed the command (ST)OP must be entered to return control to the mode where other commands can be entered.

9. (P)RINT DPAR or (P)RINT DEMAND-PARAS - This command is not implemented in the present version of SOLAMI.

10. (P)RINT SPAR or (P)RINT SUPPLY-PARAS - This command also is not implemented at present.

11. (P)RINT (CONS)TANTS - This allows the user to print the values of various constants used. If the user wants to print another list of constants then this command has to be reentered.

12. (C)HANGE NITER - By using this command the user can Change the Number of ITERations for which computations of simultaneous equations are carried out to achieve convergence.

13. (C)HANGE CONCRI - This command is used to change the CONvergence CRIterion for simultaneous equations.

14. (C)HANGE EVAR or (C)HANGE EXOGENOUS - This permits the user to change the value of any Exogenous VARiable. (Also see the NOTE at the end of (C)HANGE SVAR command).

15. (C)HANGE RVAR or (C)HANGE RECURSIVE - This command is similar to the above one and allows the user to change the value of any Recursive VARiable. (Also see the NOTE at the end of (C)HANGE SVAR command).

16. (C)HANGE SVAR or (C)HANGE SIMULTANEOUS - This command is similar to the above two commands and is used to change the value of any Simultaneous VARiable. (See the NOTE below).

NOTE: Like the corresponding PRINT commands the above three commands, nos. 14, 15 and 16, operate in two stages. After any one of these commands is entered, the SOLAMI program asks the user to enter further information on the variable number, the period for which it is to be changed and its new value. This information is entered in the form VARNO,YRQU,NUVAL, where

VARNO = the variable number whose value is to be changed, in I2 format,

YRQU = the year and quarter in F6.1 format for which the value of the variable is to be changed,

NUVAL = new value of the variable. This value must be within eleven columns and must contain a decimal point and if necessary a sign also.

VARNO,YRQU and NUVAL must be separated by a comma (,) or a dash (-).

After the value of the variable in question is changed a message to that effect will be printed out. Further variables can be changed after this. When no more variables are to be changed the command (ST)OP must be entered to return control to the mode where other commands can be entered.

17. (C)HANGE DPAR or (C)HANGE DEMAND-PARAS - This command is not implemented in the present version of SOLAMI.
18. (C)HANGE SPAR or (C)HANGE SUPPLY-PARAS - This command is also not implemented in this version of SOLAMI.
19. (C)HANGE (CONS)TANTS - This command permits the user to change the value of any constant. After this command is entered the program will ask the user to enter the number of the constant whose value is to be changed and its new value. These must be entered in the form CNO,NUVAL where:

    CNO = number of the constant to be changed,

    NUVAL = new value of the constant. This value must be within eleven columns and must contain a decimal point and, if necessary, a sign also.

    CNO and NUVAL must be separated by a comma (,) or a dash (-).

    After the old value of the constant is replaced with its new value, a message to that effect will be printed. More constants can then be changed. When no more constants are to be changed the command (ST)OP must be entered to return control to the mode where other commands can be entered.
20. (S)IMULATE (DYN)AMICALLY - By this command the user can initiate a dynamic simulation run. In this type of run, predicted values of recursive and simultaneous variables are used for their lags during simulation.
21. (S)IMULATE QRT or (S)IMULATE QUARTERLY - This allows the user to initiate a quarterly simulation run. In a quarterly simulation run, the actual values of recursive and simultaneous variables are used for their lags during simulation.
22. (S)IMULATE (RES)IDUAL or (S)IMULATE RESIDUAL-RUN - This command is not implemented in the present version of the program.
23. (H)ELP - This is a very useful command and it can be entered at various stages in the program. When entered, it prints for the user the necessary information or a short explanation on what he

should do next.

24. (M)TS - By this command the user can return control to the Michigan Terminal System (MTS) without suspending the SOLAMI program. While in MTS the user can use the various MTS commands. However, at this stage no other programs can be run. To return control back to the SOLAMI program the command RESTART must be entered.
25. (R)ERUN - This allows the user to stop the present run and rerun the simulation for the same or some other SMSA.
26. (T)ERMINATE - This command terminates the present simulation run and returns control permanently to MTS.

COMMANDS WHICH CAN BE USED AFTER THE MODEL IS SIMULATED FOR AT LEAST ONE PERIOD.

27. (P)RINT (R)ESULTS 1969.1 1969.3 1968.4 etc. This command is used for printing complete simulation results for the periods specified. There must be at least one blank between two consecutive periods. The order in which periods are entered is unimportant but their maximum number should not exceed eight. The results for all the periods simulated will be printed if their specification is completely omitted from the command.
28. (P)RINT (S)UMMARY 1969.1 1968.4 1971.3 etc. - This command is not implemented for this version of SOLAMI.
29. (P)RINT (STAT)ISTICS - This allows the user to print the statistics for residuals of recursive and simultaneous variables. After this command is entered the program will ask the user to specify the type and the number(s) of the variable(s) for which the statistics are to be printed. This specification must be entered in the form VARTYP,VARNO1,VARNO2 where:

VARTYP = RVAR for recursive variable,
= SVAR for simultaneous variable,
VARNO1 = the variable number, in I2 format, starting which the statistics are to be printed, and
VARNO2 = the variable number, in I2 format, up to and including which the statistics are to be printed.

VARTYP, VARNO1 and VARNO2 must be separated by a comma (,) or a dash (-).

After the statistics are printed a new specification for VARTYP, VARN01 and VARN02 can be entered. When no more statistics are to be printed the command (ST)OP must be entered. This will return the program control to the mode where other selective printing commands can be entered.

30. (S)IMULATE - This command enables the user to simulate the model further. The simulation mode will be the same (dynamic or quarterly) as it was when the present run was initiated.
31. (ST)OP - This command has been described above as the one which enables the user to stop a procedure. But in the case where it is used as a selective printing command, it will stop the present run and prepare the model for a new simulation run, either for the same SMSA or a new SMSA, without terminating the SOLAMI program.
32. STATUS - This prints the simulation status of the model, that is, the number of periods simulation so far and the present simulation mode.
33. (H)ELP - Same as (H)ELP above. (See command number 23).
34. (M)TS - Same as (M)TS above. (See command number 24).
35. (R)ERUN - Same as (R)ERUN above. (See command number 25).
36. (T)ERMINATE - Same as (T)ERMINATE above. (See command number 26).

A sample run demonstrating the use of all the above commands is included in the section on Simulation.

3.12 Summary List Of Commands

We give below a summary list of the commands presently available in SOLAMI.

The parenthesized letter(s) can be used as an abbreviation of the corresponding word.

Command numbers one to twenty-six can be successfully used after the SMSA that is to be simulated and the period from where simulation is to be started are defined. Command numbers twenty-seven to thirty-six, which are for selective printing of results can be successfully used only after the model is simulated for at least one period. Remember that a command entered at a wrong time will come back with a diagnostic like "**ILLEGAL COMMAND.TRY AGAIN**" without interrupting the simulation.

The probe character for SOLAMI is a question mark (?). So the command should be entered only after this question mark (?) is printed on the terminal. The maximum length of the total command should not exceed 80 characters and there must not be any blank(s) embedded in a command word. However, in between any two words or at the beginning or at the end of a word, there can be one or more blanks.

COMMANDS

1. (P)RINT (COM)MANDS
2. (P)RINT (EXP)LANATION
3. (P)RINT (IND)USTRIES
4. (P)RINT NITER
5. (P)RINT CONCRI
6. (P)RINT EVAR or (P)RINT EXOGENOUS
7. (P)RINT RVAR or (P)RINT RECURSIVE
8. (P)RINT SVAR or (P)RINT SIMULTANEOUS
9. (P)RINT DPAR or (P)RINT DEMAND-PARAS[5]
10. (P)RINT SPAR or (P)RINT SUPPLY-PARAS[5]
11. (P)RINT (CONS)TANTS
12. (C)HANGE NITER
13. (C)HANGE CONCRI
14. (C)HANGE EVAR or (C)HANGE EXOGENOUS
15. (C)HANGE RVAR or (C)HANGE RECURSIVE
16. (C)HANGE SVAR or (C)HANGE SIMULTANEOUS
17. (C)HANGE DPAR or (C)HANGE DEMAND-PARAS[5]
18. (C)HANGE SPAR or (C)HANGE SUPPLY-PARAS[5]
19. (C)HANGE (CONS)TANTS
20. (S)IMULATE (DYN)AMICALLY
21. (S)IMULATE QRT or (S)IMULATE QUARTERLY
22. (S)IMULATE (RES)IDUAL or (S)IMULATE RESIDUAL-RUN
23. (H)ELP
24. (M)TS
25. (R)ERUN
26. (T)ERMINATE

The following commands can be used only after the model is simulated for at least one period. In command numbers twenty-seven and twenty-eight

[5] These commands are not implemented in the present version of SOLAMI.

there must be at least one blank between two consecutive period specifications. The periods specification can be in any order. The results for all the simulation periods will be printed if their specification is completely omitted.

27. (P)RINT (R)ESULTS 1969.1 1969.3 1968.4 etc.
28. (P)RINT (S)UMMARY 1969.1 1968.3 1970.1 etc.
29. (P)RINT (STAT)ISTICS
30. (S)IMULATE
31. (ST)OP
32. STATUS
33. (H)ELP
34. (M)TS
35. (R)ERUN
36. (T)ERMINATE

3.13 Running the Model

Selection of a Terminal

The SOLAMI program, at present, has to be run on the University of Michigan IBM/360 computer with a 118 character terminal.

In case of any questions or difficulties the user should contact the author at the following address:

Meredith LaVoie
Institute of Labor and Industrial Relations
The University of Michigan
Ann Arbor, Michigan 48103
Phone: (313) 763-1118

Signon Procedure

The U of M computing center has a 24-hour status of MTS (Michigan Terminal System) information service which gives a recorded message on whether the system is "up" or "down". The phone number for obtaining this information is (313) 763-0420.

For signing on MTS through a terminal, use any one of the following phone numbers:

Via MEMOREX 2780 - (313) 763-0300. If you use this number then type in "go" after the connection is established. When asked "WHO ARE YOU?" you should reply with two carriage returns.

Via the data concentrator - (313) 763-1500

It is assumed that before the user actually runs the SOLAMI program he would have created all the necessary data files.

After response from the computer, signon with your ID and the password and type in:

$SOURCE SAWV:SOLAMI

(See Figure 4 on the next page).

3.14 Simulation

We explain in this section the simulation process and the working of the SOLAMI program. The simulation process is explained with the help of an actual session on a terminal and the printout from this session is given on the following pages. On the printout all the inputs from the user are in lower case letters and all the outputs from SOLAMI are in upper case letters. The explanations added by the author are given in a different type and are enclosed within parentheses.

For this actual simulation session, the data from Detroit SMSA are used. Since there are several ways in which the simulation can be done, this example should be thought of as an illustration of the simulation program only and not as our best predictions of the labor market of Detroit.

Figure 4 Instructions For Signing On The Computer

Dial the number

```
%LC10:2741
  MTS : ANN ARBOR (NC09-0068)
```

```
# sig xyzt
```

Sign on with your ID

```
# ENTER USER PASSWORD.
```

Enter your PASSWORD

```
# **LAST SIGNON WAS: 11:41.19      12-18-72
#    USER "XYZT" SIGNED ON AT    13:14.23 ON 12-18-72
```

```
# so sawv:solami
```

Enter the command
Source SAWV:SOLAMI
or
SO SAWV:SOLAMI

```
# $SET ECHO=OFF
  EXECUTION BEGINS

     *****SIMULATION OF LABOR MARKET INFORMATION*****

     **ENTER THE SMSA CODE (FOR INFORMATION TYPE – HELP)**
  ? (Enter the SMSA code)
```

Continue with the simulation.

NOTE: Computer responses are in capital letters. The user responses are in small letters.

APPENDIX C-1

LISTING OF RECURCODE AND SIMULCODE

LISTING OF CODED EQUATIONS

The following is a listing of recursive equations used for the sample run of SOLAMI for the Detroit SMSA.

```
C        P*D
          R(1)=EXP(CONSTS(1)+DP(1)+DP(2)*ALOG(CE(17)+32.0)+
         &DP(3)*ALOG(CE(9))+DP(4)*ALOG(CE(3))+
         &DP(5)*0.25*(ALOG(CE(19))+ALOG(LE(1,19))+ALOG(LE(2,19))+
         &ALOG(LE(3,19)))+DP(6)*ALOG(LR(1,1))+DP(7)*ALOG(LR(2,1)))
         &+CONSTS(2)
C          P*ND
          R(2)=EXP(CONSTS(3)+DP(8)+DP(9)*ALOG(CE(17)+32.0)+
         &DP(10)*ALOG(CE(9))+
         &DP(11)*0.25*(ALOG(CE(8))+ALOG(LE(1,8))+ALOG(LE(2,8))
         &+ALOG(LE(3,8)))
         &+DP(12)*0.25*(ALOG(CE(19))+ALOG(LE(1,19))+ALOG(LE(2,19))+
         &ALOG(LE(3,19)))+
         &DP(13)*ALOG(LR(1,2))+DP(14)*ALOG(LR(2,2)))+CONSTS(4)
C         PM1617
          R(3)=(CONSTS(5)+SP(1))*LR(1,3)
C         PM1819
          R(4)=(CONSTS(6)+SP(2))*LR(1,4)
C         PM2054
          R(5)=(CONSTS(7)+SP(3))*LR(1,5)
C         PM5564
          R(6)=(CONSTS(8)+SP(4))*LR(1,6)
C         PMG65
          R(7)=(CONSTS(9)+SP(5))*LR(1,7)
C         PF1617
          R(8)=(CONSTS(10)+SP(6))*LR(1,8)
C         PF1819
          R(9)=(CONSTS(11)+SP(7))*LR(1,9)
C         PF2044
          R(10)=(CONSTS(12)+SP(8))*LR(1,10)
C         PF4564
          R(11)=(CONSTS(13)+SP(9))*LR(1,11)
C         PFG65
          R(12)=(CONSTS(14)+SP(10))*LR(1,12)
C         PTG16
          R(13)=((R(3)+R(4)+R(5)+R(6)+R(7)+R(8)+R(9)+R(10)+R(11)+R(12))/1.00)
         &+CONSTS(15)
C         LRM1617
          R(14)=((CONSTS(16)+SP(11))+SP(12)*CE(18)+(CONSTS(17)+SP(13))*
         &ALOG10(CE(17))+SP(14)*CE(1)+SP(15)*CE(2)+SP(16)*CE(3)+SP(17)*
         &(LE(1,20)/LR(1,13))*100.0+SP(18)*LR(1,14))
```

```
C     LRM1819
      R(15)=(CONSTS(18)+SP(19))+SP(20)*CE(18)+(CONSTS(19)+SP(21))
     &*ALOG10(CE(17))+SP(22)*CE(1)+SP(23)*CE(2)+SP(24)*CE(3)+SP(25)*
     &(LE(1,20)/LR(1,13))*100.0+SP(26)*LR(1,15)
C     LRM2054
      R(16)=(CONSTS(20)+SP(27))+SP(28)*CE(18)+(CONSTS(21)+SP(29))*
     &ALOG10(CE(17))+SP(30)*CE(1)+SP(31)*CE(2)+SP(32)*CE(3)+SP(33)*
     &(LE(1,20)/LR(1,13))*100.0+SP(34)*LR(1,16)
C     LRM5564
      R(17)=(CONSTS(22)+SP(35))+SP(36)*CE(18)+(CONSTS(23)+SP(37))*
     &ALOG10(CE(17))+SP(38)*CE(1)+SP(39)*CE(2)+SP(40)*CE(3)+SP(41)*
     &(LE(1,20)/LR(1,13))*100.0+SP(42)*LR(1,17)
C     LRMG65
      R(18)=(CONSTS(24)+SP(43))+SP(44)*CE(18)+(CONSTS(25)+SP(45))*
     &ALOG10(CE(17))+SP(46)*CE(1)+SP(47)*CE(2)+SP(48)*CE(3)+SP(49)*
     &(LE(1,20)/LR(1,13))*100.0+SP(50)*LR(1,18)
C     LRF1617
      R(19)=(CONSTS(26)+SP(51))+SP(52)*CE(18)+(CONSTS(27)+SP(53))*
     &ALOG10(CE(17))+SP(54)*CE(1)+SP(55)*CE(2)+SP(56)*CE(3)+SP(57)*
     &(LE(1,20)/LR(1,13))*100.0+SP(58)*LR(1,19)
C     LRF1819
      R(20)=(CONSTS(28)+SP(59))+SP(60)*CE(18)+(CONSTS(29)+SP(61))*
     &ALOG10(CE(17))+SP(62)*CE(1)+SP(63)*CE(2)+SP(64)*CE(3)+SP(65)*
     &(LE(1,20)/LR(1,13))*100.0+SP(66)*LR(1,20)
C     LRF2044
      R(21)=(CONSTS(30)+SP(67))+SP(68)*CE(18)+(CONSTS(31)+SP(69))*
     &ALOG10(CE(17))+SP(70)*CE(1)+SP(71)*CE(2)+SP(72)*CE(3)+SP(73)*
     &(LE(1,20)/LR(1,13))*100.0+SP(74)*LR(1,21)
C     LRF4564
      R(22)=(CONSTS(32)+SP(75))+SP(76)*CE(18)+(CONSTS(33)+SP(77))*
     &ALOG10(CE(17))+SP(78)*CE(1)+SP(79)*CE(2)+SP(80)*CE(3)+SP(81)*
     &(LE(1,20)/LR(1,13))*100.0+SP(82)*LR(1,22)
C     LRFG65
      R(23)=(CONSTS(34)+SP(83))+SP(84)*CE(18)+(CONSTS(35)+SP(85))*
     &ALOG10(CE(17))+SP(86)*CE(1)+SP(87)*CE(2)+SP(88)*CE(3)+SP(89)*
     &(LE(1,20)/LR(1,13))*100.0+SP(90)*LR(1,23)
C     LFT
      R(24)=((R(3)*R(14)+R(4)*R(15)+R(5)*R(16)+R(6)*R(17)+R(7)*R(18)+
     &R(8)*R(19)+R(9)*R(20)+R(10)*R(21)+R(11)*R(22)+R(12)*R(23))/100.0)+
     &CONSTS(36)
```

END OF RECURCODE

The following is a listing of simultaneous equations used for the sample run of SOLAMI for the Detroit SMSA.

```
C        EM01
          S(1)=EXP(DP(15)+DP(16)*CE(1)+DP(17)*CE(2)+DP(18)*CE(3)+DP(19)*
         &ALOG(CE(4)/LE(1,4))+DP(20)*ALOG(R(1)/LR(1,1))+DP(21)*
         &ALOG((LR(1,1)*LS(1,1))/(LE(1,4)*(1.0+CONSTS(49))))
         &+1.0*ALOG(LS(1,1)))+CONSTS(37)
C        EM02
          S(2)=EXP(DP(22)+DP(23)*CE(1)+DP(24)*CE(2)+DP(25)*CE(3)+DP(26)*
         &ALOG(CE(5)/LE(1,5))+DP(27)*(CE(21)-LE(1,21))+DP(28)*
         &ALOG(R(2)/LR(1,2))+DP(28)*ALOG(CE(7)/LE(1,7))+DP(29)*
         &ALOG((LR(1,2)*LS(1,2))/(LE(1,5)*(1.0+CONSTS(49))))
         &+DP(29)*ALOG(LE(1,7))+1.0*ALOG(LS(1,2)))+CONSTS(38)
C        EMT
          S(3)=CS(1)+CS(2)+CONSTS(39)
C        ENM0307
          S(4)=EXP(DP(30)+DP(31)*CE(1)+DP(32)*CE(2)+DP(33)*CE(3)+DP(34)*
         &ALOG(CS(9))+DP(35)*ALOG(CE(12))+DP(36)*ALOG(LS(1,4)))+CONSTS(40)
C        ENM05
          S(5)=EXP(DP(37)+DP(38)*CE(1)+DP(39)*CE(2)+DP(40)*CE(3)+(DP(41)+
         &DP(42)*(CE(13)/CE(14)))*ALOG(CS(9))+DP(43)*ALOG(LS(1,5)))+
         &CONSTS(41)
C        ENM95
          S(6)=EXP(DP(44)+DP(45)*CE(1)+DP(46)*CE(2)+DP(47)*CE(3)+(DP(48)+
         &DP(49)*(CS(9)/CE(14)))*ALOG(CE(15))+DP(50)*ALOG(LS(1,6)))
         &+CONSTS(42)
C        ENM96
          S(7)=EXP(DP(51)+DP(52)*CE(1)+DP(53)*CE(2)+DP(54)*CE(3)+DP(55)*
         &ALOG(CS(9))+DP(56)*ALOG(CE(16))+DP(57)*ALOG(LS(1,7)))+CONSTS(43)
C        ENM04
          S(8)=EXP(DP(58)+DP(59)*CE(1)+DP(60)*CE(2)+DP(61)*CE(3)+(DP(62)+
         &DP(63)*((CE(11)/CE(10))+CONSTS(50)))*ALOG(CS(9))
         &+DP(64)*ALOG(LS(1,8))+DP(65)*CE(23))+CONSTS(44)
C        ETOTDT
          S(9)=CS(3)+CS(4)+CS(5)+CS(6)+CS(7)+CS(8)+CONSTS(45)
         & +CE(24)
C        EDT-HOUSEHOLD
          S(10)=((CS(9)-CE(24))/CE(22))*(1.0-CONSTS(46))+CONSTS(46)*(CS(9)+
         &CONSTS(47))
C        URDT-LMIS
          S(11)=((R(24)-CS(10))/R(24))*100.0*(1.0-CONSTS(48))+
         &CONSTS(48)*CE(21)
C        LFDT-LMIS NO. 2
          S(12)=CONSTS(48)*(CS(10)/(1.0-(CE(21)/100.0)))
```

END OF SIMULCODE

APPENDIX C-2

LISTING OF THE DATA FILE DT USED FOR SIMULATING THE DETROIT SMSA

```
1   030  (Line number from where the main body of data starts)
2   03  (Number of maximum lag periods in the model)
3   00  (Number of industries being simulated.  Since this is not used at present, it must be 00)
4   050  (Total number of different constants used in the model)
5   000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0   Values of
6   000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0   constants
7   000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0
8   000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0000000.0
9   000000.0000000.0000000.0000000.0000000.0000000.0000000.0000001.0000000.0000000.0
10  065  (Number of different demand parameters used in the model)
11  0.6517900.095677-0.113050.152910-.0192051.478700-0.740760.3426900.055818-.087903   Values of
12  0.117460-.0087221.609100-0.759381.912100-0.00800-0.03620-0.004400.934800-1.31800   demand
13  -0.221900.932400-0.02700-0.04320-0.011700.757800-0.00540-0.56500-0.08710-.091200   parameters
14  -.002300.0224000.0111000.1299000.1686000.7342000-.635500-.007800.0161000.0149000
15  .2331000.1186000.7524000-1.08400-.062400-.022200-.030500.4905000.1538000.5077000
16  -2.65880-.017800-.016600-.038300.2458000.4298000.5083000-10.6182-.127700.0394000
17  .12920001.549800.7361000.2025000-.172600
18  090  (Number of different supply parameters used in the model)
19  1.0101001.0133001.0018781.0025001.0058601.0101001.0133001.0012501.0033401.005860   Values of
20  -13.4678-1.64930-3.416005.33100019.2540018.599990.5190000.57356037.24470-3.51550   supply
21  -5.902702.88610011.8770017.252990.2878200.37405015.67080-0.23563-0.370670.542680   parameters
22  1.3288001.3449000.0000000.8376707.5651000.000000-0.35083-0.647550.300760-0.34162
23  0.0000000.9168403.7325000.000000-1.22800-0.362991.7802000.2692000.0000000.900440
24  -16.00690.000000-0.98220-1.557907.71140010.074060.4917300.50809016.529200.000000
25  -0.29682-1.425403.2746008.1699000.3005600.390600-2.070000.0000000.619510-2.12790
26  -0.77137-1.642000.1748000.8391608.1886600.0000003.472800-1.20580-0.19440-1.33280
27  0.0966700.5633203.4379000.000000-0.33893-0.36105-0.12478-0.703200.0000000.685960
28  1970.1     (Last year of recursive and simultaneous data stored in the file)
29  25,24,12,09    (No. of exogenous, recursive and simultaneous variables in the model and no. of lines for
30  1970.1   (Period for which values of variables follow)                    each segment of main data)
31       1.00     0.0      0.0   104.73  108.80   40.50   39.17  119.90  132.97  720.40   Values of
32      64.00   272.50 4502.0071002.6314970.0012405.00   65.00    2.46   7.8915234.00   exogenous
33       5.57    .9727     0.   1289.30 1296.60     0.      0.      0.      0.      0.    variables
34     109.03   112.13   856.63  641.64 8733.60 1739.14 1479.14  814.81  694.39 6858.09   Values of
35    4488.83 1918.9728225.24   28.700  60.081  93.212  80.409  19.362  21.753  53.825   recursive
36     45.764   43.562   8.06716256.70     0.      0.      0.      0.      0.      0.    variables
37    4942.00   908.00 5850.00 2899.00  800.00 3010.00 2143.00  532.0016523.3014936.99   Values of
38       5.5716256.70     0.      0.      0.      0.      0.      0.      0.      0.    simultaneous
                                                                                           variables
```

NOTE: Lines 30 to 38 constitute one segment of main body of data. It contains period specification and values of exogenous, recursive and simultaneous variables for that period.

```
39      1969.4
40         0.0      0.0      0.0    109.80   112.00    41.43    39.83   118.00   130.88   725.10   Second
41        64.50   271.90 4465.0070845.3114807.0012301.33    64.00     2.58     7.4715864.00   segment,
42         2.93    .9711     0.    1324.70  1342.00     0.       0.       0.       0.       0.    line nos.
43       108.67   111.18   848.06   633.22  8717.23  1734.79  1470.51   806.66   685.28  6849.51   39 to 47
44      4473.86 1907.7828126.90    31.067   61.691   93.414   80.930   20.233   26.303   57.111
45        46.451   44.080    8.17016411.87     0.       0.       0.       0.       0.       0.
46      5263.00   953.00 6216.00  2897.00   840.00  3143.00  2134.00   634.0017188.7015607.65
47         2.9316411.87     0.       0.       0.       0.       0.       0.       0.       0.
48      1969.3
49         0.0      0.0      1.00   108.00   113.43    41.23    39.90   115.60   129.14   729.20   Third
50        67.70   269.40 4457.0070511.3114708.0012186.00    63.00     2.62     7.0615407.00   segment,
51         4.37    .9695     0.    1361.60  1395.90     0.       0.       0.       0.       0.    line nos.
52       108.30   110.22   839.58   624.90  8700.88  1730.46  1461.93   798.59   676.29  6840.95   48 to 56
53      4458.95 1896.6528029.18    46.079   75.795   94.334   80.791   20.789   33.566   62.973
54        45.038   43.146    7.79116616.97     0.       0.       0.       0.       0.       0.
55      5129.00   936.00 6065.00  2875.00   826.00  2921.00  2032.00   688.0016768.6015059.36
56         4.3716616.97     0.       0.       0.       0.       0.       0.       0.       0.
57      1969.2
58         0.0      1.00     0.0    111.87   111.40    41.37    39.67   113.70   127.24   725.80
59        68.70   267.30 4426.0070160.0014609.0012160.66    62.00     2.63     6.8915503.00
60         3.90    .9679     0.    1350.00  1372.30     0.       0.       0.       0.       0.
61       107.94   109.26   831.18   616.70  8684.57  1726.13  1453.41   799.61   667.41  6832.40
62      4444.09 1885.5827932.08    39.427   67.278   93.835   81.008   21.097   27.503   56.646
63        45.204   43.805    8.26016383.21     0.       0.       0.       0.       0.       0.
64      5129.00   947.00 6076.00  2872.00   804.00  2965.00  2129.00   657.0016853.0015225.40
65         3.9016383.21     0.       0.       0.       0.       0.       0.       0.       0.
66      1969.1
67         1.00     0.0      0.0    110.33   107.67    41.10    39.33   111.90   125.55   722.40
68        68.40   264.40 4371.0069527.3114458.0012084.33    61.00     2.62     6.7015371.00
69         3.30    .9663     0.    1307.70  1315.00     0.       0.       0.       0.       0.
70       107.58   108.37   822.87   608.61  8668.28  1721.81  1444.93   782.70   658.65  6823.86
71      4429.27 1874.5827835.56    26.915   59.026   93.257   80.542   19.752   20.479   53.194
72        44.428   43.044    8.09815937.37     0.       0.       0.       0.       0.       0.
73      5235.00   948.00 6183.00  2807.00   781.00  2896.00  2118.00   586.0016678.7015055.70
74         3.3015937.37     0.       0.       0.       0.       0.       0.       0.       0.
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1968.4
    0.0     0.0     0.0  107.97  108.13   41.73   40.03  110.30  124.26  716.50
  68.10  262.70 4345.0068812.6314281.0011974.66   60.00    2.66    6.2415332.00
   2.93   .9647      0. 1318.40 1367.40      0.      0.      0.      0.      0.
 106.91  107.48  814.64  600.62 8652.03 1717.51 1436.50  774.87  650.00 6815.33
4414.51 1863.6527739.66  29.263  60.777  93.501  81.065  20.628  24.837  56.344
 45.115  43.525   8.20216089.48      0.      0.      0.      0.      0.      0.
5132.00  966.00 6098.00 2826.00  797.00 2971.00 2026.00  614.0016650.4015105.14
   2.9316089.48      0.      0.      0.      0.      0.      0.      0.      0.
1968.3
    0.0     0.0    1.00  102.37  108.00   41.37   40.17  108.00  122.87  712.30
  65.80  261.70 4318.0068113.6214157.0011867.33   59.00    2.71    6.0814756.00
   5.20   .9631    1.00 1374.00 1541.70      0.      0.      0.      0.      0.
 106.24  106.58  806.50  592.74 8635.81 1713.21 1428.12  767.13  641.47 6806.81
4399.79 1852.7827644.36  44.452  74.938  94.449  80.926  21.189  32.164  62.211
 43.798  42.607   7.82316294.78      0.      0.      0.      0.      0.      0.
4888.00  923.00 5811.00 2835.00  795.00 2880.00 1906.00  529.0016130.0014312.33
   5.2016294.78      0.      0.      0.      0.      0.      0.      0.      0.
1968.2
    0.0    1.00     0.0  107.00  106.00   41.23   39.57  106.10  121.57  705.30
  67.30  258.90 4280.0067598.3114017.0011782.33   58.00    2.68    6.2514806.00
   3.87   .9615    2.00 1348.70 1637.70      0.      0.      0.      0.      0.
 105.57  105.69  798.43  584.96 8619.62 1708.93 1419.79  759.45  633.05 6798.30
4385.13 1841.9727549.63  38.273  66.743  93.986  81.145  21.503  26.392  56.029
 44.114  43.325   8.29316095.99      0.      0.      0.      0.      0.      0.
5086.00  895.00 5981.00 2815.00  758.00 2879.00 1951.00  422.0016154.7014375.07
   3.8716095.99      0.      0.      0.      0.      0.      0.      0.      0.
1968.1
   1.00     0.0     0.0  104.63  101.77   41.10   39.43  104.60  120.42  692.60
  67.60  255.60 4296.0067031.3113870.0011680.00   57.00    2.65    6.1314781.00
   3.57   .9599      0. 1393.30 1384.60      0.      0.      0.      0.      0.
 104.46  104.69  790.45  577.28 8603.45 1704.66 1411.50  751.86  624.75 6789.80
4370.51 1831.2227455.48  26.148  58.743  93.440  80.680  20.163  19.577  52.656
 43.439  42.610   8.13115681.53      0.      0.      0.      0.      0.      0.
5085.00  899.00 5984.00 2743.00  758.00 2808.00 1935.00  553.0016084.3014377.67
   3.5715681.53      0.      0.      0.      0.      0.      0.      0.      0.
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1967.4
     0.0       0.0       0.0    102.53 [illegible]2.60     41.47     40.03    102.10    119.35    683.60
    64.90    254.00 4272.0066489.31137[illegible]6.0011532.33     56.00      2.65      6.0314733.00
     3.17     .9583     0.     1363.30 163[illegible].30      0.        0.        0.        0.        0.
   103.36    103.69    782.54    569.70 85[illegible].32 1700.40 1403.27    744.34    616.55 6781.32
  4355.94 1820.5427361.92     29.121  6[illegible].907    93.714    81.205    21.045    24.384    56.041
    44.255    43.180     8.23515857.43     0.        0.        0.        0.        0.        0.
  4871.00    918.00 5789.00 2747.00 [illegible].00 2899.00 1918.00    614.0016096.3014365.28
     3.1715857.43     0.        0.        0.        0.        0.        0.        0.        0.
1967.3
     0.0       0.0       1.00     96.70    101.13     41.13     39.97    100.80    117.98    678.90
    63.00    251.00 4271.0065956.0013652.0011433.66     55.00      2.65      5.6214278.00
     4.93     .9567     0.     1405.40 1684.40      0.        0.        0.        0.        0.
   102.24    102.69    774.72    562.23 8571.22 1696.15 1395.08    736.90    608.45 6772.84
  4341.42 1809.9227268.93     44.909    75.471    94.686    81.068    21.611    32.200    62.194
    43.007    42.353     7.85716073.93     0.        0.        0.        0.        0.        0.
  4622.00    896.00 5518.00 2718.00    775.00 2804.00 1820.00    643.0015683.4013720.06
     4.9316073.93     0.        0.        0.        0.        0.        0.        0.        0.
1967.2
     0.0       1.00      0.0    100.80     99.47     41.03     39.50     99.30    116.82    671.60
    61.50    247.00 4257.0065561.0013548.0011341.66     54.00      2.66      5.2614574.00
     4.43     .9551     0.     1376.00 1416.00      0.        0.        0.        0.        0.
   101.14    101.69    766.97    554.85 8555.15 1691.90 1386.95    729.53    600.47 676[illegible].37
  4326.95 1799.3627176.50     38.820    67.212    94.238    81.287    21.929    26.516    56.052
    43.218    43.082     8.32815879.74     0.        0.        0.        0.        0.        0.
  4947.00    882.00 5829.00 2695.00    769.00 2802.00 1887.00    592.0015950.0014117.54
     4.4315879.74     0.        0.        0.        0.        0.        0.        0.        0.
1967.1
     1.00      0.0       0.0     99.83     96.87     41.07     39.43     97.80    116.17    666.60
    62.60    244.40 4252.0065360.0013465.0011210.00     53.00      2.64      5.1214460.00
     3.93     .9535     0.     1350.00 1356.30      0.        0.        0.        0.        0.
   100.27    100.70    759.30    547.56 8539.11 1687.67 1378.85    722.23    592.59 6755.92
  4312.52 1788.8627084.61     27.262    59.654    93.722    80.824    20.594    20.194    53.036
    42.488    42.446     8.16615491.83     0.        0.        0.        0.        0.        0.
  5051.00    907.00 5958.00 2619.60    752.00 2745.00 1877.00    509.0015810.0014069.59
     3.9315491.83     0.        0.        0.        0.        0.        0.        0.        0.
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1966.4									
0.0	0.0	0.0	102.30	98.93	42.13	40.20	96.70	115.36	668.10
62.10	240.50	4212.0064880.3313387.0011029.33				52.00	2.59	5.3814764.00	
2.43	.9519	0.	1390.00	1456.00	0.	0.	0.	0.	0.
99.40	99.72	751.71	540.38	8523.10	1683.46	1370.81	715.01	584.81	6747.47
4298.15	1778.4326993.33		30.100	62.176	94.036	81.349	21.481	24.714	56.337
42.968	42.937	8.27215639.01		0.	0.	0.	0.	0.	0.
5215.00	939.00	6154.00	2581.00	765.00	2861.00	1890.00	513.0016154.0014356.56		
2.4315639.01		0.	0.	0.	0.	0.	0.	0.	0.
1966.3									
0.0	0.0	1.00	97.13	99.23	41.97	40.37	95.20	114.50	660.20
64.30	238.50	4146.0064383.0013327.0010870.00				51.00	2.48	5.3214400.00	
4.57	.9503	0.	1465.60	1480.90	0.	0.	0.	0.	0.
98.53	98.73	744.19	533.28	8507.12	1679.25	1362.81	707.86	577.13	6739.04
4283.82	1768.0526902.55		45.191	76.879	95.039	81.212	22.051	31.659	62.032
41.254	41.920	7.89415793.21		0.	0.	0.	0.	0.	0.
4994.00	919.00	5913.00	2566.00	754.00	2764.00	1770.00	633.0015865.6013832.26		
4.5715793.21		0.	0.	0.	0.	0.	0.	0.	0.
1966.2									
0.0	1.00	0.0	100.27	97.53	42.27	40.23	94.10	113.49	655.00
65.60	234.70	4138.0063684.6613206.0010696.66				50.00	2.39	5.0014419.00	
2.97	.9487	0.	1429.30	1459.60	0.	0.	0.	0.	0.
97.66	97.74	736.75	526.29	8491.17	1675.05	1354.86	700.78	569.56	6730.61
4269.54	1757.7426812.35		38.483	68.716	94.597	81.433	22.374	25.241	55.495
41.122	42.490	8.36615566.64		0.	0.	0.	0.	0.	0.
5109.00	914.00	6023.00	2535.00	740.00	2765.00	1776.00	580.0015848.3013730.98		
2.9715566.64		0.	0.	0.	0.	0.	0.	0.	0.
1966.1									
1.00	0.0	0.0	96.40	93.43	42.17	40.07	92.40	112.39	649.10
67.90	231.50	4108.0062777.3313051.0010480.00				49.00	2.30	4.8114061.00	
2.80	.9471	0.	1398.40	1401.10	0.	0.	0.	0.	0.
97.11	96.90	729.38	519.38	8475.24	1670.86	1346.96	693.77	562.08	6722.20
4255.31	1747.4926722.67		26.374	61.132	94.057	80.970	21.043	18.365	52.177
40.175	41.733	8.20515158.35		0.	0.	0.	0.	0.	0.
5076.00	903.00	5979.00	2438.00	722.00	2659.00	1742.00	521.0015459.4013511.10		
2.8015158.35		0.	0.	0.	0.	0.	0.	0.	0.

1965.4									
0.0	0.0	0.0	92.53	92.53	42.30	40.30	90.80	111.50	636.60
67.40	226.70	4084.00	61919.33	12907.00	10304.00	48.00	2.20	4.61	14175.00
2.50	.9455	0.	1422.60	1437.30	0.	0.	0.	0.	0.
96.56	96.05	722.08	512.56	8459.35	1666.68	1339.10	686.83	554.71	6713.80
4241.13	1737.29	26633.53	28.682	63.455	94.323	81.495	21.932	22.475	55.245
40.543	42.135	8.311	15277.59	0.	0.	0.	0.	0.	0.
5057.00	906.00	5963.00	2413.00	721.00	2778.00	1722.00	578.00	15597.60	13380.46
2.50	15277.59	0.	0.	0.	0.	0.	0.	0.	0.
1965.3									
0.0	0.0	1.00	86.60	91.30	41.70	40.23	89.70	111.00	622.50
65.60	224.00	4051.00	61152.66	12782.00	10142.66	47.00	2.13	4.50	13648.00
4.97	.9439	0.	1482.70	1501.40	0.	0.	0.	0.	0.
96.01	95.21	714.86	505.83	8443.49	1662.52	1331.29	679.96	547.42	6705.41
4226.99	1727.16	26544.93	43.305	77.725	95.257	81.359	22.505	29.229	60.835
38.830	41.074	7.935	15406.68	0.	0.	0.	0.	0.	0.
4767.00	882.00	5649.00	2375.00	722.00	2640.00	1651.00	611.00	15130.70	12599.47
4.97	15406.68	0.	0.	0.	0.	0.	0.	0.	0.
1965.2									
0.0	1.00	0.0	89.20	89.47	42.00	39.87	88.60	110.70	610.40
64.60	220.30	4025.00	60411.66	12662.00	9965.00	46.00	2.12	4.44	13612.00
3.30	.9423	0.	1469.60	1509.30	0.	0.	0.	0.	0.
95.46	94.36	707.71	499.19	8427.66	1658.36	1325.52	673.16	540.24	6697.02
4212.90	1717.08	26456.84	36.090	68.939	94.743	81.579	22.829	22.644	54.194
38.745	41.606	8.407	15176.33	0.	0.	0.	0.	0.	0.
4874.00	878.00	5752.00	2350.00	715.00	2619.00	1610.00	566.00	15081.60	12601.60
3.30	15176.33	0.	0.	0.	0.	0.	0.	0.	0.
1965.1									
1.00	0.0	0.0	85.80	86.70	41.90	39.83	87.60	110.20	601.60
63.10	216.60	3980.00	59713.00	12499.00	9836.66	45.00	2.15	4.42	13218.00
3.37	.9407	0.	1411.40	1449.10	0.	0.	0.	0.	0.
94.83	93.79	700.64	492.64	8411.86	1654.21	1315.80	666.43	533.15	6588.65
4198.85	1707.07	26369.30	23.487	60.610	94.143	81.115	21.499	15.596	50.737
37.888	40.814	8.247	14770.16	0.	0.	0.	0.	0.	0.
4773.00	902.00	5675.00	2274.00	685.00	2507.00	1589.00	488.00	14629.40	12349.55
3.37	14770.16	0.	0.	0.	0.	0.	0.	0.	0.

1964.4									
0.0	0.0	0.0	81.60	86.37	41.80	40.07	87.40	109.60	588.50
61.30	213.90	3984.00	59064.66	12329.00	9752.33	44.00	2.18	4.43	13135.00
3.23	.9391	0.	1428.30	1701.00	0.	0.	0.	0.	0.
94.19	95.23	693.63	486.18	8396.09	1650.08	1308.13	659.77	526.15	6680.29
4184.86	1697.11	26282.29	25.942	62.589	94.367	81.639	22.389	20.093	54.028
38.521	41.239	8.354	14907.17	0.	0.	0.	0.	0.	0.
4578.00	875.00	5453.00	2283.00	682.00	2641.00	1534.00	542.00	14563.30	12285.56
3.23	14907.17	0.	0.	0.	0.	0.	0.	0.	0.
1964.3									
0.0	0.0	1.00	77.23	85.70	41.50	39.87	86.80	109.10	585.80
61.50	212.00	3963.00	58582.66	12213.00	9606.00	43.00	2.20	4.41	12820.00
5.13	.9375	0.	1450.00	1504.00	0.	0.	0.	0.	0.
93.56	92.66	686.69	479.80	8380.34	1645.95	1300.50	653.17	519.25	6671.94
4170.91	1687.21	26195.76	40.482	76.520	95.287	81.501	22.960	26.864	59.594
36.964	40.229	7.979	15034.23	0.	0.	0.	0.	0.	0.
4446.00	858.00	5304.00	2285.00	678.00	2484.00	1503.00	566.00	14270.00	11721.70
5.13	15034.23	0.	0.	0.	0.	0.	0.	0.	0.
1964.2									
0.0	1.00	0.0	80.07	84.80	41.57	39.70	85.40	108.50	578.60
62.10	210.00	3936.00	58036.00	12082.00	9531.33	42.00	2.21	4.41	12705.00
4.40	.9359	0.	1451.70	1491.70	0.	0.	0.	0.	0.
92.92	92.09	679.82	473.50	8364.63	1641.84	1292.91	645.64	512.43	6663.60
4157.01	1677.37	26109.75	33.658	67.893	94.781	81.720	23.283	20.614	53.136
37.131	40.824	8.452	14839.78	0.	0.	0.	0.	0.	0.
4507.00	862.00	5369.00	2246.00	667.00	2426.00	1492.00	505.00	14156.70	11582.02
4.40	14839.78	0.	0.	0.	0.	0.	0.	0.	0.
1964.1									
1.00	0.0	0.0	77.13	80.73	40.90	39.23	84.60	108.20	571.10
61.50	207.30	3920.00	57570.00	12002.00	9450.66	41.00	2.21	4.37	12422.00
4.60	.9343	0.	1383.40	1386.10	0.	0.	0.	0.	0.
92.29	90.89	673.03	467.28	8348.95	1637.73	1285.37	640.17	505.71	6655.27
4143.15	1667.58	26024.24	21.428	59.848	94.195	81.253	21.948	13.840	49.841
36.492	40.080	8.293	14469.14	0.	0.	0.	0.	0.	0.
4450.00	856.00	5306.00	2210.00	658.00	2330.00	1482.00	436.00	13805.40	11506.42
4.60	14469.14	0.	0.	0.	0.	0.	0.	0.	0.

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1963.4
    0.0      0.0      0.0     75.97    80.87    41.40    39.83    83.50   107.80   562.10
   61.40   204.10 3912.0057223.0011884.00 9369.33    40.00     2.22     4.3312497.00
    3.90    .9327     0.    1374.00 1379.70     0.       0.       0.       0.       0.
   91.23    89.69   666.30   461.15 8333.29 1633.64 1277.87   633.77   499.07 6646.95
 4129.34 1657.8525939.23   23.906   61.848   94.428   81.775   22.833   18.301   53.086
   37.263   40.544   8.40114612.39    0.       0.       0.       0.       0.       0.
 4387.00   874.00 5261.00 2166.00   667.00 2423.00 1473.00   507.0013871.0011584.27
     3.9014612.39    0.       0.       0.       0.       0.       0.       0.       0.
1963.3
    0.0      0.0      1.00    71.17    80.37    41.13    39.90    82.50   107.20   554.70
   60.30   202.60 3922.0056881.6611796.00 9243.00    39.00     2.24     4.2912109.00
    5.63    .9311     0.    1402.70 1407.70     0.       0.       0.       0.       0.
   90.16    88.49   659.63   455.10 8317.67 1629.55 1270.42   627.43   492.52 6638.64
 4115.57 1648.1825854.71   38.720   75.924   95.354   81.634   23.397   25.294   58.772
   35.933   39.523   8.02714752.20    0.       0.       0.       0.       0.       0.
 4089.00   857.00 4946.00 2192.00   670.00 2325.00 1441.00   535.0013511.7011003.91
     5.6314752.20    0.       0.       0.       0.       0.       0.       0.       0.
1963.2
    0.0      1.00     0.0     75.03    79.63    41.13    39.47    81.60   107.00   546.00
   60.50   199.30 3905.0056544.0011745.00 9152.66    38.00     2.24     4.2212096.00
    5.20    .9295     0.    1382.60 1390.90     0.       0.       0.       0.       0.
   89.10    87.29   653.04   449.13 8302.07 1625.48 1263.00   621.16   486.05 6630.35
 4101.85 1638.5725770.70   32.006   67.328   94.853   81.848   23.710   19.109   52.324
   36.292   40.126   8.50114580.55    0.       0.       0.       0.       0.       0.
 4207.00   841.00 5048.00 2173.00   665.00 2313.00 1429.00   468.0013478.6011027.24
     5.2014580.55    0.       0.       0.       0.       0.       0.       0.       0.
1963.1
    1.00     0.0      0.0     71.83    75.87    40.77    39.27    81.20   106.70   541.20
   59.50   197.40 3874.0056085.6611687.00 9091.66    37.00     2.24     4.2011765.00
    6.07    .9279     0.    1339.30 1346.30     0.       0.       0.       0.       0.
   88.14    85.85   646.51   443.23 8286.50 1621.41 1255.64   614.95   479.67 6622.06
 4088.18 1629.0125687.16   20.118   59.411   94.270   81.376   22.363   12.665   49.214
   35.928   39.441   8.34414246.78    0.       0.       0.       0.       0.       0.
 4168.00   821.00 4989.00 2117.00   652.00 2242.00 1400.00   365.0013104.3010860.52
     6.0714246.78    0.       0.       0.       0.       0.       0.       0.       0.
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291      1962.4
292         0.0      0.0      0.0     70.77    75.77    41.07    39.57    80.40   106.30   538.30
293        59.00   197.00 3908.0055968.3311635.00  9011.66    36.00     2.27     4.2611993.00
294         5.00    .9263     0.    1331.30  1344.30     0.       0.       0.       0.       0.
295        87.18    84.40   640.04   437.41  8270.97  1617.36  1248.31   608.80   473.38  6613.78
296      4074.55  1619.5025604.10    22.658   61.296   94.507   81.892   23.233   17.196   52.477
297        36.902   39.914    8.45414401.24     0.       0.       0.       0.       0.       0.
298      4130.00   836.00  4966.00  2129.00   667.00  2379.00  1410.00   442.0013324.3011068.53
299         5.0014401.24     0.       0.       0.       0.       0.       0.       0.       0.
300      1962.3
301         0.0      0.0      1.00    67.60    76.13    40.97    39.97    79.50   105.80   533.40
302        59.50   194.70  3894.0055811.0011605.00  8927.66    35.00     2.34     4.3411589.00
303         7.07    .9247     0.    1403.30  1417.00     0.       0.       0.       0.       0.
304        86.21    82.96   633.64   431.67  8255.46  1613.32  1241.03   602.71   467.16  6605.51
305      4060.97  1610.0625521.53    37.697   75.272   95.441   81.744   23.779   24.410   58.273
306        35.834   38.932    8.08114554.27     0.       0.       0.       0.       0.       0.
307      3843.00   820.00  4663.00  2118.00   670.00  2290.00  1367.00   481.0012992.3010533.73
308         7.0714554.27     0.       0.       0.       0.       0.       0.       0.       0.
309      1962.2
310         0.0      1.00     0.0     69.83    75.53    41.13    39.83    78.90   105.60   527.70
311        58.90   193.20  3913.0055540.0011557.00  8823.66    34.00     2.40     4.3011646.00
312         7.37    .9231     0.    1416.70  1437.00     0.       0.       0.       0.       0.
313        85.25    81.51   627.30   426.01  8239.98  1609.28  1233.79   596.68   461.03  6597.26
314      4047.43  1600.6625439.42    31.276   66.665   94.964   81.950   24.070   18.399   51.903
315        36.450   39.566    8.55714413.13     0.       0.       0.       0.       0.       0.
316      3989.00   815.00  4804.00  2105.00   669.00  2297.00  1368.00   403.0013062.7010642.58
317         7.3714413.13     0.       0.       0.       0.       0.       0.       0.       0.
318      1962.1
319         1.00     0.0      0.0     67.67    72.90    40.57    39.23    78.40   105.50   519.50
320        57.40   190.00  3910.0054991.0011465.00  8741.00    33.00     2.40     4.4111385.00
321         8.63    .9215     0.    1390.00  1406.70     0.       0.       0.       0.       0.
322        84.29    80.96   621.03   420.41  8224.53  1605.26  1226.59   590.72   454.98  6589.01
323      4033.94  1591.3325357.80    19.828   59.050   94.425   81.469   22.697   12.049   48.794
324        36.339   38.899    8.40114114.00     0.       0.       0.       0.       0.       0.
325      3971.00   804.00  4775.00  2039.00   656.00  2217.00  1360.00   338.0012775.0010497.99
326         8.6314114.00     0.       0.       0.       0.       0.       0.       0.       0.
```

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1961.4
    0.0      0.0      0.0     66.73    73.60    41.10    39.80    77.50   105.10   511.70
   57.40   187.50  3910.0054624.0011399.00  8688.33    32.00     2.28     4.4111551.00
    7.70    .9199    0.     1381.60  1559.90    0.       0.       0.       0.       0.
   83.20    80.42   614.82   414.90  8209.11  1601.25  1219.44   584.81   449.01  6580.77
 4020.50  1582.0425276.65    23.365   61.981   94.716   81.975   23.536   16.992   52.244
  37.667   39.455    8.51214309.47    0.       0.       0.       0.       0.       0.
 3874.00   819.00  4693.00  2044.00   663.00  2323.00  1377.00   451.0012932.6010639.74
    7.7014309.47    0.       0.       0.       0.       0.       0.       0.       0.
1961.3
    0.0      0.0      1.00    62.07    72.00    40.30    39.63    76.70   104.50   501.50
   55.90   185.10  3910.0054223.0011354.00  8631.66    31.00     2.13     4.4411285.00
   10.93    .9183    0.     1403.00  1458.70    0.       0.       0.       0.       0.
   82.12    79.87   608.67   409.45  8193.72  1597.24  1212.32   578.96   443.12  6572.55
 4007.09  1572.8225195.94    39.214   76.858   95.671   81.814   24.045   24.511   58.115
  36.913   38.538    8.14014488.49    0.       0.       0.       0.       0.       0.
 3705.00   803.00  4508.00  2020.00   671.00  2257.00  1325.00   504.0012688.0010187.07
   10.9314488.49    0.       0.       0.       0.       0.       0.       0.       0.
1961.2
    0.0      1.00     0.0     62.13    70.40    40.20    39.10    76.00   104.50   492.80
   55.00   183.00  3885.0053739.3311294.00  8529.00    30.00     2.12     4.2811294.00
   11.60    .9167    0.     1412.60  1420.60    0.       0.       0.       0.       0.
   81.03    79.32   602.59   404.08  8178.35  1593.25  1205.25   573.17   437.30  6564.33
 3993.74  1563.6425115.70    33.727   68.695   95.156   82.006   24.294   19.281   52.081
  37.943   39.331    8.61714396.86    0.       0.       0.       0.       0.       0.
 3797.00   789.00  4586.00  1993.00   673.00  2259.00  1333.00   450.0012706.6010172.60
   11.6014396.86    0.       0.       0.       0.       0.       0.       0.       0.
1961.1
    1.00     0.0      0.0     57.67    66.93    39.37    38.50    74.80   104.30   482.60
   55.20   180.50  3907.0053506.0011298.00  8456.00    29.00     2.14     4.2710973.00
   13.70    .9151    0.     1407.70  1407.70    0.       0.       0.       0.       0.
   80.60    78.46   596.56   398.77  8163.02  1589.27  1198.22   567.44   431.56  6556.13
 3980.42  1554.5225035.91    23.940   61.813   94.551   81.510   22.872   14.712   50.033
  38.382   39.001    8.46214176.72    0.       0.       0.       0.       0.       0.
 3657.00   778.00  4435.00  1950.00   669.00  2231.00  1322.00   366.0012380.7010030.54
   13.7014176.72    0.       0.       0.       0.       0.       0.       0.       0.
```

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1960.4
    0.0       0.0       0.0      60.13    67.93    39.63    38.67    74.40   104.00  483.70
   54.50   179.40 3950.0053841.0011375.00 8394.66    28.00     2.15     4.3211898.00
    7.50    .9135      0.     1424.60  1426.60     0.       0.       0.       0.       0.
   80.16    77.60   590.59   393.54  8147.71  1585.29  1191.23   561.77   425.90 6547.93
 3967.16 1545.4524956.57   27.646   64.459   94.767   81.997   23.654   20.213   53.851
  39.730   39.641   8.57414369.47     0.       0.       0.       0.       0.       0.
 4138.00   838.00 4976.00 1972.00   707.00  2420.00  1337.00   486.0013322.6010866.72
    7.5014369.47     0.       0.       0.       0.       0.       0.       0.       0.
1960.3
    0.0       0.0      1.00    60.63    69.17    40.00    39.50    74.20   103.50  487.30
   54.00   176.40 3999.0054200.6611416.00 8334.66    27.00     2.13     4.3111867.00
    7.53    .9119      0.     1472.60  1486.80     0.       0.       0.       0.       0.
   79.73    76.73   584.69   388.37  8132.44  1581.33  1184.28   556.15   420.31 6539.75
 3953.93 1536.4424877.69   43.309   79.060   95.668   81.817   24.097   27.919   59.944
  38.808   38.727   8.20214522.01     0.       0.       0.       0.       0.       0.
 4116.00   828.00 4944.00 1981.00   723.00  2367.00  1295.00   557.0013339.6010669.97
    7.5314522.01     0.       0.       0.       0.       0.       0.       0.       0.
1960.2
    0.0      1.00      0.0      65.00    69.47    40.27    39.27    73.80   103.10  489.70
   55.10   176.30 4037.0054455.6611420.00 8334.00    26.00     2.14     4.4512089.00
    6.57    .9103      0.     1472.00  1469.30     0.       0.       0.       0.       0.
   79.29    75.87   578.84   383.28  8117.19  1577.38  1177.37   550.59   414.79 6531.57
 3940.75 1527.4724799.23   37.104   79.774   95.127   81.987   24.270   22.216   53.811
  39.458   39.387   8.67714394.10     0.       0.       0.       0.       0.       0.
 4395.00   820.00 5215.00 1975.00   728.00  2383.00  1314.00   474.0013561.0010960.16
    6.5714394.10     0.       0.       0.       0.       0.       0.       0.       0.
1960.1
    1.00      0.0       0.0      67.30    67.97    40.47    39.13    73.30   102.60  490.20
   56.40   174.30 4033.0054351.0011353.00 8251.33    25.00     2.16     4.5512128.00
    5.77    .9087      0.     1439.30  1442.30     0.       0.       0.       0.       0.
   78.86    75.18   573.05   378.25  8101.97  1573.43  1170.50   545.08   409.35 6523.41
 3927.62 1518.5624721.22   24.790   62.573   94.496   81.465   22.761   15.307   50.391
  39.143   38.586   8.51914071.04     0.       0.       0.       0.       0.       0.
 4659.00   822.00 5481.00 1925.00   717.00  2318.00  1292.00   395.0013567.3011269.46
    5.7714071.04     0.       0.       0.       0.       0.       0.       0.       0.
```

APPENDIX C-3

3.15 SMSA's And Selected Industrial Classifications

The SMSA's and the selected industrial classifications for which we can simulate the model are as follows:

LIST 12

SMSA	SMSA CODE	INDUSTRY CODE	INDUSTRY DESCRIPTION
DETROIT	DT	01	ALL DURABLES
		02	ALL NON-DURABLES
		20	FOOD & KINDRED PRODUCTS
		33	PRIMARY METALS
		34	FABRICATED METALS
		35	MACHINERY EX. ELECTRICAL
		36	ELECTRICAL MACHINERY
		37	TRANSPORTATION EQUIPMENT
		03	MINING & SERVICES
		04	CONTRACT CONSTRUCTION
		05	TRANSPORTATION, ETC. SERVICES
		50	WHOLESALE TRADE
		06	RETAIL TRADE
		07	FINANCE, INSURANCE & REAL ESTATE
		91	FEDERAL GOVERNMENT
		08	STATE & LOCAL GOVERNMENT
DENVER	DN	01	ALL DURABLES
		02	ALL NON-DURABLES
		20	FOOD & KINDRED PRODUCTS
		35	MACHINERY EX. ELECTRICAL
		03	MINING & SERVICES
		04	CONTRACT CONSTRUCTION
		05	TRANSPORTATION, ETC. SERVICES
		50	WHOLESALE TRADE
		06	RETAIL TRADE
		07	FINANCE, INSURANCE & REAL ESTATE
		91	FEDERAL GOVERNMENT
		08	STATE & LOCAL GOVERNMENT

SMSA	SMSA CODE	INDUSTRY CODE	INDUSTRY DESCRIPTION
MILWAUKEE	ML	01	ALL DURABLES
		02	ALL NON-DURABLES
		20	FOOD & KINDRED PRODUCTS
		33	PRIMARY METALS
		34	FABRICATED METALS
		35	MACHINERY EX. ELECTRICAL
		36	ELECTRICAL MACHINERY
		37	TRANSPORTATION EQUIPMENT
		03	MINING & SERVICES
		04	CONTRACT CONSTRUCTION
		05	TRANSPORTATION, ETC. SERVICES
		07	FINANCE, INSURANCE & REAL ESTATE
		95	WHOLESALE & RETAIL TRADE
		96	ALL GOVERNMENT

Industry code numbers 01, 02, 33, 34, 35, 36 and 37 are for manufacturing industries. Industry code numbers 03, 04, 05, 06, 50, 07, 91, 08, 95, and 96 are for non-manufacturing industries.

We have tried to use, as far as we could, SIC codes for industry codes. Where we could not use SIC odes we have created our own. A more complete explanation of these codes will follow.

INDUSTRIAL CLASSIFICATION CODES

This is an explanation of industrial classification codes for manufacturing industries.

LIST 13

MANUFACTURING INDUSTRIES	SIC OR OTHER CODE
ALL DURABLES	01*
ALL NON-DURABLES	02*
FOOD & KINDRED PRODUCTS	20
PRIMARY METAL INDUSTRIES	33
FABRICATED METAL PRODUCTS EXCEPT ORDANCE, MACHINERY, & TRANSPORTATION EQUIPMENT	34

*These are NOT SIC codes, all others ARE.

LIST 13 CONT'D

MANUFACTURING INDUSTRIES	SIC OR OTHER CODE
MACHINERY EXCEPT ELECTRICAL	35
ELECTRICAL MACHINERY, EQUIPMENT & SUPPLIES	36
TRANSPORTATION EQUIPMENT	37

Explanation of industrial classification codes for non-manufacturing industries.

LIST 14

NON-MANUFACTURING INDUSTRIES	SIC OR OTHER CODES
MINING & SERVICES	03
CONTRACT CONSTRUCTION	04
TRANSPORTATION, COMMUNICATION, ELECTRIC, GAS & SANITARY SERVICES	05
WHOLESALE TRADE	50*
RETAIL TRADE	06
FINANCE INSURANCE & REAL ESTATE	07
FEDERAL GOVERNMENT	91*
STATE & LOCAL GOVERNMENT	08
WHOLESALE & RETAIL TRADE	95
FEDERAL, STATE & LOCAL GOVERNMENT	96

A more detailed explanation of the non-manufacturing industries again will follow.

NON-MANUFACTURING INDUSTRIES		SIC OR OTHER CODE
CONTRACT CONSTRUCTION (DIVISION C) WHICH INCLUDES:		04
BUILDING CONSTRUCTION-GENERAL CONTRACTORS	SIC 15	
CONSTRUCTION OTHER THAN BUILDING CONSTRUCTION-GENERAL CONTRACTORS	SIC 16	
CONSTRUCTION-SPECIAL TRADE CONTRACTORS	SIC 17	
TRANSPORTATION, COMMUNICATION, ELECTRIC, GAS AND SANITARY SERVICES (DIVISION E) WHICH INCLUDES:		05
RAILROAD TRANSPORTATION	SIC 40	
LOCAL & SUBURBAN TRANSIT & INTERURBAN PASSENGER TRANSPORTATION	SIC 41	

*These are SIC codes, all others ARE NOT.

NON-MANUFACTURING INDUSTRIES		SIC OR OTHER CODES
MOTOR FREIGHT TRANSPORTATION & WAREHOUSING	SIC 42	
WATER TRANSPORTATION	SIC 44	
TRANSPORTATION BY AIR	SIC 45	
PIPE-LINE TRANSPORTATION	SIC 46	
TRANSPORTATION SERVICES	SIC 47	
COMMUNICATION	SIC 48	
ELECTRIC, GAS, & SANITARY SERVICES	SIC 49	
WHOLESALE TRADE		50
RETAIL TRADE (PARTIAL DIVISION F) WHICH INCLUDES:		
BUILDING MATERIALS, HARDWARE & FARM EQUIPMENT DEALERS	SIC 52	
RETAIL TRADE-GENERAL MERCHANDISE	SIC 53	
FOOD STORES	SIC 54	
AUTOMOTIVE DEALERS & GASOLINE SERVICE STATIONS	SIC 55	
APPAREL & ACCESSORY STORES	SIC 56	
MINING AND SERVICES		03
MINING (DIVISION B) WHICH INCLUDES:		
METAL MINING	SIC 10	
ANTHRACITE MINING	SIC 11	
BITUMINOUS COAL AND LIGNITE MINING	SIC 12	
CRUDE PETROLEUM AND NATURAL GAS	SIC 13	
MINING AND QUARRYING OF NONMETALLIC MINERALS, EXCEPT FUELS	SIC 14	
SERVICE (DIVISION H) WHICH INCLUDES:		
HOTELS, ROOMING HOUSES, CAMPS & OTHER LODGING PLACES	SIC 70	
PERSONAL SERVICES	SIC 72	
MISCELLANEOUS BUSINESS SERVICES	SIC 73	
AUTOMOBILE REPAIR, AUTOMOBILE SERVICES, AND GARAGES	SIC 75	
MISCELLANEOUS REPAIR SERVICES	SIC 76	
MOTION PICTURES	SIC 78	
AMUSEMENT AND RECREATION SERVICES EXCEPT MOTION PICTURES	SIC 79	
MEDICAL & OTHER HEALTH SERVICES	SIC 80	

NON-MANUFACTURING INDUSTRIES		SIC OR OTHER CODE
LEGAL SERVICES	SIC 81	
EDUCATIONAL SERVICES	SIC 82	
MUSEUMS, ART GALLERIES, BOTANICAL & ZOOLOGICAL GARDENS	SIC 84	
NONPROFIT MEMBERSHIP ORGANIZATIONS	SIC 86	
PRIVATE HOUSEHOLDS	SIC 88	
MISCELLANEOUS SERVICES	SIC 89	
FURNITURE, HOME FURNISHINGS & EQUIPMENT STORES	SIC 57	
EATING & DRINKING PLACES	SIC 58	
MISCELLANEOUS RETAIL STORES	SIC 59	
FINANCE, INSURANCE & REAL ESTATE (DIVISION G) WHICH INCLUDES:		07
BANKING	SIC 60	
CREDIT AGENCIES OTHER THAN BANKS	SIC 61	
SECURITY & COMMODITY BROKERS, DEALERS, EXCHANGES & SERVICES	SIC 62	
INSURANCE CARRIERS	SIC 63	
INSURANCE AGENTS, BROKERS & SERVICE	SIC 64	
REAL ESTATE	SIC 65	
COMBINATIONS OF REAL ESTATE, INSURANCE, LOANS & LAW OFFICES	SIC 66	
HOLDING AND OTHER INVESTMENT COMPANIES	SIC 67	
FEDERAL GOVERNMENT		91
STATE & LOCAL GOVERNMENT (PARTIAL DIVISION I) WHICH INCLUDES:		
STATE GOVERNMENT	SIC 92	
LOCAL GOVERNMENT	SIC 93	
WHOLESALE & RETAIL TRADE (DIVISION F)		95
FEDERAL, STATE & LOCAL GOVERNMENT (DIVISION I)		96

BEST COPY AVAILABLE

After signing on MTS properly enter $SOURCE SAWV:SOLAMI , the command to run the SOLAMI program.

```
#EXECUTION BEGINS

  ***** SIMULATION OF LABOR MARKET INFORMATION *****

  ** TIME: 10:51.25
  ** DATE: JAN  8, 1974

  ** ENTER THE SMSA CODE OR ITS NAME. FOR INFORMATION TYPE - HELP **

?help   (Help is typed in for more information)


  ** THE TWO CHARACTER CODES FOR THE SMSA THAT YOU MAY WISH TO SIMULATE
 ARE:-
 DT FOR DETROIT,
 DN FOR DENVER,
 ML FOR MILWAUKEE.
  ** INSTEAD OF THE TWO CHARACTER CODE THE FULL NAME OF THE SMSA CAN ALSO
 BE USED.

  ** TO TERMINATE THE SESSION TYPE IN - T OR TERMINATE,
  ** TO RETURN TO MTS WITHOUT SUSPENDING THIS PROGRAM TYPE IN - M OR MTS.
  ** TO RETURN BACK FROM MTS TO THIS PROGRAM TYPE IN - RESTART. **

  ** ENTER THE SMSA CODE OR ITS NAME. FOR INFORMATION TYPE - HELP **

?detroit   (The SMSA to be simulated is defined by entering its name or its two
           character code)


  ** DETROIT SMSA TO BE SIMULATED. THE NECESSARY DATA WILL BE READ FROM
 THE FILE SAWV:DT **   (The file from where the data will be read is defined by
                       the program)
  ** ENTER THE BEGINNING YEAR AND QUARTER OF SIMULATION IN F6.1 FORMAT.
 FOR INFORMATION TYPE - HELP **

?wiwi   (The user has made a mistake)

  ** ILLEGAL ENTRY. TRY AGAIN **

 WIWI
?help   (Help is typed in again for more information)

  ** THIS MODEL ALLOWS YOU TO SIMULATE THE SMSA'S LABOR MARKET BEGINNING
 AT ANY QUARTER FROM FIRST QUARTER, 1961 TO FOURTH QUARTER, 1972 . THE
 BEGINNING YEAR AND QUARTER OF SIMULATION SHOULD BE ENTERED IN F6.1 FORMAT.
 FOR EXAMPLE, 1969, THIRD QUARTER SHOULD BE ENTERED AS 1969.3 . THERE CAN
 BE ANY NUMBER OF BLANKS BEFORE OR AFTER THE ENTRY BUT THERE SHOULD NOT BE
 ANY BLANKS EMBEDDED IN THE ENTRY AND THE WHOLE ENTRY INCLUDING THE BLANKS
 MUST BE WITHIN 80 CHARACTERS **
```

```
 ** ENTER THE BEGINNING YEAR AND QUARTER OF SIMULATION IN F6.1 FORMAT.
FOR INFORMATION TYPE - HELP **

?1989.2  (Beginning year and quarter of simulation is defined incorrectly.  The
          latest period from where simulation can be started is 1972.4)
  ** ILLEGAL ENTRY. TRY AGAIN **

 1989.2   (The beginning year and quarter of simulation is correctly defined)
?1968.1

  ** THE BEGINNING YEAR AND QUARTER OF SIMULATION IS 1968.1 **

  ** ALL THE NECESSARY DATA HAVE BEEN READ IN FROM THE FILE SAUV:DT **

  ** ENTER COMMANDS **

?help    (More information will follow)

  ** THE FOLLOWING COMMANDS ARE PRESENTLY AVAILABLE:-

  ** (THE PARENTHESIZED LETTER(S) CAN BE USED AS AN ABBREVIATION OF THE
 CORRESPONDING WORD.)

  ** (P)RINT (COM)MANDS - FOR PRINTING A LIST OF COMMANDS AVAILABLE.
  ** (P)RINT (EXP)LANATION - FOR PRINTING A SHORT EXPLANATION OF THE MODEL.
  ** (P)RINT (IND)USTRIES - FOR PRINTING A LIST OF INDUSTRIES SIMULATED.
  ** (P)RINT NITER - FOR PRINTING NUMBER OF ITERATIONS FOR WHICH COMPU-
 ATIONS OF SIMULTANEOUS EQUATIONS ARE CARRIED OUT TO ACHIEVE CONVERGENCE.
  ** (P)RINT CONCRI - FOR PRINTING CONVERGENCE CRITERION.
  ** (P)RINT EVAR OR EXOGENOUS - FOR PRINTING EXOGENOUS VARIABLES.
  ** (P)RINT RVAR OR RECURSIVE - FOR PRINTING RECURSIVE VARIABLES.
  ** (P)RINT SVAR OR SIMULTANEOUS - FOR PRINTING SIMULTANEOUS
 VARIABLES.
  ** (P)RINT DPAR OR DEMAND-PARAS - FOR PRINTING DEMAND PARAMETERS.
  ** (P)RINT SPAR OR SUPPLY-PARAS - FOR PRINTING SUPPLY PARAMETERS.
  ** (P)RINT (CONS)TANTS - FOR PRINTING CONSTANTS.

  ** EXCEPT FOR THE FIRST THREE, THE COMMAND (C)HANGE CAN BE USED INSTEAD
 OF THE COMMAND (P)RINT FOR CHANGING ANY ENTRY IN ANY OF THE VARIOUS VEC-
 TORS AND MATRICES.[1]

  ** (S)IMULATE (DYN)AMICALLY - FOR STARTING A DYNAMIC SIMULATION RUN.
  ** (S)IMULATE QRT OR QUARTERLY - FOR STARTING A QUARTERLY SIMULATION
 RUN.
  ** (S)IMULATE (RES)IDUAL OR RESIDUAL-RUN - FOR STARTING A RESIDUAL SIM-
 ULATION RUN.  (This command is not implemented for this version of SOLAMI)
  ** (H)ELP - PRINTS FOR THE USER EXPLANATIONS WHEREVER REQUIRED.
  ** (M)TS - TO RETURN TO MTS WITHOUT SUSPENDING THIS PROGRAM. TO RETURN
 BACK FROM MTS TO THIS PROGRAM TYPE IN - RESTART.
  ** (R)ERUN - TO STOP AND RERUN THE SIMULATION FOR THE SAME OR SOME OTHER
 SMSA.
  ** (T)ERMINATE - FOR TERMINATING THIS SESSION.
```

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[1] Commands (C)HANGE DPAR and (C)HANGE SPAR are not implemented for the present version of SOLAMI.

** THE FOLLOWING COMMANDS, WHICH ARE FOR SELECTIVE PRINTING OF RESULTS SHOULD BE USED ONLY AFTER THE MODEL IS SIMULATED FOR ATLEAST ONE PERIOD.

** (P)RINT (R)ESULTS 1969.1 1969.3 1968.4 ETC. - FOR PRINTING COMPLETE SIMULATION RESULTS FOR THE PERIODS SPECIFIED.
** (P)RINT (S)UMMARY 1969.1 1968.4 1971.3 ETC. - FOR PRINTING ONLY A SUMMARY OF SIMULATION RESULTS FOR THE PERIODS SPECIFIED.

** IN THE ABOVE TWO COMMANDS THERE MUST BE ATLEAST ONE BLANK BETWEEN TWO CONSECUTIVE PERIODS. THE ORDER IN WHICH THE PERIODS ARE ENTERED IN A COMMAND LINE IS UNIMPORTANT BUT THEIR MAXIMUM NUMBER SHOULD NOT EXCEED EIGHT. THE RESULTS FOR ALL THE PERIODS SIMULATED WILL BE PRINTED IF THEIR SPECIFICATION IS COMPLETELY OMITTED FORM THE COMMAND.

** (P)RINT (STAT)ISTICS - FOR PRINTING STATISTICS FOR RESIDUALS OF RECURSIVE AND SIMULTANEOUS VARIABLES. (This command is not implemented for this version of SOLAMI)
** (S)IMULATE - TO RESTART THE SIMULATION.
** (ST)OP - TO STOP AND RERUN THE SIMULATION FOR THE SAME OR SOME OTHER SMSA.

** STATUS - FOR PRINTING THE NUMBER OF PERIODS SIMULATED SO FAR AND THE PRESENT SIMULATION MODE.
** (H)ELP - FOR OBTAINING A LIST OF SELECTIVE PRINTING COMMANDS.
** (M)TS - TO RETURN TO MTS WITHOUT SUSPENDING THIS PROGRAM. TO RETURN BACK FROM MTS TO THIS PROGRAM TYPE IN - RESTART.
** (R)ERUN - SAME AS STOP FOR THIS PART OF THE PROGRAM.
** (T)ERMINATE - FOR TERMINATING THIS SESSION.

** ENTER COMMANDS **

? print explanation (This command is entered to obtain a short explanation of SOLAMI)

** THE SIMULATION OF LABOR MARKET INFORMATION (SOLAMI) MODEL IS AN ECONOMETRIC MODEL, CONSTRUCTED TO SIMULATE THE EVOLUTION OF CERTAIN CRITICAL ASPECTS OF A LOCAL LABOR MARKET. THE GEOGRAPHIC UNIT OF ANALYSIS IS THE STANDARD METROPOLITAN STATISTICAL AREA (SMSA). THE MODEL IS THEN DESIGNED TO PROVIDE PROJECTIONS OF THE LEVELS OF EMPLOYMENT BY VARIOUS INDUSTRY GROUPINGS AND THE OVERALL UNEMPLOYMENT RATE FOR THE SMSA ON THE BASIS OF CERTAIN INPUTS, CHIEFLY LEVELS OF NATIONAL DEMAND AND NATIONAL PRODUCTION **

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? p ind

** THE FOLLOWING ARE THE SELECTED INDUSTRIAL CLASSIFICATIONS FOR WHICH WE CAN SIMULATE THE MODEL **

** INDUSTRIAL CLASSIFICATIONS **	SIC OR OTHER CODES
** MANUFACTURING INDUSTRIES **	
ALL DURABLES	01
ALL NON-DURABLES	02
FOOD AND KINDRED PRODUCTS	20*
PRIMARY METAL INDUSTRIES	33*
FABRICATED METAL PRODUCTS EXCEPT ORDNANCE, MACHINERY, AND TRANSPORTATION EQUIPMENT	34*
MACHINERY EXCEPT ELECTRICAL	35*
ELECTRICAL MACHINERY, EQUIPMENT, AND SUPPLIES	36*
TRANSPORTATION EQUIPMENT	37*
** NON MANUFACTURING INDUSTRIES **	
MINING AND SERVICES	03
CONTRACT CONSTRUCTION	04
TRANSPORTATION,COMMUNICATION,ELECTRIC,GAS, AND SANITARY SERVICES	05
RETAIL TRADE	06
FINANCE, INSURANCE,AND REAL ESTATE	07
STATE AND LOCAL GOVERNMENT	08
WHOLESALE TRADE	50*
FEDERAL GOVERNMENT	91*
WHOLESALE AND RETAIL TRADE	95
FEDERAL STATE AND LOCAL GOVERNMENT	96

NOTE: *THESE ARE SIC CODES BASED ON 1967 SIC MANUAL.
ALL OTHERS ARE NOT.

** FOR MORE DETAILED EXPLANATION SEE THE SOLAMI MANUAL **

? p niteril (The user has entered an illegal command by mistake)

** ILLEGAL COMMAND. TRY AGAIN **

P NITERIL

?p niter (niter = Number of ITERations for solution of simultaneous equations)

** COMPUTATIONS FOR SIMULTANEOUS EQUATIONS ARE ITERATED FOR A MAXIMUM OF 50 TIMES FOR ACHIEVING A CONVERGENCE.

** THE CONVERGENCE CRITERION IS 0.010 **

```
? print   evar   (User wants to print some exogenous variables)

 ** ENTER THE EXOGENOUS VARIABLE NUMBER AND THE PERIODS FOR WHICH ITS
 VALUES ARE TO BE PRINTED. FOR INFORMATION TYPE - HELP **

?help

 ** THE EXOGENOUS VARIABLE NUMBER AND THE PERIODS FOR WHICH ITS VALUES
 ARE TO BE PRINTED MUST BE ENTERED IN THE FORM - VARNO(D)YRQU1(D)YRQU2,
 WHERE:

 VARNO = NUMBER OF THE VARIABLE WHOSE VALUES ARE TO BE PRINTED (1 TO 99,
         FORMAT I2),
 YRQU1 = FIRST YEAR AND QUARTER OF THE PERIODS STARTING WHICH THE VALUES
         OF THE VARIABLE ARE TO BE PRINTED (FORMAT F6.1),
 YRQU2 = LAST YEAR AND QUARTER OF THE PERIODS UP TO WHICH THE VALUES OF
         THE VARIABLE ARE TO BE PRINTED (FORMAT F6.1),
 (D)   = DELIMITOR, A COMMA (,) OR A DASH (-).

 ** YRQU1 AND YRQU2 CAN BE ANY PERIOD FROM 1960.1 TO 1980.4, PROVIDED
 DATA FOR THE PERIODS COVERED ARE READ; BUT YRQU1 MUST BE A PERIOD EARL-
 IER THAN OR THE SAME AS THE PERIOD YRQU2.
 FOR EXAMPLE AN ENTRY LIKE - 15,1965.3,1966.4 - WILL CAUSE THE VALUES OF
 VARIABLE NUMBER 15 TO BE PRINTED FORM 1965.3 TO 1966.4. WHEN YRQU1 AND
 YRQU2 ARE SAME THE VALUE FOR ONLY ONE QUARTER WILL BE PRINTED.

 ** THE ENTRY - STOP - WILL RETURN CONTROL TO THE STATE WHERE FURTHER
 COMMANDS CAN BE ENTERED **

 ** ENTER THE EXOGENOUS VARIABLE NUMBER AND THE PERIODS FOR WHICH ITS
 VALUES ARE TO BE PRINTED. FOR INFORMATION TYPE - HELP **
     (A blank line is interpreted here as incorrect entry.  The program first looks
     for the correct delimitor)
 ** INCORRECT ENTRY. THE DELIMITOR MUST BE A COMMA (,) OR A DASH (-).
 TRY AGAIN **
?15,1968.1,1971.4

 ** INCORRECT PERIOD SPECIFICATION. EARLIEST AND LATEST PERIODS FOR WHICH
 EXOGENOUS VARIABLES CAN BE PRINTED ARE 1967.2 AND 1970.1 . TRY AGAIN **
```

(The periods specification should conform simultaneously to the periods for which data exist in the file DT, the beginning year of simulation and the maximum lagged period in the model.)

```
? print   evar (the user wants to print some exogenous variables)

 ** ENTER THE EXOGENOUS VARIABLE NUMBER AND THE PERIODS FOR WHICH ITS
VALUES ARE TO BE PRINTED. FOR INFORMATION TYPE - HELP **

?help

 ** THE EXOGENOUS VARIABLE NUMBER AND THE PERIODS FOR WHICH ITS VALUES
ARE TO BE PRINTED MUST BE ENTERED IN THE FORM - VARNO(D)YRQU1(D)YRQU2,
WHERE:

VARNO = NUMBER OF THE VARIABLE WHOSE VALUES ARE TO BE PRINTED (1 TO 99,
        FORMAT I2),
YRQU1 = FIRST YEAR AND QUARTER OF THE PERIODS STARTING WHICH THE VALUES
        OF THE VARIABLE ARE TO BE PRINTED (FORMAT F6.1),
YRQU2 = LAST YEAR AND QUARTER OF THE PERIODS UP TO WHICH THE VALUES OF
        THE VARIABLE ARE TO BE PRINTED (FORMAT F6.1),
(D)   = DELIMITOR, A COMMA (,) OR A DASH (-).

 ** YRQU1 AND YRQU2 CAN BE ANY PERIOD FROM 1960.1 TO 1980.4, PROVIDED
DATA FOR THE PERIODS COVERED ARE READ; BUT YRQU1 MUST BE A PERIOD EARL-
IER THAN OR THE SAME AS THE PERIOD YRQU2.
FOR EXAMPLE AN ENTRY LIKE - 15,1965.3,1966.4 - WILL CAUSE THE VALUES OF
VARIABLE NUMBER 15 TO BE PRINTED FORM 1965.3 TO 1966.4. WHEN YRQU1 AND
YRQU2 ARE SAME THE VALUE FOR ONLY ONE QUARTER WILL BE PRINTED.

 ** THE ENTRY - STOP - WILL RETURN CONTROL TO THE STATE WHERE FURTHER
COMMANDS CAN BE ENTERED **

 ** ENTER THE EXOGENOUS VARIABLE NUMBER AND THE PERIODS FOR WHICH ITS
VALUES ARE TO BE PRINTED. FOR INFORMATION TYPE - HELP **
     (a blank line is interpreted here as incorrect entry.  The program first looks
      for the correct delimitor)
 ** INCORRECT ENTRY. THE DELIMITOR MUST BE A COMMA (,) OR A DASH (-).
TRY AGAIN **
?15,1968.1,1971.4

 ** INCORRECT PERIOD SPECIFICATION. EARLIEST AND LATEST PERIODS FOR WHICH
EXOGENOUS VARIABLES CAN BE PRINTED ARE 1967.2 AND 1970.1 . TRY AGAIN **
(The periods specification should confirm to the periods for which data exist in the
file DT and simultaneously with the beginning year of simulation and the maximum lagged
period in the model.)
```

```
?15,1967.4,1969.3   (Specification is correct this time)

 ** THE FOLLOWING ARE THE VALUES OF EXOGENOUS VARIABLE NUMBER 15 FOR
 THE PERIODS 1967.4 TO 1969.3 **

 YEAR AND QUARTER      1967.4       1968.1       1968.2       1968.3       1968.4
 VALUE OF VARIABLE  13756.0000   13870.0000   14017.0000   14157.0000   14281.0000

 YEAR AND QUARTER      1969.1       1969.2       1969.3
 VALUE OF VARIABLE  14458.0000   14690.0000   14708.0000

?stop   (No more exogenous variables to be printed)

?print rvar   (The user now wants to print some recursive variables)

 ** ENTER THE RECURSIVE VARIABLE NUMBER AND THE PERIODS FOR WHICH ITS
 VALUES ARE TO BE PRINTED. FOR INFORMATION TYPE - HELP **

?10,1967.1,1968.4

 ** INCORRECT PERIOD SPECIFICATION. EARLIEST AND LATEST PERIODS FOR WHICH
 RECURSIVE VARIABLES CAN BE PRINTED ARE 1967.2 AND 1970.1 . TRY AGAIN **

?12,1967.2,1969.4

 ** THE FOLLOWING ARE THE VALUES OF RECURSIVE VARIABLE NUMBER 12 FOR
 THE PERIOD 1967.2 TO 1969.4 **

 YEAR AND QUARTER     1967.2      1967.3      1967.4      1968.1      1968.2
 VALUE OF VARIABLE    1799.3599   1809.9199   1820.5398   1831.2200   1841.9700

 YEAR AND QUARTER     1968.3      1968.4      1969.1      1969.2      1969.3
 VALUE OF VARIABLE    1852.7798   1863.6499   1874.5798   1885.5798   1896.6499

 YEAR AND QUARTER     1969.4
 VALUE OF VARIABLE    1907.7798

?stop    (No more recursive variables to be printed)
```

```
?  print      s var  (There must be no blanks embedded in any word as is in 's var' in this command)

  ** ILLEGAL COMMAND. TRY AGAIN **

   PRINT      S VAR
?  print     svar     (The command to print simultaneous variables is correctly entered)

  ** ENTER THE SIMULTANEOUS VARIABLE NO. AND THE PERIODS FOR WHICH ITS
 VALUES ARE TO BE PRINTED. FOR INFORMATION TYPE - HELP **
?03,1969.4-1970.1

  ** THE FOLLOWING ARE THE VALUES OF SIMULTANEOUS VARIABLE NUMBER  3 FOR
 THE PERIOD 1969.4 TO 1970.1 **

 YEAR AND QUARTER    1969.4       1970.1
 VALUE OF VARIABLE   6216.0000    5850.0000

?11,1969.1,1970.1 (Some more values of another simultaneous variable are to be printed)

  ** THE FOLLOWING ARE THE VALUES OF SIMULTANEOUS VARIABLE NUMBER 11 FOR
 THE PERIOD 1969.1 TO 1970.1 **

 YEAR AND QUARTER    1969.1       1969.2       1969.3       1969.4       1970.1
 VALUE OF VARIABLE       3.3000       3.9000       4.3700       2.9300       5.5700

?stop  (No more values of simultaneous variables to be printed)
?    print    constants

  ** ENTER NUMBERS OF THE CONSTANTS TO BE PRINTED. FOR INFORMATION TYPE
 - HELP **

?help

  ** NUMBERS OF THE CONSTANTS TO BE PRINTED MUST BE ENTERED IN THE FORM
 C1(D)C2, WHERE:
 C1  = NUMBER OF THE CONSTANT STARTING WHICH THE VALUES ARE TO BE PRINTED,
       (1 TO 999, FORMAT I3),
 C2  = NUMBER OF THE CONSTANT UP TO AND INCLUDING WHICH THE VALUES ARE TO
       BE PRINTED, (1 TO 999, FORMAT I3),
 (D) = A DELIMITOR, A COMMA (,) OR A DASH (-).

  ** C1 MUST BE LESS THAN OR EQUAL TO C2. WHEN C1 AND C2 ARE EQUAL, VALUE
 OF ONLY ONE CONSTANT WILL BE PRINTED **
```

```
 ** ENTER NUMBERS OF THE CONSTANTS TO BE PRINTED. FOR INFORMATION TYPE
- HELP **

?003-009

 ** THE FOLLOWING ARE THE VALUES OF CONSTANTS FROM CONSTANT NUMBER   3
TO CONSTANT NUMBER   9 **

NUMBER        3           4           5           6           7           8           9
VALUE        0.0         0.0         0.0         0.0         0.0         0.0         0.0

?   mts    (This command will return control to MTS)
#restart   (The control is now returned back from MTS to SOLAMI)

 ** ENTER COMMANDS **

?   change   niter

 ** ENTER A NEW VALUE FOR THE NUMBER OF ITERATIONS FOR WHICH COMPUTATIONS
OF SIMULTANEOUS EQUATIONS ARE TO BE CARRIED OUT TO ACHIEVE A CONVERGENCE
IN I3 FORMAT **
?050

 ** OLD VALUE OF THE NUMBER OF ITERATIONS FOR WHICH COMPUTATIONS OF
SIMULTANEOUS EQUATIONS ARE CARRIED OUT TO ACHIEVE A CONVERGENCE IS  50
AND ITS NEW VALUE IS  50 **

?change   niter

 ** ENTER A NEW VALUE FOR THE NUMBER OF ITERATIONS FOR WHICH COMPUTATIONS
OF SIMULTANEOUS EQUATIONS ARE TO BE CARRIED OUT TO ACHIEVE A CONVERGENCE
IN I3 FORMAT **
?075

 ** OLD VALUE OF THE NUMBER OF ITERATIONS FOR WHICH COMPUTATIONS OF
SIMULTANEOUS EQUATIONS ARE CARRIED OUT TO ACHIEVE A CONVERGENCE IS  50
AND ITS NEW VALUE IS  75 **
```

```
?  change  niter

 ** ENTER A NEW VALUE FOR THE NUMBER OF ITERATIONS FOR WHICH COMPUTATIONS
OF SIMULTANEOUS EQUATIONS ARE TO BE CARRIED OUT TO ACHIEVE A CONVERGENCE
IN I3 FORMAT **
?050   (niter is set back to its original value)

 ** OLD VALUE OF THE NUMBER OF ITERATIONS FOR WHICH COMPUTATIONS OF
SIMULTANEOUS EQUATIONS ARE CARRIED OUT TO ACHIEVE A CONVERGENCE IS  75
AND ITS NEW VALUE IS  50 **


?  change   concri  (concri = CONvergence CRiterion for the solution of simultaneous
                     equations)
 ** ENTER A NEW VALUE FOR THE CONVERGENCE CRITERION IN F6.3 FORMAT **
?0.05

 ** OLD VALUE OF CONVERGENCE CRITERION IS  0.010 AND ITS NEW VALUE IS
0.050 **


?  c   concri

 ** ENTER A NEW VALUE FOR THE CONVERGENCE CRITERION IN F6.3 FORMAT **
?0.01

 ** OLD VALUE OF CONVERGENCE CRITERION IS  0.050 AND ITS NEW VALUE IS
0.010 **
?c      evar

 ** ENTER THE EXOGENOUS VARIABLE NUMBER, THE PERIOD FOR WHICH IT IS TO
BE CHANGED AND ITS NEW VALUE. FOR INFORMATION TYPE - HELP **
?help

 ** THE EXOGENOUS VARIABLE NUMBER,THE PERIOD FOR WHICH IT IS TO BE CHA-
NGED AND ITS NEW VALUE MUST BE ENTERED IN THE FORM - VARNO(D)YRQU(D)NVL,
WHERE:

VARNO = NUMBER OF THE VARIABLE WHOSE VALUE IS TO BE CHANGED (1 TO 99,
        FORMAT I2),
 YRQU = YEAR AND QUARTER OF THE PERIOD FOR WHICH VALUE OF THE VARIABLE
        IS TO BE CHANGED (FORMAT F6.1). YRQU CAN BE ANY PERIOD BETWEEN
        1960.1 AND 1980.4, PROVIDED DATA FOR THAT PARTICULAR PERIOD HAVE
        BEEN READ.
NVL   = NEW VALUE OF THE VARIABLE. THIS VALUE MUST BE WITHIN ELEVEN COL-
        UMNS AND MUST CONTAIN A DECIMAL POINT AND IF NECESSARY A SIGN
        ALSO.
(D)   = DELIMITOR, A COMMA (,) OR A DASH (-).

 ** ENTER THE EXOGENOUS VARIABLE NUMBER, THE PERIOD FOR WHICH IT IS TO
BE CHANGED AND ITS NEW VALUE. FOR INFORMATION TYPE - HELP **
?05,1969.2,98.2

 ** OLD VALUE OF VARIABLE NUMBER  5 FOR THE YEAR 1969.2 IS     111.4000
AND ITS NEW VALUE IS      98.2000 **
?05,1969.2,111.4

 ** OLD VALUE OF VARIABLE NUMBER  5 FOR THE YEAR 1969.2 IS      98.2000
AND ITS NEW VALUE IS     111.4000 **
?st   (No more exogenous variables to be changed)
```

```
? change niter

 ** ENTER A NEW VALUE FOR THE NUMBER OF ITERATIONS FOR WHICH COMPUTATIONS
 OF SIMULTANEOUS EQUATIONS ARE TO BE CARRIED OUT TO ACHIEVE A CONVERGENCE
 IN I3 FORMAT **
?050   (niter is set back to its original value)

 ** OLD VALUE OF THE NUMBER OF ITERATIONS FOR WHICH COMPUTATIONS OF
 SIMULTANEOUS EQUATIONS ARE CARRIED OUT TO ACHIEVE A CONVERGENCE IS  75
 AND ITS NEW VALUE IS  50 **


? change   concri  (concri = convergence criterion for the solution of simultaneous
                    equations)
 ** ENTER A NEW VALUE FOR THE CONVERGENCE CRITERION IN F6.3 FORMAT **
?0.05

 ** OLD VALUE OF CONVERGENCE CRITERION IS  0.010 AND ITS NEW VALUE IS
 0.050 **


?  c   concri

 ** ENTER A NEW VALUE FOR THE CONVERGENCE CRITERION IN F6.3 FORMAT **
?0.01

 ** OLD VALUE OF CONVERGENCE CRITERION IS  0.050 AND ITS NEW VALUE IS
 0.010 **
?c      evar

 ** ENTER THE EXOGENOUS VARIABLE NUMBER, THE PERIOD FOR WHICH IT IS TO
 BE CHANGED AND ITS NEW VALUE. FOR INFORMATION TYPE - HELP **
?help

 ** THE EXOGENOUS VARIABLE NUMBER,THE PERIOD FOR WHICH IT IS TO BE CHA-
 NGED AND ITS NEW VALUE MUST BE ENTERED IN THE FORM - VARNO(D)YRQU(D)NVL,
 WHERE:

 VARNO = NUMBER OF THE VARIABLE WHOSE VALUE IS TO BE CHANGED (1 TO 99,
         FORMAT I2),
 YRQU  = YEAR AND QUARTER OF THE PERIOD FOR WHICH VALUE OF THE VARIABLE
         IS TO BE CHANGED (FORMAT F6.1). YRQU CAN BE ANY PERIOD BETWEEN
         1960.1 AND 1980.4, PROVIDED DATA FOR THAT PARTCULAR PERIOD HAVE
         BEEN READ.
 NVL   = NEW VALUE OF THE VARIABLE. THIS VALUE MUST BE WITHIN ELEVEN COL-
         UMNS AND MUST CONTAIN A DECIMAL POINT AND IF NECESSARY A SIGN
         ALSO.
 (D)   = DELIMITOR, A COMMA (,) OR A DASH (-).

 ** ENTER THE EXOGENOUS VARIABLE NUMBER, THE PERIOD FOR WHICH IT IS TO
 BE CHANGED AND ITS NEW VALUE. FOR INFORMATION TYPE - HELP **
?05,1969.2,98.2

 ** OLD VALUE OF VARIABLE NUMBER  5 FOR THE YEAR 1969.2 IS     111.4000
 AND ITS NEW VALUE IS      98.2000 **
?05,1969.2,111.4

 ** OLD VALUE OF VARIABLE NUMBER  5 FOR THE YEAR 1969.2 IS      98.2000
 AND ITS NEW VALUE IS     111.4000 **
?st (No more exogenous variables to be changed)
```

```
?   change      recursive

 ** ENTER THE RECURSIVE VARIABLE NUMBER, THE PERIOD FOR WHICH IT IS TO
 BE CHANGED AND ITS NEW VALUE. FOR INFORMATION TYPE - HELP **
?99,1969.1,77.3

 ** INCORRECT ENTRY. THE VARIABLE NUMBER MUST BE BETWEEN 1 AND 24. TRY
 AGAIN ** (There are only 24 recursive variables defined in the present run - see
?12,1980.2,11.2                                  Appendices I and II)

 ** INCORRECT PERIOD SPECIFICATION. EARLIEST AND LATEST PERIODS FOR WHICH
 RECURSIVE VARIABLES CAN BE CHANGED ARE 1967.2 AND 1970.1 . TRY AGAIN **
?12,1968.2,56.2

 ** OLD VALUE OF VARIABLE NUMBER 12 FOR THE YEAR 1968.2 IS   1841.9700
 AND ITS NEW VALUE IS      56.2000 **
?12,1968.2,1841.97

 ** OLD VALUE OF VARIABLE NUMBER 12 FOR THE YEAR 1968.2 IS     56.2000
 AND ITS NEW VALUE IS   1841.9700 **
?stop   (No more recursive variables to be changed)


?    change   svar

 ** ENTER THE SIMULTANEOUS VARIABLE NUMBER,THE PERIOD FOR WHICH IT IS TO
 BE CHANGED AND ITS NEW VALUE. FOR INFORMATION TYPE - HELP **
?05,1969.3,123.6

 ** OLD VALUE OF VARIABLE NUMBER  5 FOR THE YEAR 1969.3 IS    826.0000
 AND ITS NEW VALUE IS     123.6000 **
?05,1969.3,826.0

 ** OLD VALUE OF VARIABLE NUMBER  5 FOR THE YEAR 1969.3 IS    123.6000
 AND ITS NEW VALUE IS     826.0000 **
?stop   (No more simultaneous variables to be changed)

? change constants

 ** ENTER NUMBER OF THR CONSTANT TO BE CHANGED AND ITS NEW VALUE. FOR
 INFORMATION TYPE - HELP **
?help

 ** THE NUMBER OF THE CONSTANT TO BE CHANGED AND ITS NEW VALUE MUST BE
 ENTERED IN THE FORM - C(D)NVL, WHERE:

 C   = NUMBER OF THE CONSTANT TO BE CHANGED (1 TO 999, FORMAT I3).
 NVL = NEW VALUE OF THE CONSTANT. THIS VALUE MUST BE WITHIN ELEVEN COL-
       UMNS AND MUST CONTAIN A DECIMAL POINT AND IF NECESSARY A
       SIGN ALSO.
 (D) = A DELIMITOR, A COMMA (,) OR A DASH(-).

 ** ENTER NUMBER OF THR CONSTANT TO BE CHANGED AND ITS NEW VALUE. FOR
 INFORMATION TYPE - HELP **
?099,-23.0

 ** INCORRECT ENTRY. NUMBER OF THE CONSTANT MUST BE BETWEEN 1 AND  50.
 TRY AGAIN **
```

```
?044,8.0

 ** OLD VALUE OF CONSTANT NUMBER  44 IS         0.0   AND ITS NEW VALUE
 IS       8.000 **
?044,0.0

 ** OLD VALUE OF CONSTANT NUMBER  44 IS         8.000 AND ITS NEW VALUE
 IS       0.0    **
?stop (No more constants to be changed)

?   simulate  (The simulation mode - dynamic or quarterly - must also be defined)

 ** ILLEGAL COMMAND. TRY AGAIN **

    SIMULATE
?  simulate    dynamically

 ** THIS MODEL CAN BE SIMULATED FOR A TOTAL OF  0 PERIODS. YOU HAVE SO
 FAR SIMULATED  0 PERIODS ** (The maximum number of periods that can be simulated
 depends on the beginning period of simulation and the last period of data in the file)
 ** ENTER THE NUMBER OF PERIODS FOR THIS SIMULATION RUN IN I2 FORMAT **
?12

 ** INCORRECT ENTRY. TRY AGAIN **
?-2

 ** INCORRECT ENTRY. TRY AGAIN **
?02

 ** SIMULATION FOR A TOTAL OF  2 PERIODS DONE. THE BEGINNING PERIOD OF
 SIMULATION IS 1968.1 AND THE LAST PERIOD IS 1968.2 . YOU MAY PRINT THE
 RESULTS USING PROPER COMMANDS **

 ** ENTER SELECTIVE PRINTING COMMANDS. FOR INFORMATION TYPE - HELP **

?help

 ** THE FOLLOWING COMMANDS, WHICH ARE FOR SELECTIVE PRINTING OF RESULTS
 SHOULD BE USED ONLY AFTER THE MODEL IS SIMULATED FOR ATLEAST ONE PERIOD.

 ** THE PARENTHESIZED LETTER(S) CAN BE USED AS AN ABBREVIATION OF THE
 CORRESPONDING WORD.

 ** (P)RINT (R)ESULTS 1969.1 1969.3 1968.4 ETC. - FOR PRINTING COMPLETE
 SIMULATION RESULTS FOR THE PERIODS SPECIFIED.
 ** (P)RINT (S)UMMARY 1969.1 1968.4 1971.3 ETC. - FOR PRINTING ONLY A
 SUMMARY OF SIMULATION RESULTS FOR THE PERIODS SPECIFIED.

 ** IN THE ABOVE TWO COMMANDS THERE MUST BE ATLEAST ONE BLANK BETWEEN
 TWO CONSECUTIVE PERIODS. THE ORDER IN WHICH THE PERIODS ARE ENTERED IN
 A COMMAND LINE IS UNIMPORTANT BUT THEIR MAXIMUM NUMBER SHOULD
 NOT EXCEED EIGHT. THE RESULTS FOR ALL THE  PERIODS SIMULATED WILL BE
 PRINTED IF THEIR SPECIFICATION IS COMPLETELY OMITTED FORM THE COMMAND.
```

```
 ** (P)RINT (STAT)ISTICS - FOR PRINTING STATISTICS FOR RESIDUALS OF
RECURSIVE AND SIMULTANEOUS VARIABLES.
 ** (S)IMULATE - TO RESTART THE SIMULATION.
 ** (ST)OP - TO STOP AND RERUN THE SIMULATION FOR THE SAME OR SOME OTHER
SMSA.
 ** STATUS - FOR PRINTING THE NUMBER OF PERIODS SIMULATED SO FAR AND THE
PRESENT SIMULATION MODE.
 ** (H)ELP - FOR OBTAINING A LIST OF SELECTIVE PRINTING COMMANDS.
 ** (M)TS - TO RETURN TO MTS WITHOUT SUSPENDING THIS PROGRAM. TO RETURN
BACK FROM MTS TO THIS PROGRAM TYPE IN - RESTART.
 ** (R)ERUN - SAME AS STOP FOR THIS PART OF THE PROGRAM.
 ** (T)ERMINATE - FOR TERMINATING THIS SESSION.

?   status

 ** THIS MODEL CAN BE SIMULATED FOR A TOTAL OF  9 PERIODS. YOU HAVE SO
FAR SIMULATED  2 PERIODS. THE FIRST PERIOD IS 1968.1 AND THE LAST PERIOD
IS 1968.2 **

 ** THIS IS A DYNAMIC SIMULATION RUN **
?   p    results    1985.1  1969.4
** ILLEGAL SIMULATION YEAR-QUARTER 1985.1 **

 ** PERIOD 1969.4 HAS NOT BEEN SIMULATED **
```

? print results 1968.2

** SIMULATION RESULTS FOR THE DETROIT SMSA FOR 1968.2 **

**V A R I A B L E **		E M P L O Y M E N T **		RESIDUAL **
** TYPE	*NO.**	ACTUAL	** PREDICTED **	**
RECURSIVE	1	105.570	105.157	0.413
RECURSIVE	2	105.690	105.674	0.016
RECURSIVE	3	798.430	798.426	0.004
RECURSIVE	4	584.960	584.955	0.005
RECURSIVE	5	8619.617	8619.594	0.023
RECURSIVE	6	1708.930	1708.911	0.019
RECURSIVE	7	1419.790	1419.762	0.028
RECURSIVE	8	759.450	759.450	-0.000
RECURSIVE	9	633.050	633.059	-0.009
RECURSIVE	10	6798.297	6798.266	0.031
RECURSIVE	11	4385.129	4385.078	0.051
RECURSIVE	12	1841.970	1841.936	0.034
RECURSIVE	13	27549.629	27549.430	0.199
RECURSIVE	14	38.273	38.278	-0.005
RECURSIVE	15	66.743	66.754	-0.011
RECURSIVE	16	93.986	93.986	0.000
RECURSIVE	17	81.145	81.285	-0.140
RECURSIVE	18	21.503	21.503	0.000
RECURSIVE	19	26.392	26.392	-0.000
RECURSIVE	20	56.029	56.029	0.000
RECURSIVE	21	44.114	44.114	0.000
RECURSIVE	22	43.325	43.326	-0.001
RECURSIVE	23	8.293	8.293	0.000
RECURSIVE	24	16095.988	16098.387	-2.398
SIMULTANEOUS	1	5086.000	4980.418	105.582
SIMULTANEOUS	2	895.000	899.406	-4.406
SIMULTANEOUS	3	5981.000	5879.824	101.176
SIMULTANEOUS	4	2815.000	2790.777	24.223
SIMULTANEOUS	5	758.000	772.647	-14.647
SIMULTANEOUS	6	2879.000	2833.685	45.315
SIMULTANEOUS	7	1951.000	1959.468	-8.468
SIMULTANEOUS	8	422.000	412.604	9.396
SIMULTANEOUS	9	16154.699	15997.687	157.012
SIMULTANEOUS	10	14375.066	15235.547	-860.480
SIMULTANEOUS	11	3.870	3.870	0.0
SIMULTANEOUS	12	16095.988	15848.895	247.094

```
? simulate  (Simulation will proceed in dynamic mode as that was the original mode
            for this run)
 ** THIS MODEL CAN BE SIMULATED FOR A TOTAL OF  9 PERIODS. YOU HAVE SO
FAR SIMULATED  2 PERIODS **

 ** ENTER THE NUMBER OF PERIODS FOR THIS SIMULATION RUN IN I2 FORMAT **
?04

 ** SIMULATION FOR A TOTAL OF  6 PERIODS DONE. THE BEGINNING PERIOD OF
SIMULATION IS 1968.1 AND THE LAST PERIOD IS 1969.2 . YOU MAY PRINT THE
RESULTS USING PROPER COMMANDS **


?rerun  (The user wants to start a fresh simulation run)

 ** ALL CLEAR. YOU ARE NOW READY FOR THE NEXT SIMULATION RUN **

 ** ENTER THE SMSA CODE OR ITS NAME. FOR INFORMATION TYPE - HELP **

?dt

 ** DETROIT SMSA TO BE SIMULATED. THE NECESSARY DATA WILL BE READ FROM
THE FILE SAWV:DT **

 ** ENTER THE BEGINNING YEAR AND QUARTER OF SIMULATION IN F6.1 FORMAT.
FOR INFORMATION TYPE - HELP **

?1969.4

 ** THE BEGINNING YEAR AND QUARTER OF SIMULATION IS 1969.4 **

 ** ALL THE NECESSARY DATA HAVE BEEN READ IN FROM THE FILE SAWV:DT **

 ** ENTER COMMANDS **
?  simulate   quarterly

 ** THIS MODEL CAN BE SIMULATED FOR A TOTAL OF  2 PERIODS. YOU HAVE SO
FAR SIMULATED  0 PERIODS **

 ** ENTER THE NUMBER OF PERIODS FOR THIS SIMULATION RUN IN I2 FORMAT **
?02

 ** SIMULATION FOR A TOTAL OF  2 PERIODS DONE. THE BEGINNING PERIOD OF
SIMULATION IS 1969.4 AND THE LAST PERIOD IS 1970.1 . YOU MAY PRINT THE
RESULTS USING PROPER COMMANDS **

 ** ENTER SELECTIVE PRINTING COMMANDS. FOR INFORMATION TYPE - HELP **
?   status (Other selective printing commands can also be entered)

 ** THIS MODEL CAN BE SIMULATED FOR A TOTAL OF  2 PERIODS. YOU HAVE SO
FAR SIMULATED  2 PERIODS. THE FIRST PERIOD IS 1969.4 AND THE LAST PERIOD
IS 1970.1 **

 ** THIS IS A QUARTERLY SIMULATION RUN **

?terminate  (The simulation will be terminated and control will return to MTS.  If
 the user wants to simulate again he should start all over again by entering the command
 ** END OF SESSION. THANK YOU **                          $SOURCE SAWV:SOLAMI)
#EXECUTION TERMINATED
```

APPENDIX D

AN UNEMPLOYMENT INSURANCE MODEL

Stephen T. Marston*

4.0 Introduction

The central and by far the most important support for unemployed workers in America is the unemployment insurance (UI) system. Established in 1935 UI paid out $2.2 billion in benefits to five million people in 1969. This support is paid as a right of the insured worker; it does not require a humiliating demonstration of poverty. Neither does a jury sit in judgement of this compensation; only a routine administrative decision is usually necessary to secure payments. The fundamental decisions are left to economic forces: the ebb and flow of employment, the distribution of employment among firms and individuals and the level of wages. These factors determine UI benefit payments, on the one hand, and UI employer contributions, on the other.

The objective of this model is to provide accurate forecasts of the levels of UI variables in Detroit, Michigan. Specifically three quantities will be projected for the Detroit standard metropolitan statistical area (SMSA):

1. The Total Cost of UI Benefits - The amount of compensation paid out during a future time period.
2. Insured Unemployment - The number of individuals reporting a week of unemployment under the UI program.
3. UI Benefit Exhaustions - The number of people who will receive their final UI payment and become ineligible for further compensation.

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* The research on this model was sponsored by the Manpower Administration, Office of Research and Development, United States Department of Labor, under contract 71-24-70-02 and 91-26-74-03. The views represented in this paper are the sole responsibility of the author and do not necessarily reflect the views of the Department of Labor.

4.0.1 State UI Policy Guidance

Each of the above quantities is useful in forming state policies and laws in the UI area. UI benefit payments are drawn out of state funds contributed by employers for UI purposes. The fund must maintain a positive balance, yet it must not be allowed to grow unnecessarily large. In the long run optimal employer contribution rates should be designed to minimize the excess of employer contributions over UI payments, subject to the constraint that the fund must retain a positive balance at all times. These optimal employer contribution rates can only be calculated with reference to accurate long-run projections of future UI payments. Optimal employer contribution rates would minimize the economic distortion caused by compulsory employer contributions. In the long run optimal employer contribution rates should be one of the goals of state UI legislation.

In the short run accumulated UI fund balances should be used as productively as possible. State UI fund balances are deposited with the U.S. Treasury where they earn a substantial return. The goal of month-to-month state policy should be to requistion only the minimum funds from that account necessary to meet future UI expenditures. Any larger requisition results in the wastage of earnings which would otherwise accrue in the U.S. Treasury account. Estimation of the minimum requisition requires a short-run projection of UI expenditures. Accurate projections could possibly save the states large sums annually in foregone earnings. Thus projections of UI benefit payments can help guide state planning-programming-budgeting in both the long run and the short run.

The number of insured unemployed workers is equal to the number of continued UI claims made and will be an indicator of the activity to be expected in the Employment Security branch offices. It will also be useful to compare the insured unemployment with total unemployment to get a view of the adequacy of the UI system. Also useful in this view is the number of benefit exhaustions. When people exhaust their UI benefits they are forced to provide income for themselves in other ways. Hence they may become welfare burdens or require other expenditures of the state.

In addition to providing forecasts of the three useful quantities mentioned above, this model will provide answers to critical questions about the UI system itself, particularly regarding the costs and benefits of proposed alterations to the UI system. For example, if the Michigan State Legislature increases the maximum duration of UI benefits from 26 to 39 weeks, what will be the increase in insured unemployment, the increase in the cost of UI payments, and the decrease in the number of benefit exhaustions? This question can be asked for any reasonable increase or decrease in the maximum duration of benefits, and the model will provide estimates of the number of insured unemployed, amount of payments and exhaustions that will result.

Other types of questions which can be answered by this model are the effect upon insured unemployment, payments and exhaustions of increases in the industrial coverage of the Michigan UI system, alterations in the rules for making monetary determinations for new UI claimants, or changes in the average amount of payments. The model will simulate the proposed UI system and generate forecasts of these variables for the new system. The forecasts will be useful to lawmakers in estimating the costs of their proposals and in judging whether the UI system they propose will achieve the income security they seek.

4.0.2 Manpower Issues

The Insured Unemployment equation of this model focuses on the process by which insured unemployed workers find their way back to employment. In so doing it illuminates some issues relating to the duration of unemployment: How does an individual's chance of finding employment depend upon the length of time he has been unemployed? How does his chance of finding employment depend upon the "tightness" of the labor market? To what extent might an individual's chance of becoming employed be influenced by the payment of UI benefits? These issues are addressed and some hypotheses are advanced.

The method of dealing with these issues is a probabilistic time analysis introduced recently by economists studying "labor turnover" [19, 28, 13]. Viewed from a methodological point this UI model is an application of labor turnover economics.

Labor turnover has received increasing attention among economists because of a desire to look beyond the stock nature of employment and unemployment and examine the important flows between employment, unemployment and leaving the labor force. It is, for instance, of critical importance whether a given level of unemployment consists of a large number of people who remain unemployed only briefly, or, alternatively, by fewer people who remain unemployed much longer. What data exist suggest that the United States is characterized by rapid labor turnover, rather than by a large, stagnant unemployment pool. It is also important whether the high unemployment of a particular socio-economic group is due to short job tenure or long unemployment duration. The appropriate remedy for unemployment will depend very much upon the answers to these questions.

4.0.3 Current Development of the Model

The model is currently in the form of final equations which have been tested successfully over the sample period for Detroit from 1966 through 1971. The next step is to test the model for its predictive power beyond the sample period and run simulations to test alternative policies. This task is progressing under a doctoral grant from the Manpower Administration.

While the model has been developed for Detroit, it is equally applicable to the entire state of Michigan. This would involve reestimating the equations using state data. The model should be thought of as a prototype for similar models which could be developed for other states or for other SMSAs. Since UI systems differ among the states, models for other states will differ from the one for Michigan, but will retain the same basic structure. This is, of course, the great advantage of state or SMSA-level UI models: their scope is no larger than the UI systems themselves.

The model has not yet been linked up to other models such as the LMIS employment model. This would consist of specifying and estimating and equation to forecast layoff rates from the employment model. Some attention has been devoted to this goal, but incompatibilities between the published data on employment and the published data on layoff rates[1] have so far prevented realization.

4.1 An Overview of the UI Model

4.1.1 The Variables and Data

Figure 5 lays out the provisions of the Michigan UI law in diagramatic form. The system is similar to that of the other states. A recently laid off worker who is covered by UI may make an initial claim and receive a determination of the number of weeks for which he is eligible to collect UI benefits. After a one week waiting period he is eligible for payments by making a continued claim each week. If the person is unemployed longer than his determination, he may receive extended benefits or become an exhaustee. During this process he may delay filing his initial claim, be disqualified, become employed or leave the labor force.

This diagram is too detailed to be used directly to generate an estimable UI model. Figure 6 has been drawn to simplify the UI system, leaving out administrative minutae and concentrating on the main flows.

Each of the categories represented by a box in Figure 6 corresponds to a variable in the model. Each variable represents the number of people in that category. Each of the arrows represents a transition from one category to another and generally requires the passage of time. So the model can be viewed as a stochastic chain relating the number of people in each category intertemporally.

This form of the model is desirable for three reasons:

1) The Michigan UI laws and worker behavior determine the relations in an understandable way.
2) The data available at Michigan Employment Security Commission (MESC) correspond to the categories it defines.
3) It leads to a model which is related closely enough to the UI laws that changes in those laws can be introduced and their effects deduced.

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[1] See [36] p. 117 for a discussion of these incompatibilities.

Figure 5 Flow Chart For Unemployment Insurance Claims

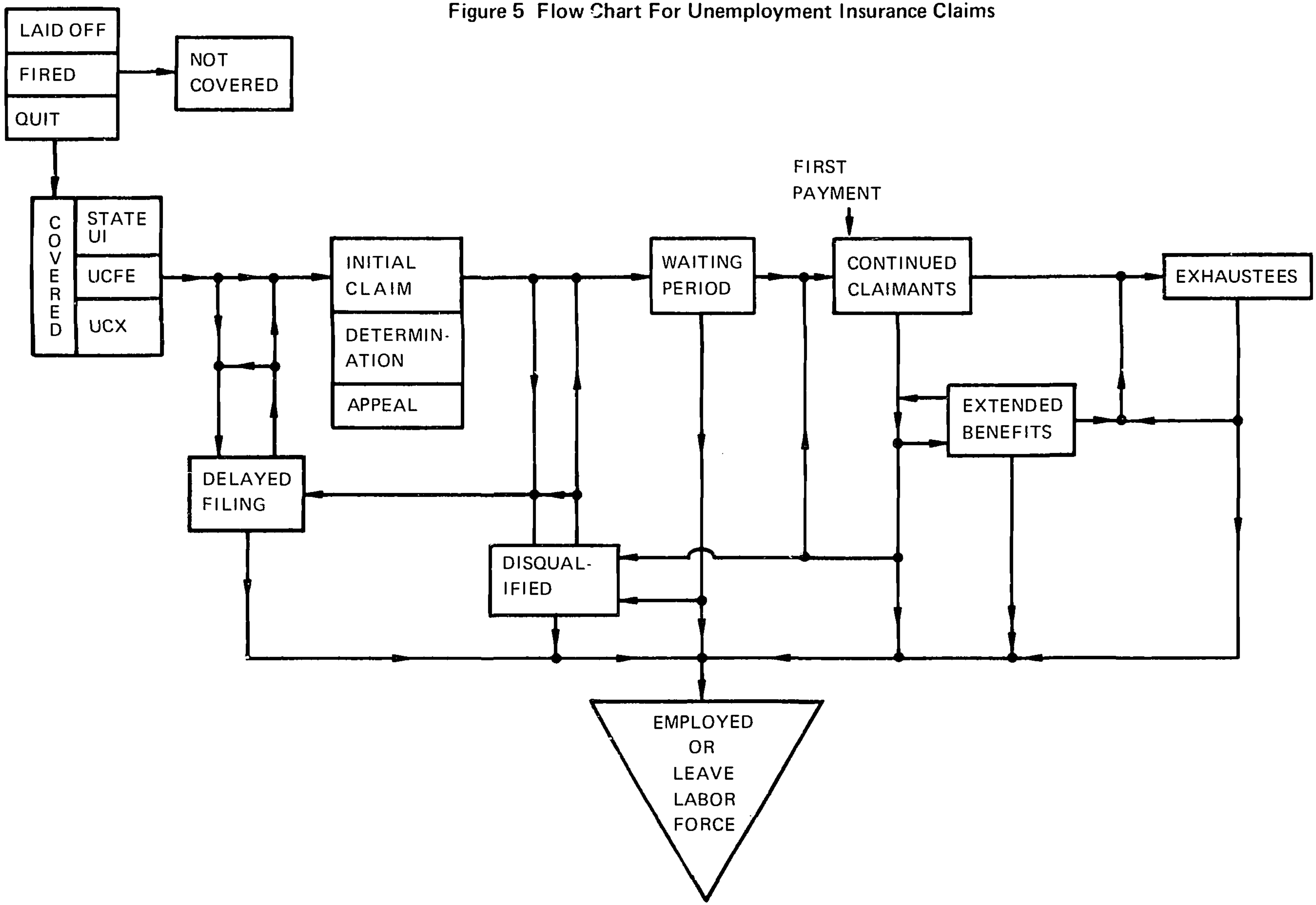
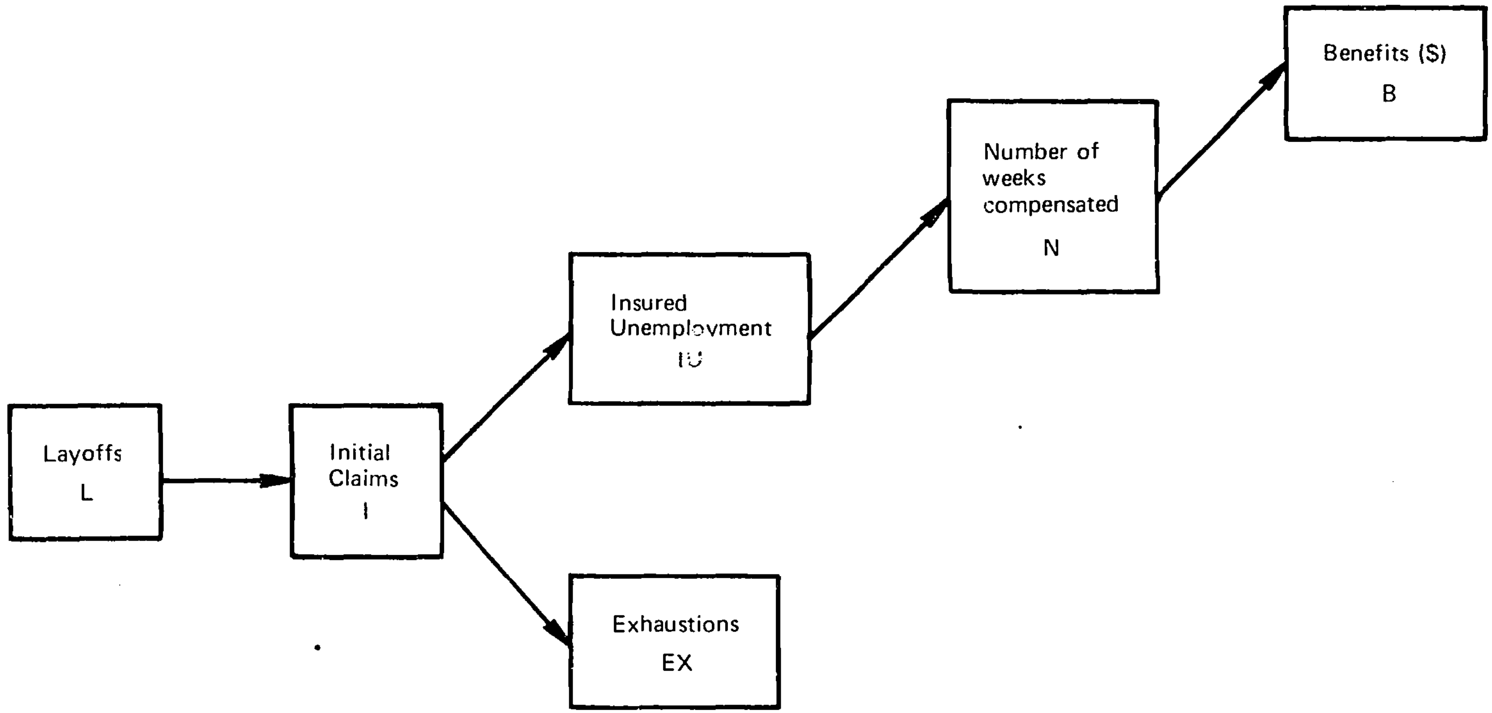


Figure 6 *Simplified Flow Chart For UI Variables and Equations*



4.1.2 An Overview of the Model

The cost of UI benefits (B) is closely related to the number of insured unemployed workers (UI). This cost in dollars can be found by multiplying the number of weeks compensated (N) by the average amount of one payment. The number of weeks compensated is slightly less than the number of insured unemployed (allowance must be made for waiting weeks and disqualifications) and the average payment is primarily a function of recent wages. These simple relationships define two econometric equations, the first of which gives benefit costs as a function of the number of weeks compensated and the second of which gives the number of weeks compensated as a function of insured unemployment.

The size of insured unemployment has long been considered a difficult quantity to forecast and the forecasting problems that exist are more severe on the state or SMSA level than they are on the national level. One difficulty is that the SMSA unemployment rate may not be used as a driving variable to determine SMSA insured unemployment, although the national unemployment rate is used by the UI Service to predict the number of recipients of federal unemployment compensation programs. This is due to the origin of state unemployment data: on the state and SMSA levels, the number of total unemployed (and, thus, the unemployment rate) is calculated originally from the number of insured unemployed [5].[2] The Current Population Survey (CPS), which gives national unemployment rates, though available for metropolitan areas, is not commonly reported and used. This leaves the labor market analyst with an unemployment figure which has been derived from the insured unemployment figure and should not be used to re-calculate the insured unemployment figure. This would amount to calculating A from B and B from A without obtaining any net improvement in information. The state unemployment figures are quite useful generally, but not for direct use in a UI model.

Even if an independent unemployment estimate were available (such as from the CPS) there would be problems with using it to predict insured unemployment. The insured unemployed are primarily "job losers",

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[2] The so-called "70-step procedure".

whereas total unemployment includes "job leavers" and "new entrants and reentrants to the labor force." This is because new entrants to the labor force are not covered under existing Michigan UI laws and job leavers must endure a substantial disqualification period before receiving benefits. Reentrants are mostly uncovered. The relative size of the four aggregates changes over the course of the business cycle, leading to an often observed phenomenon where the insured unemployment rate rises relative to the unemployment rate in the beginning of an economic downturn and reverses itself during the upswing [12].

The LMIS predictions, therefore, are based upon the layoff rates from the Job Openings and Labor Turnover Sample (JOLTS). Two equations are used: (1) The first equation predicts the number of initial UI claims from the number of layoffs. The difference between the two results from layoffs in non-covered industries and laid-off workers who delay filing or do not file for UI. (2) The second equation predicts the number of insured unemployed from the number of initial claims. This is done by using a system of "continuation rates" (analogous to survival rates in population models) to predict the number of people receiving UI from the number who made initial claims in previous months. The two equations work together to predict insured unemployment from layoffs.

A final equation predicts benefit exhaustions (EX) from initial claims using a similar "continuation rate" method to predict the number of initial claimants from previous months who are still unemployed at the end of their maximum benefit duration.

4.1.3 List of Variables and Equations

This model includes six primary variables and two secondary variables. The primary variables influence each other directly, while the secondary variables influence the operation of the model indirectly by modifying the relationships among the primary variables.

1) Primary Variables

   A. Layoffs (L)

   B. Initial Claims (I)

   C. Insured Unemployment (IU)

   D. Exhaustions (EX)

   E. Number of Weeks Compensated (N)

1) Primary Variables (cont.)

F. Amount of Benefit Payments (B)

2) Secondary Variables

A. Unemployment Rate (u)

B. Rate of Accessions in Manufacturing (A)

Three of these variables are exogenous to the system: layoffs, the unemployment rate and the rate of accessions in manufacturing. Each of the other five variables has an equation to forecast it. Minor variables are defined for temporary purposes in situations where they are required. The letters a and b are used repeatedly to represent equation parameters.

There are five equations in the model, each relating two primary variables to each other. The equations are named according to the name of the dependent variable of the equation.

3) Equations

A. Initial Claim

B. Insured Unemployment

C. Exhaustions

D. Number of Weeks Compensated

E. Amount of Benefit Payments

The insured unemployment equation and the exhaustions equation are similar in that they both use a non-stationary Markov specification and a non-linear method of estimation. These similarities make it convenient to treat them together in Sections 4.3 and 4.4. The initial claims, number of weeks compensated and benefit payments equations are similar in that they are all specified in a more traditional linear regression framework. This appears in Section 4.5.

4.2 Two Non-Linear, Non-Stationary Markov Processes: Insured Unemployment, Exhaustions

4.2.1 Definition of Insured Unemployment

Continued claims are filed by covered unemployed workers who have previously filed an initial claim and are returning to collect UI benefits in subsequent weeks. The number of continued claims during a time period is defined as insured unemployment.[3] Initial claims in previous periods generate continued claims in the current period and continued claims, in turn, generate UI benefit payments (also in the current period). Thus the number of continued claims during a time period forms a very useful intermediate variable between initial claims and UI payments.

4.2.2 Determinants of Insured Unemployment

Insured Unemployment during any month or week will be a function of:

1) The number of initial claims in previous periods. (As recently as the previous week and as far back as 26 weeks earlier.) The higher the number of initial claims in previous periods the higher the number of people who can potentially make continued claims in the current period.

2) The "tightness" of the labor market. The more workers who are able to find jobs during previous periods, the fewer of them who will require UI in the current period and will make a continued claim to apply for it. The present model summarizes the unemployed worker's ability fo find work during any period in the "continuation rate": the probability of remaining unemployed during the current period. This is equal to unity minus the probability of finding employment or dropping out of the labor force.

The probability of finding employment for a particular cohort of people is postulated to be a function of (a) how long the cohort has been unemployed already and (b) the demand for labor sources. Hyman Kaitz [19] has shown that the longer a person has been unemployed the less likely he is to find a job by the end of the current period. The

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3 In administrative data continued claims are allocated to the week in which they were filed. However they cover insured unemployment of the preceding week. Hence there is an accounting problem in adjusting the timing of claims to that of insured unemployment. Also, in some jurisdictions there may be bi-weekly claims taking, which requires further adjustment. See Appendix D-6 for data transformation to eliminate both problems.

higher is labor demand the more likely a particular individual is to be hired.

3) The potential duration of payments assigned to UI applicants in previous periods. The longer the potential duration given, the longer the time during which applicants will be eligible for UI and the more initial claimants will still be making continued claims during the current period, because people who made initial claims in earlier time periods will still be eligible to make continued claims. This will mean that longer potential durations will result in more continued claims during the current period.

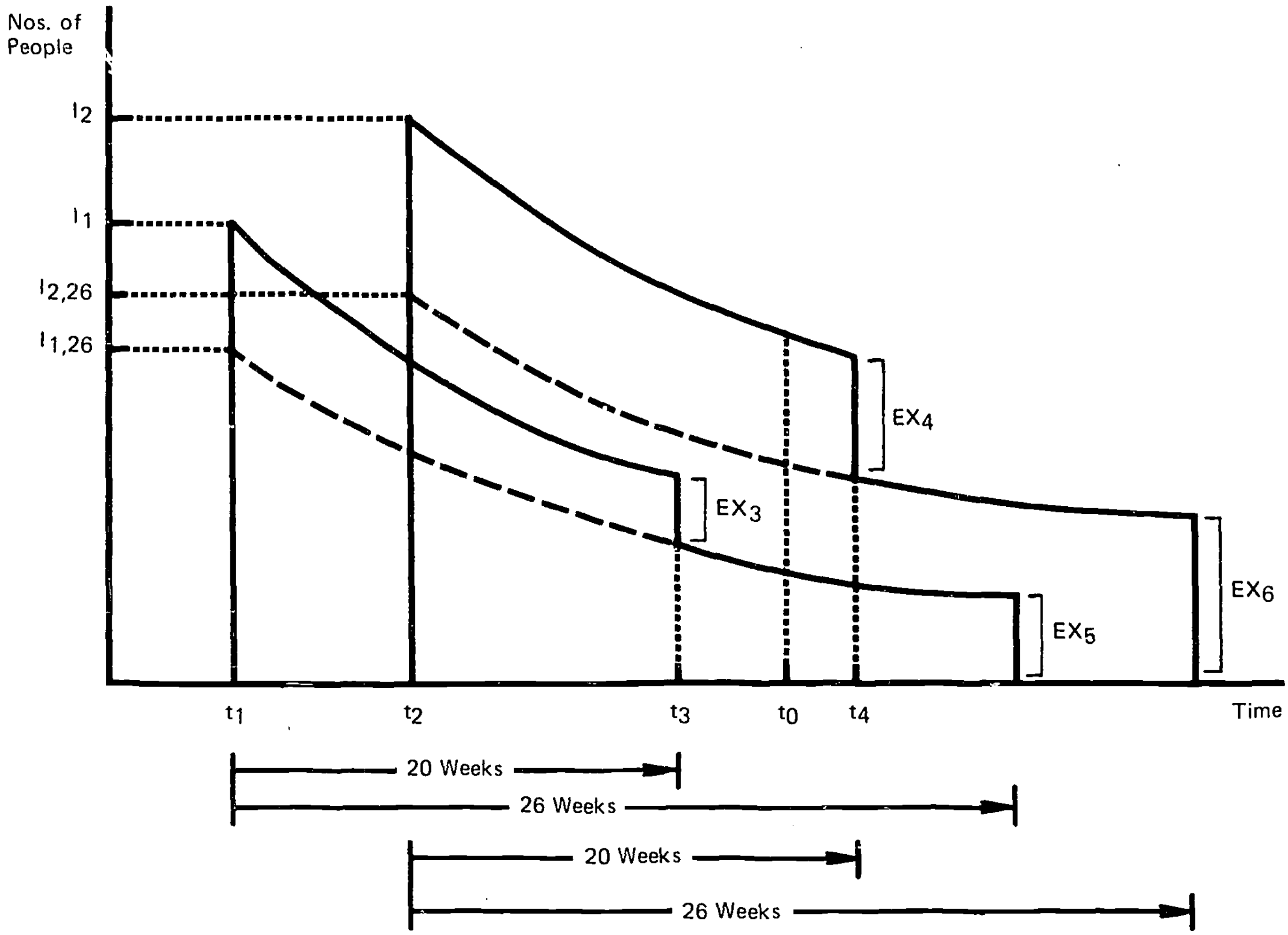
4.2.3 Graphical Presentation

These simple relations lead to a very interesting time dependence. Before trying to grapple with it mathematically it is useful to study a simple picture of the process.

Suppose (in Figure 7) I_1 people file initial claims in week t_1; $I_{1,26}$ of them are eligible for 26 weeks of benefits and $I_{1,20} = I_1 - I_{1,26}$ are eligible for 20 weeks. As time passes the number of continued claimants declines until week t_3 when EX_3 people who were only eligible for 20 weeks exhaust these benefits. After this week only the people who were eligible for 26 weeks of payments survive and decline in number. Similarly for the I_2 people filing initial claims in week t_2. At a particular week t_0 the number of continuing claimants is equal to the number of claimants remaining from $I_{1,26}$ plus the number of claimants remaining from I_2. This means the graphs may be added vertically to calculate the total number of continued claims in any period.

The slope of the curved lines changes as the continuation rate changes. The slope of these lines expresses how many of the UI claimants "survive" into the next period. If the continuation rate is one the curve will be horizontal and the slope will be zero, depicting the situation where no one is leaving the UI system to accept employment, and continued claims are constant between time periods. Conversely, if every UI claimant returned to work during one week the curve would decline almost vertically and the slope would become very negative. In all cases the slope will be between these two extremes and will always

Figure 7 Insured Unemployment



be negative. The present model allows this slope to change in every period depending upon the length of time since initial claim (for example $t_0 - t_1$, for the group which entered in period t_1, assuming t_0 is the current period) and the level of labor demand. For any particular period, say t_0, the slope will differ for the group which entered in t_1 as compared with the slope for the group which entered in t_2 because aggregate labor demand is the same (since we are looking at a single time period) and the length of time since initial claim is different. The first group will always have a "flatter" (less negative) slope at t_0 because its members have been unemployed longer and therefore are less likely to find a job during the current period.

4.2.4 Definitions

Let

$X_{t,p,k}$ = the number of people making a continued claim in week t, who filed their initial claims in week p and who are eligible for k weeks of payments (k = potential duration of benefits).

$I_{p,k}$ = the number of people receiving first payments in week p and eligible for k weeks of benefits.

IU_{tk} = the number of people making a continued claim in week t and who are eligible for k weeks of payments.

IU_t = the number of people filing continued claims in week t; $IU_t = \sum_k IU_{tk}$ = Insured unemployment in week t.

Consider $X_{t,t-i,k}$, the number of people making a continued claim in week t, who filed their initial claim i weeks previous to t and who are eligible for k weeks of payments. Compare this number of people with $X_{t-1,t-i,k}$, the number of people in the same cohort of insured unemployed (same initial claim data and same duration), but counted in the previous week, t-1, rather than t. During the time between week t-1 and week t some of the UI claimants of week t-1 will find jobs, leave the labor force or be disqualified and therefore will not make a claim in week t. However, it is not possible for any new claimants to enter in week t; this is because we are restricting our view to a single cohort who entered in week t-i. Therefore $X_{t-1,t-i,k}$ will necessarily be greater than or equal to $X_{t,t-i,k}$.

Let us define a continuation rate, r, which will be the fraction of UI claimants from a particular cohort who "survive" into the next week. Then

$$X_{t,t-i,k} = rX_{t-1,t-i,k} \tag{61}$$

$$0 \leq r \leq 1.$$

r will certainly not be a constant. It may be different in different weeks t, for different lengths of time i since initial claim, or for different durations k. For complete generality, then,

$$X_{t,t-i,k} = r_{t,i,k} X_{t-1,t-i,k} \tag{62}$$

where the subscripts on r indicate indices which may be relevent to the value of r. Similarly, for the previous week,

$$X_{t-1,t-i,k} = r_{t-1,i,k} X_{t-2,t-i,k} \tag{63}$$

Substituting (63) into (62),

$$X_{t,t-i,k} = r_{t,i,k} r_{t-1,i,k} X_{t-2,t-i,k} \tag{64}$$

Continuing this process for i substitutions

$$X_{t,t-i,k} = \left(\prod_{m=0}^{i-1} r_{t-m,i,k} \right) X_{t-i,t-i,k} \tag{65}$$

Now

$$I_{t-i,k} = X_{t-i,t-i,k} \tag{66}$$

because the number of people making continued claims in week t-i and entering in period t-i is equal to the number of people filing initial claims in period t-i. Define

$$b_{tik} = \prod_{m=o}^{i-1} r_{t-m,i,k} \tag{67}$$

b_{tik} can be interpreted as the probability of remaining unemployed for i weeks, since it is the product of the probabilities of remaining unemployed during each of the i intervening weeks.

Substituting (66) and (67) into (65),

$$X_{t,t-i,k} = b_{tik} I_{t-i,k} \tag{68}$$

IU_{tk} is equal to the sum of continued claims in period t over all cohorts:

$$IU_{tk} = \sum_{i=0}^{k-1} X_{t,t-i,k} \tag{69}$$

or $$IU_{tk} = \sum_{i=0}^{k-1} b_{tik} I_{t-i,k} \tag{70}$$

This equation has a simple interpretation for insured unemployed workers with potential duration of k weeks. b_{tik} is the fraction of such workers unemployed in week t after i weeks of unemployment. Similarly $b_{tik} I_{t-i,k}$ is the number of such workers still unemployed in week t after making initial claims in week t-i. Equation (70) merely states that the number of insured unemployed workers can be calculated by adding up the numbers of workers still unemployed from all previous weeks t-i which are recent enough that the workers will not have exhausted their benefits.

4.2.5 Aggregating Over Potential Duration of Benefits, k

LMIS does not presently have data for Detroit on IU_{tk} or I_{tk}: that is, observations on insured unemployment and initial claims broken down by potential duration (k). Instead it has only the respective sums

$$IU_t = \sum_{k=1}^{K} IU_{tk} \quad \text{and} \quad I_t = \sum_{k=1}^{K} I_{tk} \tag{71}$$

where K = maximum potential duration. We have, however some disaggregate data on initial claims for all of Michigan. Therefore the Detroit model must be aggregated over potential duration, k.

$$IU_t = \sum_{k=1}^{K} IU_{tk} = \sum_{k=1}^{K} \sum_{i=0}^{k-1} X_{t,t-i,k}. \tag{72}$$

Rearranging the summations,

$$IU_t = \sum_{i=0}^{K-1} \sum_{k=i+1}^{K} X_{t,t-k,k}. \tag{73}$$

Substituting for $X_{t,t-i,k}$ from (68)

$$IU_t = \sum_{i=0}^{K} \sum_{k=i+1}^{K} b_{tik} I_{t-i,k}. \quad (74)$$

Assuming the continuation rates do not depend upon k

$$IU_t = \sum_{i=0}^{K-1} b_{ti} \sum_{k=i+1}^{K} I_{t-i,k}. \quad (75)$$

This equation tells us that the proper independent variables for explaining IU_t are $\sum_{k=i+1}^{K} I_{t-i,k}$ rather than the variables of the existing data set, which are $I_{t-i} = \sum_{k=1}^{K} I_{t-i,k}$. We will be using all of the initial claims (summing over all k) whereas we should use only those initial claims which begin a UI payment schedule long enough to extend payment into the current period (summing from i+1 to K). This misspecification of the equation will cause bias in the coefficients and lower the predictive power of the regression. A new factor must be introduced to resolve the contradiction.

Let χ_k be the fraction of initial claimants assigned a potential duration of k weeks.

Then $I_{tk} = \chi_k I_t$. (76)

$$\sum_{k=i+1}^{K} I_{t-i,k} = \left(\sum_{k=i+1}^{K} \chi_k \right) I_t = \delta_i I_t \quad (77)$$

where $\delta_i = \sum_{k=i+1}^{K} \chi_k$ is the fraction of initial claimants receiving a determination of more than i weeks. In other words δ_i is the fraction of initial claimants who will not have exhausted their payments i weeks after their initial claim.

Analysis of disaggregate data for all of Michigan suggests

$$\chi_k = \begin{Bmatrix} 0, & k<11 \\ \alpha, & 11 \leq k < 26 \\ \beta, & k=26 \end{Bmatrix} \quad (78)$$

where $\alpha \simeq .037$ and $\beta \simeq 0.44$.[4]

This implies

$$\delta_i = \begin{Bmatrix} 1, & i<10 \\ 1-(i-11)\alpha, & 10 \leq i \leq 26 \end{Bmatrix} \tag{79}$$

Then

$$IU_t = \sum_{i=0}^{K-1} \delta_i \, b_{ti} \, I_{t-i} \tag{80}$$

Equation (80) is very similar to equation (70), except that (80) applies to all insured unemployed workers and (70) applies only to insured unemployed workers with a determination of k weeks. The interpretation is also similar: I_{t-i} workers file initial claims in week t-i. i weeks later $b_{ti}\, I_{t-i}$ workers are still unemployed. Only a fraction δ_i of these are still insured; the others have exhausted their benefits. This leaves $\delta_i\, b_{ti}\, I_{t-i}$ workers who are both unemployed <u>and</u> insured. The total of insured unemployed workers is found by adding up all of the insured unemployed workers having filed initial claims during each of the previous 26 weeks.

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4 Verbal explanation: The shortest potential duration is 10 1/2 weeks (ten full payments and a half payment in the eleventh week). This potential duration is assigned to people who have worked 14 weeks in the year preceding their layoff. The maximum potential duration is 26 weeks and is assigned to people who have worked 35 or more weeks in the year preceding their layoff. An eye-ball scan of the Michigan data suggests that approximately an equal number of UI initial claimants are assigned potential durations falling within each of the weekly intervals between 11 and 25 weeks. Call the fraction of initial claimants assigned a potential duration within that interval α for each such week. A significantly larger fraction, nearly half, of the initial claimants receive a maximum potential duration (26 weeks). Call this fraction β. Since all of these fractions must sum to the whole,

$$15\,\alpha + \beta = 1.$$

β is estimated as the mean fraction of initial claimants receiving maximum potential durations over a two year sample and α is calculated from the fraction above.

A slightly better model would make α and β random variables, but would require the missing data.

4.2.6 Specification of the Continuation Rates

r_{ti} is the conditional probability that a person will remain unemployed in week t given that the person has been unemployed i-1 weeks. The conditional probability of leaving unemployment is $q_{ti} = 1 - r_{ti}$. If we are referring to a cohort of people, r_{ti} and q_{ti} are the corresponding fractions of the cohort not finding employment and finding employment, respectively.

What can be said *a priori* about the functional form of the equation determing r_{ti}?

A. Kaitz [19] has shown that r_{ti} is a rising function of i, indicatting the probability of remaining unemployed rises, and the probability of becoming employed during the current week falls, as the period of one's unemployment increases.

This trend may be due to either or both of two reasons:

1) Individual explanations: The longer a worker has been unemployed the more his human capital depreciates, the less he searches for a job and the less attractive he is to employers. Therefore the longer he is unemployed the less likely he is to find a job during the current week.

A worker may search less vigorously for a job because he becomes discouraged about the chances of finding employment after weeks of trying.[5] He may become less attractive to employers after many weeks of unemployment because prospective employers perceive his unemployment as evidence of his lack of ability. Furthermore the unemployed worker may explore the most promising job opportunities soon after his layoff and, failing to find employment in any of these first-choice job opportunities, he will be forced to consider progressively less encouraging firms. These later-searched firms will be less likely to hire the worker and may be less numerous as well, leading to a diminished probability of finding a job in the later weeks of his unemployment spell.

The above factors serve to make r_{ti} an increasing function of i,

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5 This is similar to the "discouraged worker" effect, except that the worker does not leave the labor force, he only fails to search as energetically as he did previously.

but there are a few additional factors which have the opposite effect: A worker may search more vigorously for a job after a long period of unemployment because of a decline in his personal wealth due to his reduced income.[6] Also the experience of failure to find a job may induce a decline in the aspiration level of the worker, both in terms of the wage and in terms of working conditions the worker is seeking in his next job.[7] If the worker's minimum demands fall as his spell of unemployment grows longer he might be willing to accept a poor job that he would not otherwise considered, raising his chances of finding some job in later time periods.

2) Aggregation bias: Workers with high employability leave the pool of the unemployed soonest, leaving behind the less attractive workers, who have a smaller probability of finding a job. Therefore the longer a group has been unemployed the fewer easily employable workers it contains and the smaller the fraction of the group who will become employed during the current week.

For the purpose of this forecasting model it is unnecessary to statistically identify the above factors. It is only required that an aggregate contour of r_{ti} for all insured unemployed workers be specified.[8] Here we may be guided by the assumption that continuation rates rise as unemployment lengthens at least during the first few months of unemployment. This is supported by empirical evidence [19, 28] and the preponderance of *a priori* reasons.

B. The r_{ti} may fall for the initial few weeks after layoff. This would indicate an increasing likelihood of finding employment during

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6 This factor may be modified by UI itself: Every person studied here is receiving income in the form of UI payments.

7 Charles Holt has made this the key factor in his search theory [16].

8 For the purpose of studying the hiring process and the job search behavior of unemployed workers it is desirable to evaluate the relative importance of the above factors. It is possible to achieve this goal with the present model by fitting it to data disaggregated into homogenous subgroups. The results of such disaggregations will be reported later.

the first few weeks of unemployment as the worker overcomes his initial inertia and begins to search effectively for a job. The continuation rates reported by Kaitz display such an effect [19].

C. The continuation rates must be a function of a variable which expresses the excess of supply over demand for labor during the current period. This variable will be referred to as E_t. It may be the SMSA unemployment rate, or the SMSA rate of accessions in manufacturing, or some other variable.

Two specifications have proven successful in some applications:

$$r_{ti} = a_1 + a_2 i^{a_3} e^{a_4 i} + \varepsilon_t \qquad \begin{array}{l} 0<a_1<1 \\ a_2<0 \\ 0<a_3 \\ a_4<0 \end{array} \tag{81}$$

$$r_{ti} = a_1 + a_2 e^{a_3 i} + a_4 e^{a_5 i} E_t + \varepsilon_t \qquad \begin{array}{l} 0<a_1<1 \\ a_2<0 \\ a_3<0 \\ 0<a_4 \text{ if } E_t \text{ is unemployment rate} \end{array} \tag{82}$$

ε_t is assumed to have zero mean and constant variance and be serially uncorrelated. The a's are parameters.

Specification (81) has been used in cases where weekly observations are available. It does not include the variable E_t because that variable is only available monthly. Specification (81) leads to a stationary distributed lag model in the sense that the distributed lag coefficients $b_{ti}\left(= \prod_{m=0}^{i} r_{t-m,i-m}\right)$ are not functions of time. Figure 8 diagrams $E\left(q_{ti}\right) = 1 - a_1 - a_2\, i^{a_3} e^{a_4 i}$ (the conditional probability of finding employment).

The conditional probability of finding employment during the current week given an unemployment spell of i weeks.

Figure 8 Specification (3.21)

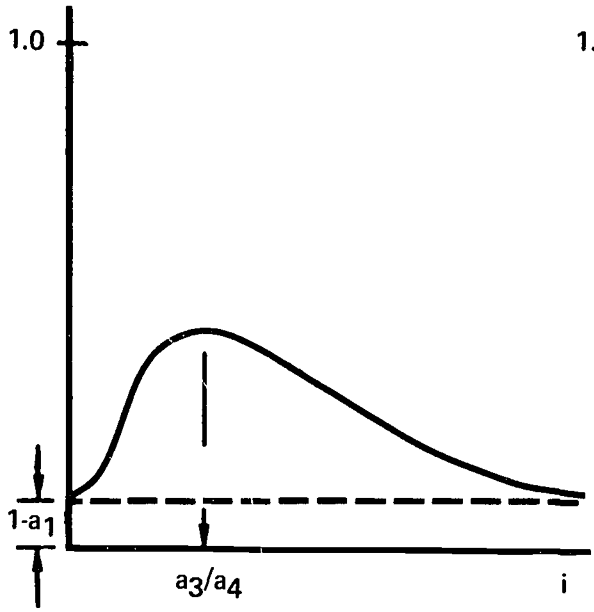
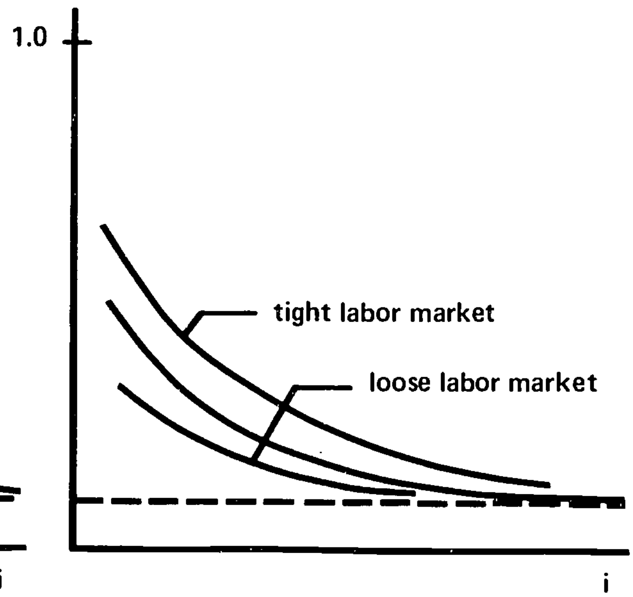


Figure 9 Specification (3.22)



$E(q_{ti})$ rises in the range of low i due to the dominance of the term $a_3{}^i$ (a_3 positives). Eventually the damping influence of $e^{a_4 i}$ (a_4 negative) forces the curve to reach a peak (at $i = |a_3/a_4|$) then decline exponentially to the asymptote $1-a_1$. This means that no matter how long an individual has been unemployed he still has a probability of $1-a_1$ of finding employment.

Specification (82) has been used in cases where monthly data are employed. It does not include a rising portion in the curve $E(q_{ti})$ because the monthly time intervals are too long to pick up any effect so transitory. It does allow the continuation rates to change with time by including a term involving an interaction between E_t and i, allowing the influence of E_t to damp out or increase as i increases.

4.2.7 <u>The Insured Unemployment Equation as an Extension of a Markov Process</u>

The present model can be thought of as being derived from the class of models known as Markov chains.

A Markov chain[9] is characterized by various "states" and the matrix of probabilities of transitions between these states. An individual must be in one of these states at any one time. In the "simple" Markov chain the process obeys three assumptions:

1) Stationarity. The individuals' transition probabilities are constant through time.

2) Markovian assumption. The transition probabilities depend only upon the current state of the individual and not upon his history of previous states.

2) Homogeneity of the population. The various members of the population are assumed to have the same transition probabilities. This assumption allows the model to identify the transition probabilities of the entire population with the transition probabilities of each individual in the population.

In this context the present UI process can be represented by a cohort of individuals who make an initial claim for UI in week t-i and make continued claims for UI for i-1 weeks. In week t they have three "destination states":

State[10]	Probability
1) Make another UI claim	$r_{ti} - e_{ti}$
2) Find employment	$1 - r_{ti}$
3) Exhaust payments without finding employment	e_{ti}

Since we are looking at the entire cohort of individuals who make initial claims in week t-i this cohort will contain within it various "determinations" and some fraction of the individuals in it, e_{ti}, will exhaust benefits.[11] The individuals will make another UI claim if they fail to find employment but do not exhaust payments. Therefore the

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9 The discussion of assumptions borrows from McFarland [22].

10 Another possible destination state would be for the individual to leave the labor force. However UI recipients are paid substantially not to do so, or at least not to admit doing so. Therefore UI data can not be used to study this state.

11 The value of e_{ti} is calculated in Appendix D-1.

fraction of the cohort remaining in this state is $r_{ti} - e_{ti}$. The probability of finding employment is unity minus the probability of not finding employment.

The above three probabilities form the first column of the Markov transition matrix:

Destination State \ Origin State	1	2	3
1	$r_{ti} - e_{ti}$	0	0
2	$1 - r_{ti}$	0	0
3	e_{ti}	0	0

$$P_{ti} = \begin{bmatrix} r_{ti} - e_{ti} & 0 & 0 \\ 1 - r_{ti} & 0 & 0 \\ e_{ti} & 0 & 0 \end{bmatrix}, \quad i = 1, \ldots, 26 \qquad (83)$$

The first column of probabilities sums to one as required. The other six probabilities are either impossible or can not occur in the present data set.

The above matrix represents an extension of the simple Markov transition matrix. First consider the dependence of the probabilites upon the variable i. This may be considered a relaxation of either assumption (1) or assumption (3) above or both. If non-stationarity is allowed we may assume the chances of an individual making a particular transition depend upon how long he has been unemployed. This corresponds to explanation (1) on page 131. If heterogeneity is allowed we may assume constant, but different transition matrices for each individual. Explanation (2) on page 131 assumes the r_{ti} are different for different individuals. The e_i must be unequal across individuals (heterogeneity) since in general UI claimants have different determinations and will exhaust their benefits after different numbers of weeks of payments. This heterogeneity will lead to an expected population transition matrix in which the transition probabilities are functions of i (McFarland [22]).

It is possible to distinguish between non-stationarity and heterogeneity of the transition matrix by partitioning the population into homogeneous subsets. The transition probabilities of the population subsets can then be compared to determine whether signigicant differences have been discovered. A test for dependence of the transition probabilities upon i can also be performed at the disaggregate level to test for non-stationarity of the i-dependent type. It is probable that both heterogeneity and non-stationarity of the above types exist.

The dependence of P_{ti} upon t allows further non-stationarity of the transition matrix. The necessity of this extension follows from the effects of changing economic conditions upon a worker's chances of finding employment. Stationary Markov chains are capable of making predictions in such an environment only a few periods ahead, an unsatisfactory result for this project. The non-stationary chain describes the UI claimant as subject to continuously changing transition probabilities and should remain accurate over a much longer range of time than a stationary model would.

4.2.8 Differences in Data

A substantial difference between this and other Markov estimations is not theoretical but relates only to the type of data available. In usual Markov estimations, observations exist before and after a 1-step transition so that the transition probabilities can be easily estimated. In the present case the observations are available only after a series of i transitions have been completed. In a simple Markov chain the i-step transition matrix would be merely the i-th power of the 1-step transition matrix. In this case each of the i transition matrices between an initial claim and a continued claim i weeks later are different, and so the i-step transition matrix is the product of the intervening transition matrices.

$$P_{ti}(i) = \prod_{m=0}^{i} P_{t-m,i-m} \qquad (84)$$

where $P_{ti}(i)$ = i-step transition matrix for individuals starting in week t-i.

This new transition matrix can be applied to a vector of the number of individuals in each of the three "origin" states to determine their numbers after the i-week period.

$$X_{ti} = P_{ti}(i)\, X_{t-i,0} \qquad (85)$$

where X_{ti} = column vector of numbers of people in defined states in time t after i transitions.

Furthermore the data that exist are aggregate data, not subdivided by the length of stay in a particular state. For such data

$$X_t = \sum_{i-0}^{K} X_{ti} = \sum_{i=0}^{K} P_{ti}\,(i)\, X_{t-i,0} \qquad (86)$$

The model derived earlier is merely a single scalar equation of this matrix equation, the equation for the state "make UI claim". This identity if shown in Appendix D-2. Note that the other two scalar equations would predict the number of individuals in the "employment" and "exhaustion" states. These equations will be estimated later.

4.2.9 Exhaustions

Exhaustees are workers who have received their last UI payment and are no longer eligible for UI, but are still unemployed. If a worker is laid off and makes an initial claim he is given a "determination", a fixed number of weeks for which he will be elibible for benefits. The determination can not exceed 26 weeks and may be as short as 11 weeks, depending upon how long he was at his previous job. Over the last six years an average of 44% of initial claimants received the maximum duration of 26 weeks.

Suppose the worker makes his initial claim in week t and is given a determination of k weeks. He will receive his first payment in week t+1 and his final payment in week t+k. If he is still unemployed thereafter he becomes an exhaustee. The data on exhaustions reported by MESC branches is a count of the number of final payments made during each month.

4.2.10 Benefit Exhaustions Equation

The benefit exhaustions equation is very similar to the insured unemployment equation because exhaustees must have been insured unemployed workers in the weeks previous to the current week. The only difference between an insured unemployed worker and an exhaustee is that the exhaustee has come to the end of his maximum duration of payments. The number of exhaustions can be expressed as the number of workers who have remained unemployed i weeks and who also have a determination of i weeks (k=i). Writing this out in an equation,

$$EX_{ti} = \chi_i(b_{ti}I_{t-i}). \tag{87}$$

The expression in parentheses represents the number of workers making initial claims in week t-i who are still unemployed in week t. The number of people exhausting benefits in week t will be only the fraction of this group with a determination of i weeks. So the number of benefit exhaustions arising from initial claims made i weeks earlier is found by multiplying the parenthesized expression by χ_i (see page 129). The total number of exhaustions is the above number summed over all previous weeks:

$$EX_t = \sum_{i=0}^{K} \chi_i \, b_{ti} \, I_{t-i} \tag{88}$$

This is the exhaustions equation. The only difference between the exhaustions equation and the insured unemployment equation (80) is that the weights of the summation in the former case are $\{\chi_i\}$, the fraction of initial claimants with a determination of exactly i weeks, rather than $\{\delta_i\}$, the fraction of initial claimants with determinations of i weeks or greater. The difference reflects the fact that we are now interested in the number of people who do exhaust benefits in the current week, rather than those who have not yet exhausted their benefits in the current week.

The continuation rates, which again determine b_{ti} according to equation (67), are specified and estimated in the same way as they are for the insured unemployment equation.

4.2.11 Estimation of the Insured Unemployment and Exhaustions Parameters

Three equations constitute the continued claims model:

1. $$IU_t = \sum_{i=0}^{K} \delta_i b_{ti} I_{t-i} \tag{80}$$

2. $$b_{ti} = \prod_{m=0}^{i} r_{t-m,i-m} \tag{67}$$

3. $r_{ti} = \overline{r}_{ti} + \varepsilon_t$ (89)

where $\overline{r} = E(r_{ti})$ follows one of the specifications on page 133. Let

$$\overline{b}_{ti} = \prod_{m=0}^{i} \overline{r}_{t-m,i-m} \tag{90}$$

then

$$IU_t = \sum_{i=0}^{K} \delta_i \overline{b}_{ti} I_{t-i} + U_t \tag{91}$$

where U_t is a random term whose form and properties are derived in Appendix D-3. Equation (91) is of the form

$$IU_t = \overline{IU}(a_1,\ldots,a_5; E_t,\ldots, E_{t-26}, I_t,\ldots, I_{t-26}) + U_t \tag{92}$$

where the function $\overline{IU}$ is non-linear in the parameters a. A non-linear least-squares method of estimation has been chosen to estimate the parameters. The method minimizes the error mean square

$$s^2 = \frac{1}{n-p} \sum_{t=1}^{n} [IU_t - \overline{IU}(a;E,I)]^2 \tag{93}$$

by means of stepwise Gauss-Newton iterations. It will converge to consistent estimates of the parameters under the assumptions of fixed independent variables and zero expectations of the error term U_t. Appendix D-3 shows that the error term has zero expectation, but is autocorrelated to the K-th degree. Appendix D-4 shows how the non-linear least squares method can be used to estimate the residual autocorrelation parameters simultaneously with the structural parameters. Using this method a new disturbance term is minimized which is not autocorrelated. The result is an improvement in the efficiency of the estimation.

4.3 Empirical Results for the Insured Unemployment and Exhaustions Equations

4.3.1 Use of Monthly Data

In order to use monthly data to estimate the IU exhaustions equations, which have been specified in weekly terms, the model must be summed over the 4.3 weeks which comprise a month. In this process it is desirable to retain the current definition of the continuation rate as the probability of remaining unemployed another week given an unemployment spell of i weeks. This can be accomplished subject to the necessary assumption that continuation rates be constant during a single month. The details of this process are given in Appendix D-5.

Monthly data permits specifications of the continuation rates which allow the continuation rates to rise and fall with changes in the tightness of the labor market. The tightness of the labor market is expressed in the labor market indicator E_t. Several quantities were tried as E_t, and tested according to their ability to explain continuation rates.

4.3.2 Comparison of Specifications of the Continuation Rates

A comparison of the resulting estimations appears in Table 8. Statistics to the left of the double line are calculated from the insured unemployment equation (80) and statistics to the right of the double line are from the exhaustions equation (88). Both of these equations require specification of the continuation rates; different specifications of these rates are listed vertically down the page. All of the specifications have the same functional form (82), but different assumptions are made about the parameters (a_i) and about the variable E_t.

Specifications 1 and 2 do not use any of the variables E_t and are calculated for comparison purposes. The first requires the continuation rates to be constant and the second allows them to vary only with the duration of unemployment. Estimation 1 calculates the continuation rates at .79 and .86 respectively for the IU and exhaustions equations. Both of these estimates should be taken as averages over the 26 weeks of insured unemployment, with more weight given in the exhaustions equation to the later weeks of unemployment. Since later continuation rates are higher, the estimated rates are higher for the exhaustions equation.

The more realistic specification 2 improves the explanatory power of the two equations and adds some information about the behavior of continuation rates. The negative signs of a_2 and a_3 indicate that

TABLE 8: ESTIMATIONS OF THE INSURED UNEMPLOYMENT AND EXHAUSTIONS EQUATIONS

Functional Form For Continuation Rates: $\bar{r}_{ti} = a_1 + a_2 e^{a_3 i} + a_4 e^{a_5 i} E_t + a_6 D_t$

Data: January, 1966 through December, 1971

	Equation:	Insured Unemployment			Exhaustions		
No.	Specifications of Continuation Rates	Mean Squared Error $(10)^5$	R-SQR	Parameters	Mean Squared Error	R-SQR	Parameters
1	Continuation rates constant $(a_2=a_3=a_4=a_5=a_6=0)$	25.5	.633	a_1= .79 (.0076)	1024.	.379	a_1= .87 (.0029)
2	Continuation rates rise with the duration of unemployment $(a_4=a_5=a_6=0)$	18.4	.735	a_2= −.96 (.039) a_3= −.036 (.0053)	977.	.407	a_2= −.81 (.039) a_3= −.0068 (.004)
3	Rates change with $E_t = u_t$ $(a_6=0)$	9.10	.867	a_4= .014 (.017)	443.	.727	a_4= .014 (.014)
4	$E_t = A_t$ $(a_6=0)$	10.1	.855	a_4= −.0086 (.007)	398.	.754	a_4= −.018 (.005)
5	$E_t = A_t/u_t$ $(a_6=0)$	5.84	.916	a_4= −.024 (.012)	280.	.827	a_4= −.018 (.011)
6	Same with auto layoff dummy $(a_6 \neq 0)$	4.72	.933		284.	.828	
7	$E_t = (A_t - \%Q_t)/u_t$	4.91	.929	a_4= −.047 (.030)	240.	.854	a_4= −.015 (.012)
8	$E_t = \%REH_t/u_t$	7.14	.897	a_4= −.14 (.13)	255.	.845	a_4= −.16 (.097)
9	$E_t = A_t/u_t$ auto-correlated error	2.89	.963		195.	.896	
10*	$E_t = {}_t/u_t$ $(a_1 \leq 1)$ autocorrelated error	3.08	.961		195.	.896	

*Selected as final estimation

continuation rates rise, but at a declining rate as the duration of unemployment rises. This is in agreement with the discussion of page 134. These two estimations produce some confidence in the method, but neither specification explains enough of the variance to be acceptable for projection purposes.[12]

The Detroit SMSA unemployment rate is most often used as the indicator of labor market tightness, and so it is tried here to explain continuation rates. The introduction of the unemployment rate substantially improves both equations, and the positive sign on a_4 implies, as expected, that continuation rates rise during periods of high unemployment. The MSE of each equation is reduced by more than half and the predictive power of the equation is much improved. This result lends substantial justification to the use of non-stationary continuation rates.

The unemployment rate can be criticized as being too inclusive to accurately reflect the probability of finding employment. The unemployment rate is a stock variable produced by two distinct labor turnover flows: losing a job to enter unemployment and finding a job to leave unemployment.[13] Only the latter transition determines continuation rates, and the frequency of this transition is measured in the SMSA rate of accessions. Specification 4 uses the rate of accessions to drive the continuation rates[14], giving an improvement in the exhaustions equation,

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12 Specification 2 is about as good as simple linear approaches to the estimation. A linear regression of the form $IU_t = \sum_{i=0}^{K} b_i T_{t-i} + \varepsilon_t$ (b_i's are constants) allows a more complex time dependence than Specification 2, but still assumes stationary continuation rates. Such a linear regression is found to predict better than Specification 2 but not nearly as well as Specification 3.

13 As well as transitions into and out of the labor force.

14 Since the Labor Turnover Sample, which provides the data on accessions, is sparse in the non-manufacturing industries, only the manufacturing accessions can be used.

but a slight deterioration in the IU equation.[15] The negative sign of a_4 indicates that continuation rates rise when accession rates fall, as expected. The estimation does not provide a clear-cut decision as to whether the unemployment rate or the accessions rate should be the preferred driving variable, but confirms that both variables explain some variance.

A closer look at the labor market suggests than an interaction between the two variables can explain more variance than either of them separately. Consider the probability that a particular individual in a pool of NU homogeneous unemployed workers will find employment. If NA workers are hired from the pool, the individual's chance of being among them is NA/NU. This ratio will equal one minus the individual's continuation rate and will represent an average continuation rate in a heterogenous labor pool. It expresses accessions as a fraction of the number of unemployed workers. If we create an interaction variable equal to the ratio of the accession rate to the unemployment rate (A/u), this variable will be approximately equal to NA/NU[16] and can be used as a powerful driving variable for the continuation rates. Line 5 shows that the new interaction variable is a substantially better predictor than is either A or u. The MSE in predicting both insured unemployment and exhaustions falls by almost half and the R-SQR's rise by 5 to 10 percent. The negative sign of a_4 indicates that continuation rates rise as the new variable falls, as expected.

Specification 7 introduces a special effect in July due to the annual auto layoffs. The workers unemployed by these layoffs are nearly

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15 The deterioration of the IU equation may be due to the method of calculating the unemployment rate. Since the unemployment rate is calculated from insured unemployment, there is a definitional link between u and IU, which does not exist between A and IU (page 120).

16 $$\frac{A}{u} = \frac{NA/NE}{NU/NL} = \frac{NA}{NU}\left(\frac{NL}{NE}\right) = \frac{NA}{NU}\left(\frac{NE + NU}{NE}\right) = \frac{NA}{NU} + \frac{NA}{NE}.$$

NA= number of accession, NU= number of unemployed, u= unemployment rate, NE= employment, NL= labor force. The second term will be negligible, about 1/20th the size of the first term, because NE is at least an order of magnitude greater than NU.

certain to be rehired within a month and so do not search for other work. It is also possible that they may not be employed long enough to collect benefits, even though they make an initial claim. These characteristics separate auto layoff workers from other unemployed workers and so a dummy variable has been defined to represent them. The dummy variable has a value of one in July for the cohort of people in their first month of unemployment, and zero otherwise. The specification improves the IU equation enough to justify its continued use.

Some accessions merely count people who quit one job to accept another without passing through unemployment and without receiving UI. Thus accession might rise during a period of high job turnover merely because quits have risen, without the insured unemployed gaining any better chance to find a job. Specification 7 and 8 represent two attempts to quantify this effect so as to better predict the employment prospects for the insured unemployed. Specification 7 is the same as specification 6 except that instead of accessions in the numerator of the driving variable it substitutes accessions minus quits, the number of accessions not accounted for by simultaneous quits. The success of this specification depends upon the majority of quitting workers being "job changers" rather than entrants to the unemployment pool. Otherwise their accession to a job should be counted. The empirical results do not clearly indicate whether this specification is an improvement over specification 6, since it improves the exhaustions equation but detracts from the IU equation. Because only a substantial improvement would justify introducing the new turnover variable, quits, the specification was dropped.

Specification 8 limits our view of accessions to only "rehires", workers hired after a temporary layoff from the same firm.[17] This quantity will exclude job changers, but will also exclude unemployed people who find new jobs. The empirical result is ambiguous and the specification was dropped. The error introduced by the phenomenon of job changers is therefore left as a random factor, fortunately a small one.

Line 9 uses specification 6 for the continuation rates, but

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17 Accession ≡ New hires + rehires. Rehires are reported monthly by the Job Openings and Labor Turnover Sample.

Figure 10 Insured Unemployment In Thousands Of Continued Claims Per Month

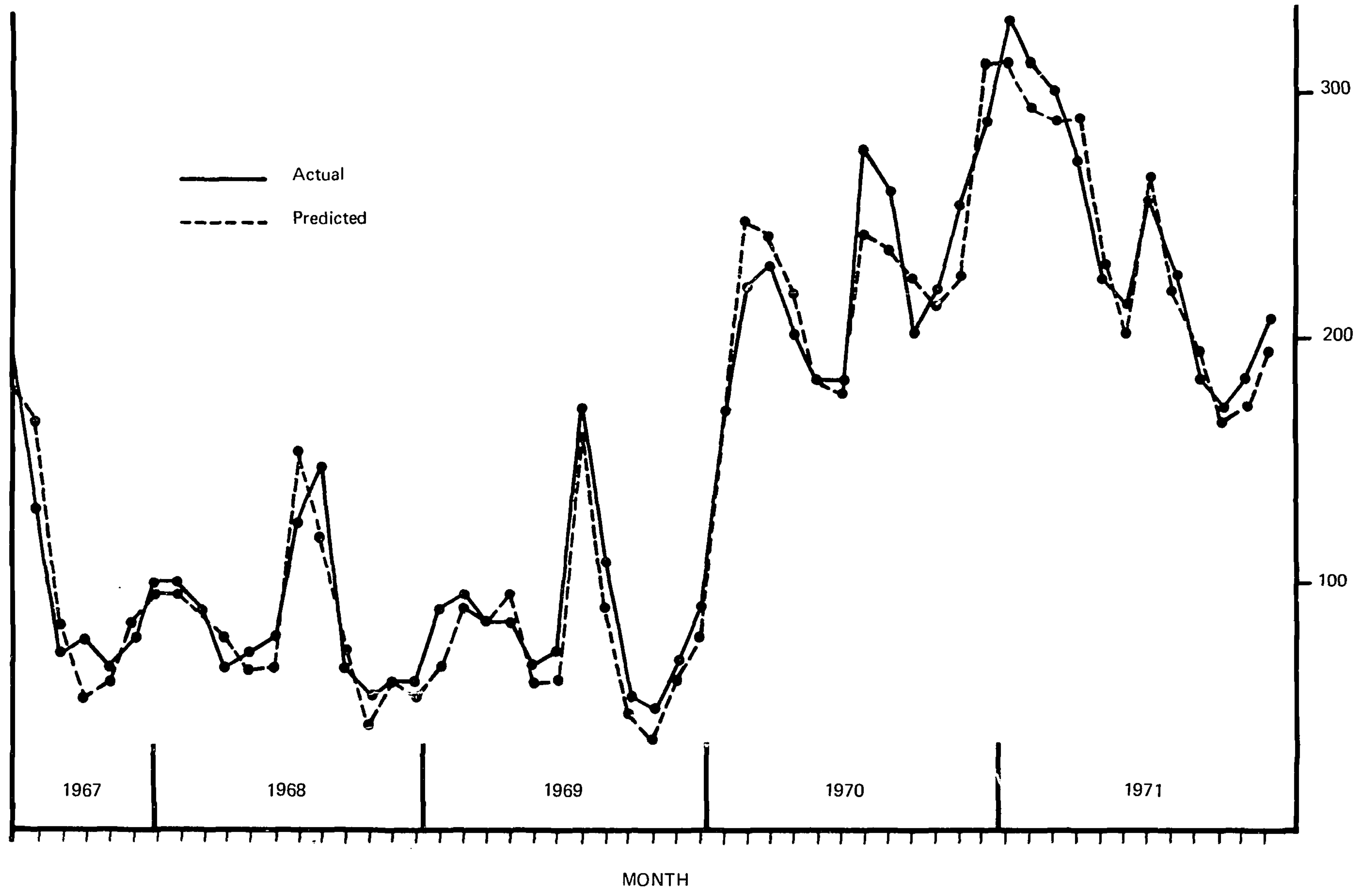
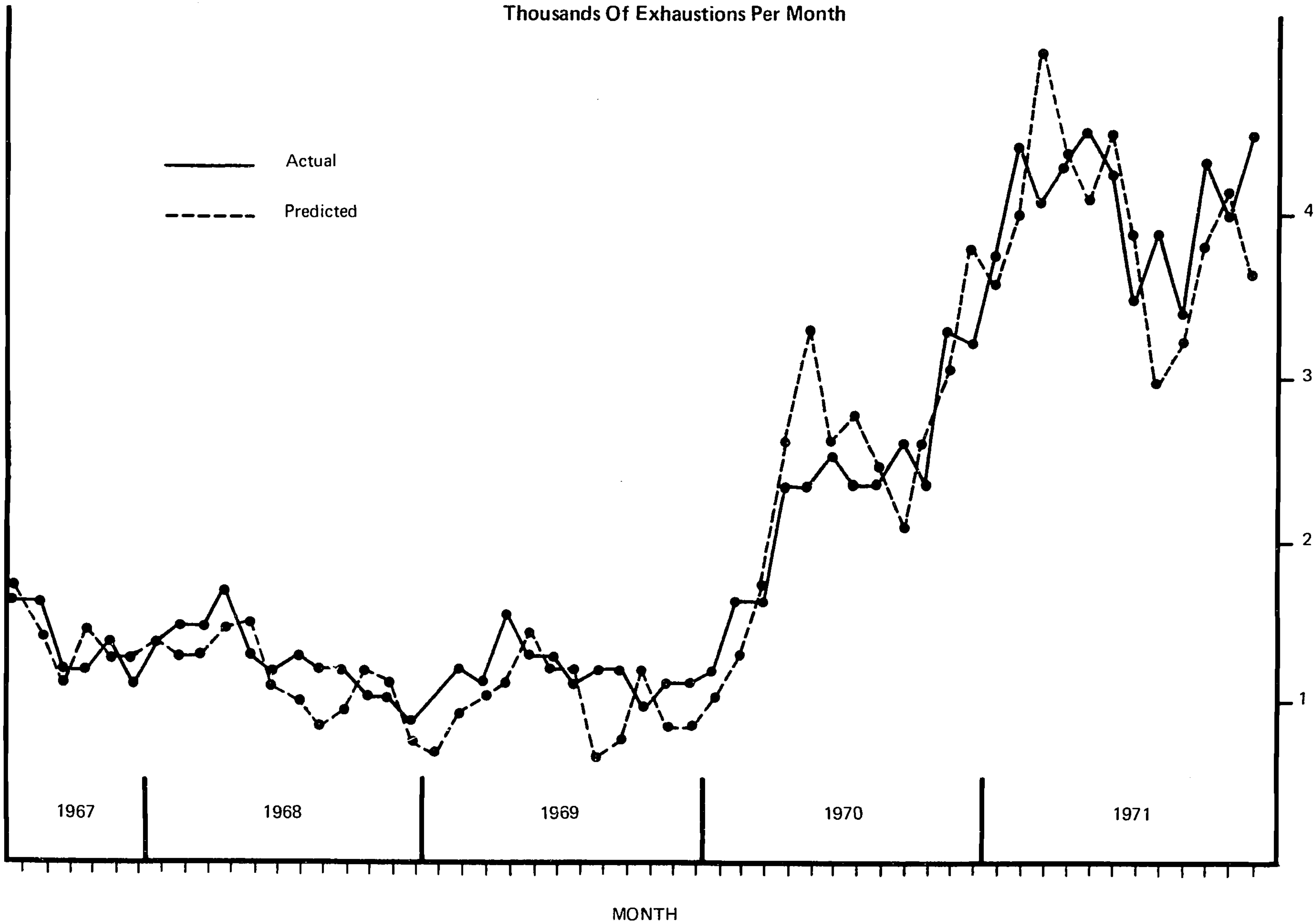


Figure 11 Unemployment Insurance Exhaustions In Thousands Of Exhaustions Per Month



estimates the model assuming an autocorrelated error term to improve the efficiency of the estimation (Appendix D-4). The autocorrelated specification results in a substantial improvement in the mean squared error of both equations. Furthermore almost all of the 6 autocorrelation coefficients are significant, in the sense that the coefficients are substantially more than their standard errors. Thus the a priori specification of the error process is confirmed and the over-all equation is improved in predictive ability.

Only a minor difficulty remains in that the estimated value of a_1 is very slightly greater than 1. Since a_1 is the asymptotic value of the continuation rate, it makes no sense for a_1 to be greater than 1.0. Furthermore the difference between a_1 and 1.0 is not significant. It was decided therefore to impose the restriction that a_1 be less than or equal to 1.0. The restriction of course increases the mean squared error of the equations, but the increase is so slight that the constraint must be considered entirely compatible with the data. This is especially true for the exhaustions equation, where the mean squared error increases only about .01%.

The above recapitulation describes the non-linear estimation process employed for the insured unemployment and exhaustions equations. It is not quite as simple as the familiar linear estimation process, yet the same guide is used: minimize the mean squared error of the equations subject to a priori knowledge of the statistical processes. The final results are two equations which can be expected to predict well and correspond with our view of the reemployment process.

4.3.3 Predictive Ability of the Equations During the Sample Period

Table 9 and Figures 10 and 11 compare the observed and predicted values of the final insured unemployment equation and exhaustions equation respectively, over the sample period. In both cases the equations predict values very close to the actual values, and in neither case do the equations reveal systematic error. These figures give further evidence of the predictive power of the final equations.

TABLE 9

COMPARISON OF PREDICTED VALUES WITH ACTUAL VALUES FOR INSURED UNEMPLOYMENT AND EXHAUSTIONS

Year	Month	Insured Unemployment		Exhaustions	
		Actual	Predicted	Actual	Predicted
1967	2	135419	153392	1093	1004
	3	152300	174676	1308	1187
	4	134142	155697	1870	1873
	5	100159	116610	1895	2612
	6	86358	96555	1532	2087
	7	104165	101546	1632	1741
	8	135954	170122	1675	1508
	9	73704	85614	1198	1099
	10	81868	55191	1175	1517
	11	68361	65322	1328	1236
	12	86037	89013	1141	1027
1968	1	108044	104163	1392	1369
	2	98349	97942	1396	1256
	3	95048	98242	1493	1281
	4	72672	78831	1682	1446
	5	75829	72215	1284	1553
	6	84345	72090	1292	1089
	7	132658	162592	1297	1022
	8	151553	125587	1196	867
	9	71394	77995	1173	957
	10	59077	49637	1056	1229
	11	66534	62460	992	1084
	12	69226	58525	902	752
1969	1	96621	74834	1041	701
	2	93055	88276	1105	887
	3	68886	91748	1144	1055
	4	85137	96036	1498	1087
	5	70085	68135	1327	1507
	6	76980	65472	1234	1147
	7	163358	179434	1095	1233
	8	113680	93226	1249	676
	9	56763	55881	1181	747
	10	55608	43484	933	1249
	11	63357	65154	1135	848
	12	37923	34773	1158	842

TABLE 9

COMPARISON OF PREDICTED VALUES WITH ACTUAL
VALUES FOR INSURED UNEMPLOYMENT
AND EXHAUSTIONS (CONT.)

Year	Month	Insured Unemployment		Exhaustions	
		Actual	Predicted	Actual	Predicted
1970	1	179933	1773[illegible]	1198	[illegible]26
	2	2[illegible]4599	23[illegible]033	1527	1214
	3	23586[illegible]	2493[illegible]3	1663	1797
	4	2[illegible]0511	214964	2307	26[illegible]9
	5	187376	198396	2434	2822
	6	190471	179167	2522	2555
	7	234372	248428	2438	2867
	8	263519	241177	2383	2485
	9	190743	221067	2547	2[illegible]84
	10	226281	2106[illegible]7	2391	2697
	11	251145	220731	3324	3[illegible]19
	12	236558	310231	3331	3921
1971	1	324986	315324	3826	37[illegible]3
	2	253932	2733[illegible]	4165	3723
	3	307436	295845	4229	52[illegible]8
	4	268521	282639	4365	4418
	5	220342	2384[illegible]2	4641	42[illegible]5
	6	2[illegible]0219	198873	4239	4487
	7	2597[illegible]9	268556	3598	4[illegible]27
	8	231192	223[illegible]3	4[illegible]12	3[illegible]14
	9	181422	195414	3413	3192
	10	175872	172118	4452	3969
	11	181623	173232	3960	4181
	12	2114[illegible]1	194617	4641	3749

4.3.4 Estimated Continuation Rates

Table 10 lists the parameters estimated from the final IU equation and the final exhaustions equation, together with their standard errors. Table 11 presents the continuation rates calculated by substitution of the estimated parameters into the functional form (82) of the continuation rates. The rates are arranged with different rows corresponding to different durations of unemployment and different columns corresponding to different labor demands.

Figures 12 and 13 diagram the continuation rates estimated from the IU equations. The diagrams have been arranged so that the horizontal axis is the duration of unemployment and different contours represent differing labor demands. The lowest contour pictures continuation rates in a tight labor market, the middle contour, in an average labor market and the highest contour, in a loose labor market, The demand for new workers is quantified in the variable E_t (=A/u): an "average" labor market occurs when E_t is equal to its mean value and a "tight" or "loose" labor market occurs when E_t is a standard deviation above or below its mean value.

4.3.5 Implications of the Estimated Continuation Rates:

The following observations can be made about the estimated continuation rates.

1) The estimated continuation rates are in the interval [0, 1] as is required by their interpretation as a probability.

2) For a given unemployment duration, a lower continuation rate always accompanies a higher labor demand, and vice versa. This lends further credence to the definition of continuation rates as the probability of remaining unemployed.

3) Continuation rates rise with duration for the entire 26 weeks of unemployment insurance payments, indicating that the longer an unemployed worker remains unemployed the less chance he has of finding employment during a succeeding time interval. This result is in agreement with both a priori reasoning and empirical results from other studies (p. 131). The effect is most clearly visible in rates from the IU equation, which have narrower confidence intervals, but is also

TABLE 10

PARAMETERS FROM FINAL EQUATIONS

	Insured Unemployment		Exhaustions	
	a_i	Standard Error	a_i	Standard Error
1	1.0	0.	1.0	0.
2	-.425	.113	-.135	.0428
3	-.226	.0735	-.0276	.0278
4	-.0989	.0529	-.0581	.0742
5	-.0822	.0913	-.0434	.122
6	-.0639	.0599	-.348	.108

RESIDUAL AUTOCORRELATION PARAMETERS

	Insured Unemployment		Exhaustions	
	d_i	Standard Error	d_i	Standard Error
1	.559	.156	.667	.162
2	.279	.174	.280	.195
3	.048	.172	.022	.197
4	-.237	.161	-.432	.207
5	.029	.157	-.107	.190
6	-.127	.142	.134	.193

TABLE 11

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CONTINUATION RATES ESTIMATED FROM INSURED UNEMPLOYMENT EQUATION

Labor Demand:	Low		Average		High	
Weeks of Unemployment	Rate	Standard Error	Rate	Standard Error	Rate	Standard Error
2	.693	.027	.648	.027	.6[illegible]3	.035
4	.797	.010	.759	.014	.721	.021
6	.864	.019	.832	.019	.830	.019
8	.923	.020	.881	.017	.853	.019
10	.937	.017	.913	.016	.890	.022
12	.956	.013	.936	.017	.916	.026
14	.968	.011	.952	.019	.935	.030
16	.977	.009	.963	.020	.949	.033
18	.983	.009	.971	.021	.959	.034
20	.987	.009	.977	.021	.967	.035
22	.990	.009	.981	.021	.973	.034
24	.992	.009	.985	.021	.977	.033
26	.994	.008	.987	.020	.981	.032

CONTINUATION RATES ESTIMATED FROM EXHAUSTIONS EQUATION

Labor Demand:	Low		Average		High	
Weeks of Unemployment	Rate	Standard Error	Rate	Standard Error	Rate	Standard Error
2	.849	.022	.820	.042	.792	.068
4	.857	.019	.831	.029	.805	.047
6	.866	.013	.842	.019	.818	.029
8	.873	.007	.852	.009	.830	.015
10	.881	.004	.861	.004	.841	.008
12	.888	.005	.869	.008	.851	.013
14	.894	.008	.877	.013	.860	.021
16	.900	.011	.885	.018	.869	.028
18	.906	.014	.892	.022	.878	.034
20	.911	.017	.898	.025	.885	.038
22	.916	.020	.905	.028	.893	.042
24	.921	.022	.910	.030	.899	.045
26	.926	.024	.916	.032	.906	.047

Figure 12 Continuation Rates Estimated From Insured Unemployment Equation

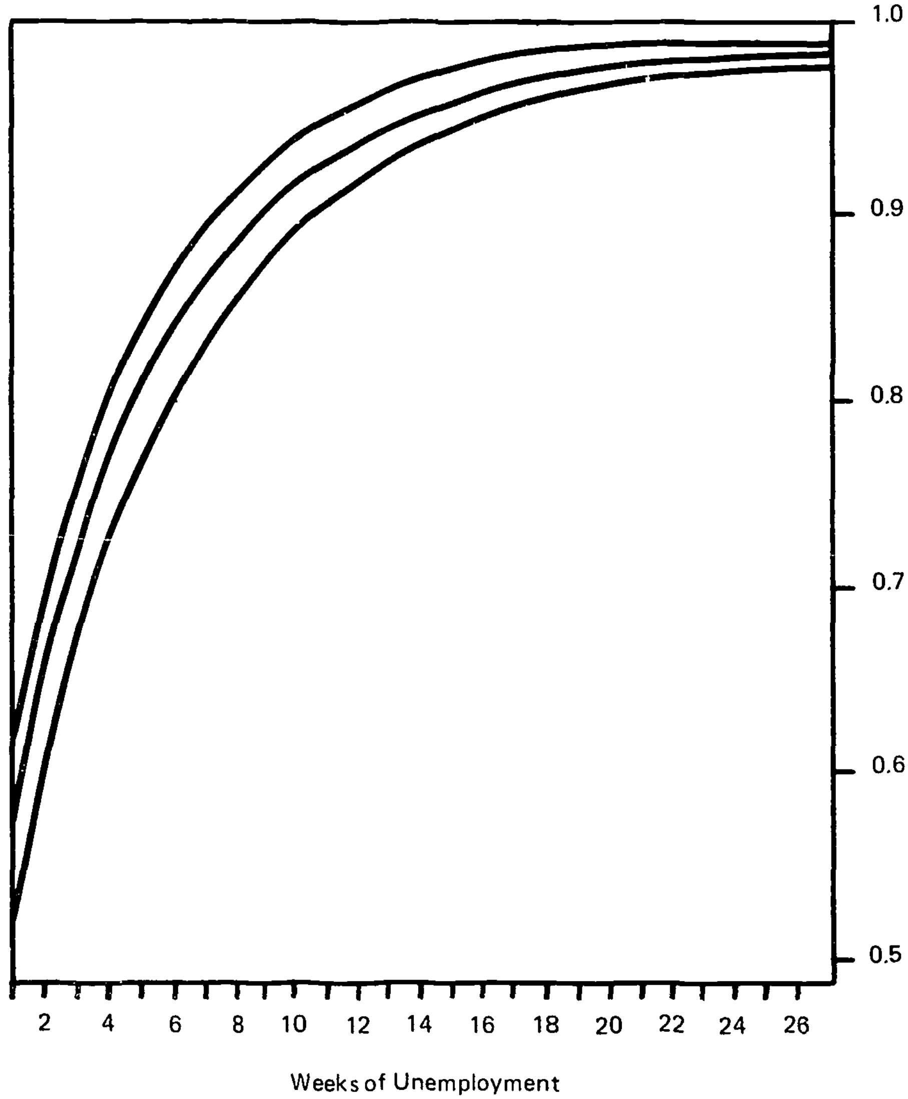
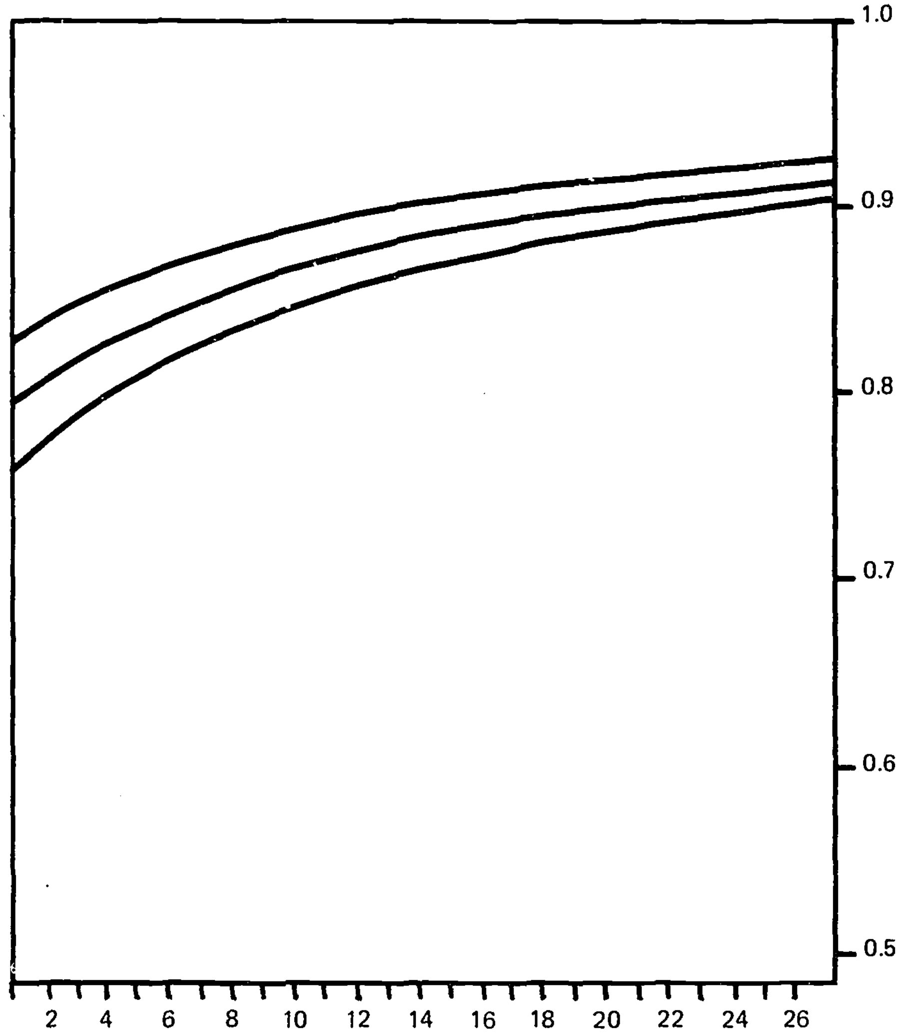


Figure 13 Continuation Rates Estimated From Exhaustions Equation



apparent in the rates from the exhaustions equation.

This should be considered one of the dominant features of job search. It is useful to think of the unemployed as being ordered in a queue, rather than being an amorphous "pool" or a "reserve army". The queue is ordered with the most employable workers at its head and its least employable workers at its tail. The empirical finding of rising continuation rates means that the longer a worker has been unemployed the further back in the queue he is likely to be found.

4) All three continuation rate curves are asymptotic to the values of one. A continuation rate of one corresponds to a certainty of remaining unemployed during the next week. A worker's chance of getting a job never declines to that low a level; however it tends to that extreme as the duration of unemployment becomes very long. A worker who has already been unemployed for many weeks has very little chance of getting a job during the next week, though his chance never actually falls to zero. For example an insured worker who has been unemployed 25 weeks has only about 1% chance of becoming employed during his 26th week of unemployment.

5) One surprising result of the estimation is the tight curvature of the continuation rate graphs. The curves are steeply sloped during the first eight weeks of unemployment, but flatten out for longer durations. During the first eight weeks of unemployment the continuation rate (for average labor demand) rises .31 (from .57 to .88), but during the next eight weeks it rises only 0.08 (to 0.96). Of course any curve of the exponential form used will have a decreasing slope, but the rate of this decline is entirely determined by the data and must be considered an empirical result.

The abrupt decline in re-employment rates can also be seen in the numbers b_{ti} defined in equation (67). These numbers are the fraction of workers still unemployed in week t after i weeks of unemployment. Assuming "average" labor demand, b_{ti} declines from 1.0 at i=0 to .10 at i=8, and to 0.05 at i-26. This means that 90% of the workers laid off get jobs during the first eight weeks of unemployment, but of the remaining 10% of the laid-off workers only half of them get jobs during the entire 18 remaining in the maximum UI benefit period. This makes clear that the workers remaining unemployed after eight weeks experience a particularly difficult time finding a job as compared to the majority of workers laid off.

The most likely explanation of this phenomenon is in terms of a heterogeneous labor market. Most insured unemployed workers undergo a short spell of unemployment, 90% of them leaving the UI roles within eight weeks of their initial claim. Some of these short-term unemployed workers may even be on relatively fixed layoff, being fairly certain of recall by an auto manufacturer. The low continuation rate in the short durations reflects these workers' high probability of returning to work.

After the short-term unemployed workers have regained employment a small group of difficult to employ workers remain unemployed. The high continuation rates after eight weeks reflect their small chance of finding employment. The existence of such groups means only that continuation rates will rise; in order for the continuation rates to rise as rapidly as they do in the early weeks it is necessary that these groups be very distinct and that they have substantially different rates of re-employment. The empirical finding that continuation rates rise rapidly during the short unemployment durations is most likely evidence for a markedly heterogeneous unemployed labor force, where the heterogeneity implies markedly different rates of re-employment.

It is implausible that the steep rise of the continuation rates can be explained alternatively by rapid deterioration of an individual's chances of re-employment. The individual factors which may explain an increase in continuation rates (described on p. 131) can not be expected to operate so quickly as to produce drastic changes in a worker's employability within a few weeks. For example a worker's real or perceived human capital can not be expected to depreciate rapidly during two or three weeks of unemployment. Nor is it likely that the worker slows his job search substantially during the first few weeks of unemployment.

In summary, the finding that continuation rates rise rapidly during the first few weeks of unemployment implies a substantial inequality within the unemployed labor force in terms of different workers' ability to find a job. This is not to deny the possiblity of declining individual re-employment rates, but only that whatever individual effects occur are swamped by the aggregation effects.[18]

4.4 Three Linear Equations: Initial Claims, Number of Weeks Compensated and Amount of Benefits

4.4.1 Initial Claims Equation

A covered worker will usually file an initial claim for UI within the week immediately following his layoff. However, the worker may delay filing for a few weeks[19] or may never file for UI benefits. Thus, the number of initial cliams in the current week will be a function of the number of layoffs in the current and a few previous weeks.

Special studies done in Indiana [1] and Ohio [6] show that most covered workers file for UI within two or three weeks of being laid off. This means there will be initial claims arising from layoffs in both the current and previous months, since a worker laid off near the end of the previous month may make an initial claim in the current month. But only an insignificant number of initial claims will arise from layoffs more than one month before the current month. Expressing his dependence in a distributed lag,

$$I_t = a_1 L_t + a_2 L_{t-1}, \qquad (94)$$

where I_t = initial claims in month t

and L_t = layoffs in month t.

The numbers a_1 and a_2 are the (marginal) fractions of covered laid-off

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18 In fact individual re-employment rates may rise (due to declining aspirations). Aggregate re-employment rates would still fall.

19 Technically the worker may delay filing as long as he wants, subject only to the requirement that he have sufficient "credit weeks" (weeks of covered employment) during the year preceding his initial claim. He could delay filing up to 38 weeks and still have the minimum 14 credit weeks during the previous year. Thus, the legal restrictions on delaying filing are very loose and will rarely penalize the worker for delay. See Michigan Employment Security Act, 1970.

workers who file for UI. These fractions can not be considered constants[20] since they represent the outcome of the workers' economic decisions as to when and whether they will file for UI.

The decisions may not be entirely rational, but they will reflect some balance between the costs and benefits of UI:

1) The cost of filing: the trouble of becoming informed about the UI system, the transaction costs of collecting benefits, and the psychological discomfort of being publicly supported.

2) The benefits of filing: the total amount of weekly UI payments over the expected duration of unemployment. This will be larger, the longer the worker expects to be unemployed.

The costs of filing will remain roughly constant over time, but the expected benefits will change with the tightness of the labor market and, hence, with economic indicators of the demand for labor. Thus, the fractions a_1 and a_2 can be taken to be functions of economic indicators.[21] Choosing linear functions and defining E_t as the relevant economic indicator,

$$a_1 = b_0 + b_1 E_t \quad (95)$$

and

$$a_2 = b_2 + b_3 E_{t-1}, \quad (96)$$

Substituting (95) into (94),

$$I_t = a_1 b_0 L_t + a_1 b_1 L_t E_t + a_2 b_2 L_{t-1} + a_2 b_3 L_{t-1} E_{t-1}. \quad (97)$$

4.4.2 Empirical Results

Two indicators were used as the variable E_t and each was found to have an independent influence over the decision to file for UI. The variables are the same as the ones used in the insured unemployment

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20 Variation in the fraction of laid-off workers filing initial claims is recognized in the method for calculating unemployment [38].

21 This does not mean the worker studies these statistics to forecast how long he will be unemployed; the worker has more direct information in the form of whether he has job leads, whether his acquaintances are bing laid off or hired, etc. The specification assumes only that the economic indicator E_t is correlated with the personal information of the worker.

equation; the SMSA rate of accessions and the SMSA unemployment rate.[22]

The estimated equation is of the form

$$I_t = \text{monthly dummies} + a_1 L_t + a_2 L_t A_t + a_3 L_t u_t + a_4 L_{t-1} + a_5 L_{t-1} A_{t-1} + a_6 L_{t-1} u_{t-1} \; . \qquad (96)$$

The variable L_t represents a problem for the estimation, since layoff rates are not readily available for the non-manufacturing sector of the SMSA. Hence, it is necessary to assume that layoff rates in the non-manufacturing sector are equal to layoff rates in the manufacturing sector. Then the number of layoffs is equal to the layoff rate in manufacturing multiplied by total employment. The specification will be fairly accurate if layoff rates in the two sectors are highly correlated, except for seasonal differences, which are accounted for by the monthly dummies.

Estimates of the coefficients appear below:[23]

$$I_t = \text{monthly dummies} + \underset{(.133)}{0.209 L_t} - \underset{(0.018)}{0.108 L_t A_t}$$

$$+ \underset{(0.018)}{0.115 L_t u_t} + \underset{(0.111)}{0.656 L_t} - \underset{(.023)}{0.080 L_{t-1} A_{t-1}} \qquad (98)$$

R-SQR = 0.94

The statistical fit of the equation is close, though it would be much closer if non-manufacturing layoff data were available. This equation is identical to equation (96) except for the inclusion of

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22 Again the method of calculating the unemployment rate leads to some circularity; it would be preferable not to use the unemployment rate in this equation. See p.120. However, given the fact that the unemployment rate must be included in the equation and the fact that the only available estimate of the unemployment rate is calculated from UI claims, it is better to include u as an indirect factor than as a direct factor. The specified equation is driven by layoffs, and the unemployment rate enters only indirectly to influence the transition rate between layoffs and initial claims. This is superior to using the unemployment rate to determine initial claims, though some spurious correlation unavoidably remains.

23 The estimated standard errors of the parameters appear in parentheses below the estimated parameters of all the linear equations.

monthly dummy variables and the exclusion of the term $L_{t-1}u_{t-1}$ because its coefficient is found to be insignificant. The other interaction terms are significant, indicating that the fraction of laid-off workers filing initial claims for UI does indeed vary with the demand for labor. The signs on the interaction terms indicate the fraction of laid-off workers filing a claim increases with an increase in the unemployment rate or with a fall in the rate of accessions. This coincides with our understanding of the laid-off worker's decision to file an initial claim, since both an increase in the unemployment rate and a fall in the rate of accessions occur during a fall in the demand for labor. This fall in the demand for labor should, and does, cause an increase in the fraction of laid-off workers who file initial claims.

To find the magnitude of this effect, the initial claims equation is summed over the two months we allow for initial claims to be made:

$$I = \text{monthly dummies} + 0.865L + 0.115Lu - 0.188LA \qquad (99)$$

For mean values of the unemployment rate and the accessions rate the above equation implies the (marginal) fraction of laid-off workers making initial claims is 0.73. Thus if there are 100 extra lay-offs there will be about 73 extra initial claims, during either the same month or the next month. But for each one percent increase in the unemployment rate there will be 12 more initial claims, and for each one percent increase in the rate of accessions there will be 19 fewer initial claims arising from the 100 layoffs. There is no independent source of data with which to compare these figures, but they appear plausible, both in direction and magnitude. The intuitive plausibility of the equation and its close statistical fit, allow us some confidence in its ability to predict initial claims.

4.4.3 Number of Weeks Compensated

Not everyone who files a continued claim for UI, and is therefore defined as "insured unemployed", receives a UI payment. The claimant must serve one "waiting week" before he receives any payments, or he may be disqualified from benefits, either temporarily or permanently, for various enumerated offenses, such as refusing to accept suitable employment. These exceptions reduce the number of weeks actually compensated slightly below the number of insured unemployed. There is no strong reason to suspect that the gap between these two numbers varies cyclically, and the data suggest that it does not: regressions using cyclical variables such as the unemployment rate and the rate of accessions to explain the gap were ineffective. Yet a substantial variation exists since the simple regression of the dependent variable "number of weeks compensated" on the independent variable "insured unemployment", gives a coefficient of determination of only 0.86.

The explanation lies in the timing of claims and payments. A payment is recorded one or two weeks after the corresponding claim is made. A claim filed at the beginning of the current month will correspond to a payment in the same month, but a claim filed at the end of the current month will correspond to a payment in the next month. Payments recorded in the current month will correspond to claims in both the current and previous months. This leads to a moving average specification,

$$N_t = a_0 + a_1 IU_t + a_2 IU_{t-1}. \qquad (100)$$

where N_t = number of weeks compensated during month t.

In the actual estimation monthly dummy variables were included to reflect the different seasonal pattern of N as compared with that of IU.

$$N_t = \text{monthly dummies} + \underset{(0.0405)}{0.455 IU_t} + \underset{(0.0400)}{0.354 IU_{t-1}}$$

R-SQR = 0.975

The close fit of this equation, exemplified by the high coefficient of determination, and the small standard errors of the estimated parameters, provides empirical substantiation for the relationship formulated on *a priori* grounds. The estimated parameters show that 100 additional insured unemployed in one month will lead to about 46 additional UI payments in the same month and about 35 additional UI payments in the next month, leaving about 19 of the additional claimants to go without payments.

4.4.4 Total Amount of Benefits

During the sample years benefit rates ranged from \$16 to \$87 per week,[24] depending on the former wages of the insured worker and the number of his dependents. Dividing the beneficiaries into groups, the average benefit rate paid in Detroit is a weighted sum of the rates for different groups:

$$\frac{B}{N} = \sum_i R_i \frac{N_i}{N} \,. \tag{101}$$

where R_i = the benefit rate for the ith group of beneficiaries

N_i = the number of beneficiaries in the ith group

N = the number of weeks compensated = $\sum_i N_i$

B = total amount of benefits (in dollars)

In order to evaluate the above expression we need some theory of the relationship between the weights, N_i/N, and the benefit rates, R_i. A complete analysis would be beyond the bounds of this study, but even a simple view of the components of insured unemployment is useful.

When labor demand is high and insured unemployment is low we would expect to have a disproportionately large number of "disadvantaged" groups on the UI roles. This is because "disadvantaged" workers by definition are workers who have trouble finding employment, even when aggregate labor demand is high. As labor demand falls, progressively more employable workers are laid off and claim UI, so that the proportion of disadvantaged workers in the insured unemployment roles falls also. If we assume further that disadvantaged workers receive lower wages when they work and, conversely, that the more employable workers laid off during a cyclical downswing are likely to be higher wage workers, then the average wage paid to insured unemployed workers (prior to layoff) during a period of high labor demand will be less than during a period of low labor demand. Since higher previous wages will bring a worker higher UI payments we conclude that average UI benefit rates will be higher during periods of high unemployment.

It is convenient to use the variable "number of weeks compensated" to represent labor demand. It is related in a linear equation to insured

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[24] Since January 1, 1972, the maximum weekly benefit rate has been changed to $92.

unemployment and has the same timing as the dependent variable, B (see previous section). Therefore the average benefit rate is assumed to be a linear function of the number of weeks compensated:

$$\frac{B_t}{N_t} = a_1 + a_2 N_t \ . \qquad (102)$$

Multiplying by N_t,

$$B_t = a_1 N_t + a_2 N_t^2 \ . \qquad (103)$$

Total benefits are thus a quadratic function of the number of weeks compensated.

The above equation fits the data extremely closely, and both of its parameters are highly significant:

$$B_t = -294{,}000 + \underset{(3.60)}{47.9\ N_t} + \underset{(1.26)}{5.77 \times 10^{-5}}\ N_t^2 \qquad (104)$$

R-SQUARE = 0.990

Dividing the above equation by N gives the average benefit rate for different levels of N, the number of weeks compensated. To explore this dependence the average benefit rate has been calculated for three values of N: the mean value of N, a value of N one standard deviation less than the mean, and a value of N one standard deviation more than the mean. Table 12 shows that the average benefit rate changes substantially over the business cycle and that the changes are in accord with the previous discussion. When there are few people on the UI roles these tend to be the low-wage, low-benefit rate individuals. But looser labor markets find higher-wage, higher-benefit rate individuals on the UI roles.

These calculations show that the parameters of the estimated equation are in agreement with a priori reasoning about the components of insured unemployment. Taken with the extremely close fit of the regression, they provide confidence in the equation as a forecasting tool.

4.5 The Unemployment Insurance Model in Perspective

4.5.1 Summary of Equations

TABLE 12

Average Weekly Benefit Rate

in a Changing Labor Market

Number of weeks compensated per month	Aggregate labor demand	Average weekly benefit rate	Approximate corresponding weekly income before layoff[1]
mean - standard deviation = 57,000	high	$46.00	$80.00
mean = 122,000	average	$52.55	$94.00
mean + standard deviation = 188,000	low	$57.18	$103.00

1 These are the weekly incomes which would yield the average weekly benefit rate in the column to the left. The average income of UI recipients is greater than this amount because of the ceilings on benefit rates and the payment of partial benefits. See Michigan Employment Security Act, 1970.

1) Initial Claims

$$I_t = \text{monthly dummies} + a_1L_t + a_2L_tA_t + a_3L_tu_t + a_4L_{t-1} + a_5L_{t-1}A_{t-1} \quad (105)$$

2) Insured Unemployment

$$IU_t = \sum_{i=o}^{K} \delta_i \, b_{ti} \, I_{t-i} \quad (106)$$

$$\text{where } b_{ti} = \prod_{m=o}^{i} r_{t-m,\, i-m} \quad (107)$$

$$\text{and } r_{ti} = a_1 + a_2e^{a_3i} + a_4e^{a_5i} A_t/u_t + a_6D_t \quad (108)$$

3) Exhaustions

$$EX_t = \sum_{i=o}^{K} \chi_i \, b_{ti} \, I_{t-i} \quad (109)$$

b_{ti} same as above

4) Number of Weeks Compensated

$$N_t = \text{monthly dummies} + a_1IU_t + a_2IU_{t-1} \quad (110)$$

5) Amount of Benefits

$$B_t = a_o + a_1N_t + a_2N_t^2 \quad (111)$$

4.5.2 The UI Model in Perspective

The five equations which comprise this model have been specified in accordance with the structure of the MIchigan UI system and economic theory. They have been estimated with optimal econometric techniques and practical administrative UI data. They have been tested for their predictive power within the sample period. They have been studied for their implications about manpower behaviors and these implications have been scrutinized for their applicability to the real world of Detroit workers. No system of equations can be certified to provide error-free forecasts, but the scientific procedure followed in developing this system is the most likely to provide accurate projections, useful for policy guidance.

The only task remaining to validate this model is a dynamic simulation to test the model's predictive power outside the sample period. This requires a special computer program, which is currently under development. Simultaneously work is progressing to mathematically simulate proposed UI systems. The goal here is to forecast the level of claims, payments and exhaustions of revised UI systems before the systems are instituted. This will be of great value to those who want to alter the existing UI system, but wish to know beforehand what level of benefits and costs will result.

The most immediate application of this model is to the requisition of state funds from the U.S. Treasury. Accurate forecasts of UI benefits may allow great gains in interest payments because the state will be able to determine the minimum level of liquid funds necessary to carry on its transactions. In essence the State Employment Service will be more able to perform modern planning-programming-budgeting analysis on its UI finds.

This short-run goal should serve to initiate implementation of the model at State Employment Services on a current basis. After experience has been gained with the model more long-range benefits can be realized; the model can help answer questions about UI legislation and manpower issues. Thus the model, which is institued on a limited basis at first, can eventually become a key scientific tool for use throughout the agencies of UI administration.

APPENDIX D-1

THE CONDITIONAL PROBABILITY OF EXHAUSTING UI BENEFITS

Consider a group of UI claimants who made their initial claims in week t-i. Of the people still receiving UI in week t-1, what fraction will exhaust payments in week t? In order for them to exhaust payments, two conditions must apply to them:

1) They do not get a job in week t. The probability of this outcome is the continuation rate, r_{ti}.
2) They have a determination of i weeks. The fraction of initial claimants having this particular determination is χ_i (see p. 129). In week t only UI claimants with determinations of i weeks or greater are still receiving payments. The number of such people is

$$\sum_{k=i}^{K} \chi_k = \delta_{i-1} \qquad (112)$$

So the fraction of people still receiving payments in week i-1 and who have a determination of i weeks is χ_i/δ_{i-1}.

The above two events are independent, so the probability that both events will occur simultaneously is the product of their probabilities:

$$e_{ti} = \frac{r_{ti}\ \chi_i}{\delta_{i-1}} \qquad (113)$$

APPENDIX D-2

THE EQUIVALENCE OF THE MARKOV PROCESS AND THE INSURED UNEMPLOYMENT EQUATION:

This discussion will begin with equation (85) of 4.3. The first element of the column vector X_{ti} is the number of people in the UI state. The number of people in that state with 0 weeks of claims is the number of initial claims in that week. The first equation, therefore,

$$IU_{ti} = \left[\prod_{m=0}^{i} \left(r_{ti} - e_{ti} \right) \right] I_{t-i}. \tag{114}$$

The factor in brackets is the i-step transition probability, substituting from the 1-step transition matrix on page 138. The task of this appendix is to prove the proposition that the above equation is the same as equation (80) and therefore that

$$\left[\prod_{m=0}^{i} \left(r_{ti} - e_{ti} \right) \right] I_{t-i} = \delta_i b_{ti} I_{t-i} = IU_{ti} \tag{115}$$

The proof will employ mathematical induction. It has two parts:

1) Prove the proposition is true for $C_{t-i,0}$:

The equation states

$$IU_{t-i,0} = \left(r_{t-i,0} - e_{t-i,0} \right) I_{t-i} = \delta_0 b_{t-i,0} I_{t-i} \tag{116}$$

Substituting

$$r_{t-i,0} = 1, \; e_{t-i,0} = 0, \; \delta_0 = 1 \text{ and } b_{t-i,0} = r_{t-i,0} = 1,$$

both equations reduce to the identity:

$$IU_{t-i,0} = I_{t-i} \tag{117}$$

2) Prove that if the proposition is true for $IU_{t-1,i-1}$ then it is also true for IU_{ti}:

Assume $IU_{t-i,i-1} = \delta_{i-1} b_{t-1,i-1} I_{t-i}$. (118)

Then $IU_{ti} = \left(r_{ti} - e_{ti} \right) \left(\delta_{i-1} b_{t-1,i-1} I_{t-i} \right),$ (119)

where $\left(r_{ti} - e_{ti} \right)$ is the 1-step transition probability at time t.

Substituting $e_{ti} = \dfrac{X_i \, r_{ti}}{\delta_{i-1}}$ from Appendix D-1.

$$IU_{ti} = r_{ti} - \frac{\chi_i r_{ti}}{\delta_{i-1}} \delta_{i-1} b_{t-1,i-1} I_{t-i} \quad (120)$$

Using $\delta_{i-1} - \chi_i = \delta_i$ and $b_{ti} = r_{ti} b_{t-1,i-1}$, (121)

$$IU_{ti} = \delta_i b_{ti} I_{t-i}. \quad \text{Q.E.D.} \quad (122)$$

Summing over i, $IU_t = \sum_{i=0}^{K} IU_{ti} = \sum_{i=0}^{K} \delta_i b_{ti} I_{t-i}$. (123)

This last equation is the insured unemployment equation, showing how it can be derived from an extended Markov process.

APPENDIX D-3

THE PROPERTIES OF THE DISTURBANCE TERM OF THE INSURED UNEMPLOYMENT EQUATION

b_{ti} is the only random variable in the insured unemployment equation (80). It is a random variable because it is a function of the vector $\bar{r}$, which is a function of the random vector $\underline{\varepsilon}$.

$$b_{ti} = \prod_{m=0}^{i} \left(\bar{r}_{t-m,i-m} + \varepsilon_{t-m} \right) \quad . \qquad (124)$$

Let $\bar{b}_{t-i}$ be the non-random part of b_{ti} and $\tilde{b}_{ti}$ be the random part of b_{ti}.

Then $b_{ti} = \bar{b}_{ti} + \tilde{b}_{ti}$ (125)

where $\bar{b}_{ti} = \prod_{m=0}^{i} \bar{r}_{t-m,\ i-m}$ (126)

and carrying out the product in (117)

$$\tilde{b}_{ti} = \bar{r}_{ti}\ \bar{r}_{t-1,i-1}\ \varepsilon_{t-2} \cdots + \bar{r}_{ti}\ \varepsilon_{t-1}\ \bar{r}_{t-2,i-2} \cdots + \bar{r}_{ti}\ \varepsilon_{t-1}\ \varepsilon_{t-2} \cdots$$

$$+ \varepsilon_t\ \bar{r}_{t-1,i-1}\ \bar{r}_{t-2,i-2} \cdots + \varepsilon_t\ \varepsilon_{t-1}\ \varepsilon_{t-2} \cdots \varepsilon_{t-26} \qquad (127)$$

$E\ \tilde{b}_{ti} = 0$ because $\underline{\varepsilon}$ is not autocorrelated and $E\ \varepsilon_t = 0$.

Substituting (118) into the insured unemployment equation,

$$IU_t = \sum_{i=0}^{K} \delta_i \left(\bar{b}_{ti} + \tilde{b}_{ti} \right) I_{t-1} \qquad (128)$$

$$IU_t = \sum_{i=0}^{K} \delta_i\ \bar{b}_{ti}\ I_{t-1} + U_t, \qquad (129)$$

where $U_t = \sum_{i=0}^{K} \delta_i\ \tilde{b}_{ti}\ I_{t-1}$ is the disturbance term of the (130) insured unemployment equation.

$$E\left(U_t\right) = \sum_{i=0}^{K} \delta_i\ E\left(\tilde{b}_{ti}\right) I_{t-1} = 0. \qquad (131)$$

Let p represent the number of weeks of lag in the autocorrelation function of the disturbance term. Then the autocovariance function of the insured unemployment equation is given by,

$$E\left(U_t\, U_{t-p}\right) = E\left\{\sum_{i=0}^{K} \delta_i\, \tilde{b}_{ti}\, I_{t-i}\right\}\left\{\sum_{j=0}^{K} \delta_i\, \tilde{b}_{t-p,j}\, I_{t-j-p}\right\} \qquad (132)$$

$$E\left(U_t\, U_{t-p}\right) = \sum_{i=0}^{K}\sum_{j=0}^{K} \delta_i\, \delta_j\, E\left(\tilde{b}_{ti}\, \tilde{b}_{t-p,j}\right) I_{t-i}\, I_{t-j-p} \qquad (133)$$

Now $$\tilde{b}_{ti} = \sum_{n=0}^{i}\left(\prod_{\substack{m=0\\ m\neq n}}^{i} \bar{r}_{t-m,i-m}\right)\varepsilon_{t-n} + \text{cross terms.} \qquad (134)$$

Likewise $$\tilde{b}_{t-p,j} = \sum_{n=0}^{j}\left(\prod_{\substack{m=0\\ m\neq n}}^{j} \bar{r}_{t-p-m,j-m}\right)\varepsilon_{t-p-n} + \text{cross terms,} \qquad (135)$$

so $$\tilde{b}_{ti}\, \tilde{b}_{t-p,j} = \sum_{n=p}^{i}\left(\prod_{\substack{m=0\\ m\neq n}}^{i} \bar{r}_{t-m,i-m}\right)\left(\prod_{\substack{m=0\\ m\neq n}}^{j} \bar{r}_{t-p-m,j-m}\right)\varepsilon_{t-n}^{2} + \text{cross terms.} \qquad (136)$$

Defining $\sigma^2 = E\,(\varepsilon_t^2)$ (137)

$$E\left(\tilde{b}_{ti}\, \tilde{b}_{t-p,j}\right) = \sigma^2 \sum_{n=p}^{i}\left(\prod_{\substack{m=0\\ m\neq n}}^{i} \bar{r}_{t-m,i-m}\right)\left(\prod_{\substack{m=0\\ m\neq n}}^{i} \bar{r}_{t-p-m,j-m}\right) \qquad (138)$$

therefore $$E\left(\tilde{b}_{ti}\, \tilde{b}_{t-p,j}\right) = \left\{\begin{array}{l} 0 \text{ for } p>i \\ >0 \text{ for } 0\leq p\leq i \end{array}\right\}. \qquad (139)$$

Since all of the terms in the sum in (138) are positive, the larger the lag p, the smaller the autocovariance of the disturbance U.

Returning to equation (133) and combining it with the information from (139) we can reach two conclusions:

1) The disturbance is heteroscedastic. Equation (133) gives the variance of the disturbance when p=0. It varies roughly with the square of the variable I_t (initial claims).
2) The distrubance is autocorrelated. The autocorrelation is positive for lags of 1 week through K weeks and declines as the length of the lag increases. For lags greater than K the autocorrelation is zero.

It is not surprising that autocorrelation of the continued claims disturbances exists, since a random error in a continuation rate in one week will carry over into later weeks. For example suppose an exogenous shock raises the continuation rate in week t, resulting in more than the expected number of continued claims in that week. Some of these additional claimants will continue to make claims in week t+1 even if the continuation rate drops back to its expected value. Therefore the high continuation rate in week t leads to high continued claims in both week t and week t+1 (and weeks t+2 through t+K). The continued claims disturbances will be all positive from week t through week t+k. In general this "overflow" effect will cause the residuals to be highly positively correlated.

APPENDIX D-4

A TRANSFORMATION TO IMPROVE THE EFFICIENCY OF THE ESTIMATION BY REDUCING AUTOCORRELATION OF THE DISTURBANCE TERM

Appendix D-3 shows that the disturbance term U_t is autocorrelated of degree K. This is verified in the actual estimations by the finding that the residuals from the first fitting are very highly correlated.

We assume the residuals are a K-th order Markov process:

$$U_t = \sum_{m=1}^{K} d_m U_{t-m} + U_t^1. \tag{140}$$

The $\{d_m\}$ are assumed to be approximately constant (but unknown) autocorrelation parameters. The term U_t^1 is assumed to be an unautocorrelated disturbance term. Thus we have two disturbance terms: U_t, which is autocorrelated and U_t^1 which is not autocorrelated. We now transform the equation so that the disturbance term is U_t^1 rather than U_t.

Write the model of Insured Unemployment as

$IU_t = \overline{IU}_t(\underline{a}) + U_t$, where $\overline{IU}$ is the non-linear function of the parameter vector $\underline{a}$ in equation (80). Then

$$IU_t = \overline{IU}_t(\underline{a}) + \sum_{m=1}^{K} d_m U_{t-m} + U_t^1. \tag{141}$$

Substituting the definition of the autocorrelated residuals,

$$U_{t-m} = IU_{t-m} - \overline{IU}_{t-m}(\underline{a}), \tag{142}$$

gives
$$IU_t = \overline{IU}_t(\underline{a}) + \sum_{m=1}^{K} d_m[IU_{t-m} - \overline{IU}_{t-m}(\underline{a})] + U_t^1 \tag{143}$$

or
$$IU_t = F_t(\underline{d},\underline{a}) + U_t^1 \tag{144}$$

This last equation expresses IU_t as the sum of a new non-linear function of the two vectors of parameters $\underline{a}$ and $\underline{d}$ and the unautocorrelated error term, U_t^1. This equation is used directly to estimate the parameters $\underline{a}$ and $\underline{d}$ by choosing parameters $\hat{\underline{d}}$ and $\hat{\underline{a}}$ which minimize the sum of the squares of the residuals defined by

$$\hat{U}_t = IU_t - F_t(\hat{\underline{d}},\hat{\underline{a}}). \tag{145}$$

The minimization is performed subject to the constraint that the sum of the error terms $\hat{U}_t$ be approximately zero. This is necessary because the estimation minimizes the sum of square of U_t^1 rather than $\hat{U}_t$, creating the possibility that the residuals $\hat{U}_t$ will not be centered about zero even though

$$E\ (U_t^1) = 0.$$

The restriction is imposed by expressing the residuals U_t in equation (140) as deviations from their mean, $\overline{U}$. The error specification is rewritten

$$U_t = \sum_{m=1}^{K} d_m \left(U_{t-m} - U_t^1\right). \qquad (146)$$

To see the implications of this specification it is only necessary to sum U_t from the above equation over all t.

$$\sum_t U_t = \sum_{m=1}^{K} d_m \ (\sum_t U_{t-m} - \sum_t \overline{U}) + \Sigma U_t^1 \qquad (147)$$

The first term on the right-hand side is approximately zero, leaving

$$\sum_t U_t \cong \sum_t U_t^1 \qquad (148)$$

The estimated residuals $\hat{U}_t$ bear an equivalent relationship to the estimated residuals $\hat{U}_t^1$.

$$\sum_t \hat{U}_t \cong \sum_t \hat{U}_t^1 \qquad (149)$$

The quantity $\sum_t \hat{U}_t^1$ will be exactly zero only if there is a constant term in the function F_t. Since there is no such constant term the quantity term $\sum_t \hat{U}_t^1$ will not necessarily be exactly zero, but it will be very small compared to the absolute size of the residuals $\hat{U}_t^1$ or $\hat{U}_t$.[26] For the purposes of this estimation,

$$\sum_t \hat{U}_t \cong 0. \qquad (150)$$

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26 The least-squares method minimizes the sum of squares, $\sum_t \hat{U}_t^1$. This will require that the residuals be approximately centered about zero, with about half of the residuals positive and half negative. Thus the sum $\sum_t \hat{U}_t^1$ will be near zero.

Therefore the mean $\overline{U}_t$ will also be approximately zero and specification (146) will be identical to (140). The practical effect of specification (146) is therefore to impose the constraint that the sum of the error terms U_t be very small but otherwise not to influence the estimation.

It is easy to show that this method is equivalent to the Hildreth-Liu method if the original function is linear and is the same as partial differencing the original variables in the case where the original function is linear and the autocorrelation parameters are known. The current method merely generalizes the philosoply behind those methods to the case of non-linear functions. It is often desirable to make allowance for autocorrelation of residuals in applications of least-squares methods to time series data, whether the functions estimated are linear or non-linear.

APPENDIX D-5

RESOLVING THE DIFFERENCES BETWEEN A WEEKLY MODEL AND MONTHLY DATA

1) The continuation rates are a function of the number of weeks since the workers made initial claims. In the weekly model that concept is well-defined since a worker making his i-th weekly continued claim has been unemployed i weeks. In the monthly model a person in his second month of claims may have been unemployed between 1 and 8 weeks depending upon whether he made his initial claim in the beginning or end of the first month and whether he made his continued claim in the beginning or end of the second month. It is therefore necessary to establish a reference point in each month at which point all claims are assumed to occur. Each reference point will be defined by its time in weeks since initial claim. The durations are calculated as the average time which has elapsed since initial claim for all workers making continued claims during that month. Considering a single cohort of workers who made their initial claim in month 0, the duration of insured unemployment is tabulated in column 2 of Table 13. The coefficients δ_i, which represent the fraction of initial claimants who have not yet exhausted their benefits, are calculated using equation (79), and the duration of unemployment at the reference point in each month. These are tabulated in column 3.

2) The coefficients b_{ti} (the fraction of initial claimants still unemployed after i weeks of payments) can no longer be calculated as the simple product of the continuation rates. If a continuation rate persists for $(d_i - d_{i-1})$ weeks, as we assume in the monthly model, the continuation rate for the i-th month is $r_i\ (d_i - d_{i-1})$, where d_i = the number of weeks of unemployment of the reference point for the i-th month. The coefficients b_{ti} can be calculated from

$$b_{ti} = \prod_{m=o}^{i} r_{t-m,i-m}\ (d_m - d_{m-i}) \qquad (151)$$

3) A UI recipient can make a claim for each week he is unemployed, totaling about 4 claims per month, even though he can only make 1 initial claim in month 0. Therefore a factor (W_i) must be included in the insured unemployment equation to represent the number of claims which will be

made in month i if all continuation rates are equal to one. The factors are tabulated in column 3.

The actual equation used to forecast insured unemployment from monthly data is

$$IU_t = \sum_{i=o}^{K} W_i \delta_i b_{ti} F_{t-i} \qquad (152)$$

The equation can be derived formally by summing the weekly equation in the time domain under the assumptions of constant δ_i and b_{ti} over the length of one month.

4) Similar factors can be derived for the exhaustions equation. They appear in columns 5 through 7. The only difference is that payments (including final payments, which are used to count exhaustions) are recorded about a week later than are claims.

5) This careful adjustment of the model is justified because it preserves the identity of the continuation rates between weekly and monthly models. Without these considerations it would be necessary to define separate weekly and monthly continuation rates, destroying the coherence of the concept.

TABLE 13

Coefficients Use to Aggregate
Weekly to Monthly Model

	Insured unemployment equation			Exhaustions equation		
Month (i)	Average duration of unemployment assuming IC in month 0 (d_i)	Fraction of initial claimants who have not exhausted (δ_i)	Weekly claims per month (W_i)	Average duration (d_i)	Fraction of initial claimants who exhaust in month i (χ_i)	Weekly payments per month (W_i)
0	1.075	1.0	2.68	1.43	0.	.810
1	4.33	1.0	4.33	3.44	0.	4.33
2	8.66	1.0	4.33	8.00	.00233	4.33
3	12.9	.929	4.33	12.3	.0303	4.33
4	17.2	.769	4.33	16.6	.0372	4.33
5	21.5	.572	4.33	21.0	.0372	4.33
6	25.	.478	2.68	24.5	.131	3.494
7*		0	0	26.0	.441	0.25

* A UI recipient would make his 26th (and final) claim in the last week of month 6 if he made his initial claim in the last week of month 0. Thus there can be no claims in month 7. However, because of the (approximately one week) lag in recording payments a final payment may be recorded in the first week of month 7.

APPENDIX D-6

MEASURING INSURED UNEMPLOYMENT

Minor inconsistencies created by the complexity of the Michigan UI system and the method of data collection, are easily resolved by proper data transformation.

1) In administrative data continued claims are recorded during the week in which they were filed. However they cover insured unemployment of the preceding week because claimants must file after completion of a week of insured unemployment. Therefore insured unemployment in week t is equal to the number of continued claims in week t+1, not t.

2) Some jurisdictions take claims on a bi-weekly basis: either "two weeks compensable" (TWC), or "waiting week and first compensable" (WWFC). Each of these bi-weekly claims represents two weeks of insured unemployment, rather than one week. Since separate data is collected for each of these types of data, a simple transformation gives the number of waiting week insured unemployment (WIU) and compensable insured unemployment (CIU) in week t:

$$WIU_t = TW_{t+1} - WFC_{t+1} - WFC_{t+2} \quad (153)$$

$$CIU_t = TC_{t+1} - TWC_{t+1} - TWC_{t+2} \quad (154)$$

where TW_t is the total number of waiting weeks claimed in week t and TC_t is the total number of compensable weeks claimed in week t.

3) Weeks of unemployment are insured whether they are waiting weeks or compensable. Therefore insured unemployment is defined as:

$$IU_t = WIU_t + CIU_t \quad (155)$$

4) These transformations are applied to weekly data before they are aggregated to monthly data. The monthly aggregation is performed by adding all of the claims for week wholly within a month plus a fraction of the claims taken in weeks included within two months. The fraction is equal to the number of days of the week within the particular month.

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