TESTING FOR LABOR MARKET EQUILIBRIUM WITH AN EXACT EXCESS DEMAND DISEQUILIBRIUM MODEL

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Abstract—The standard disequilibrium model is supplemented with outside information on the extent of market excess demand. Estimation of this supplemented model is considerably less involved than that of the standard model, and certain desirable structural features, such as improved dynamics, are obtained. In addition, a simple nested test of the hypothesis of market equilibrium is available. The model is estimated with aggregate U.S. post-war labor market data, and the econometric test rejects the hypothesis of labor market equilibrium.

I. Introduction

THE presence or absence of labor market equilibrium is crucial for macroeconomics. Even more so than the mechanism generating expectations, the assumption of market clearing determines whether a macroeconomic model produces Classical or Keynesian results. Equilibrium models of the labor market have been estimated, most prominently by Lucas and Rapping (1970); however, it is not obvious that such models can be reconciled with the short-run behavior of the labor market. A disequilibrium model allows for the possibility that the real wage may not clear the labor market and that some agents may be rationed.[1] It is a more general formulation since with a disequilibrium model it is often possible to construct a nested econometric test of the hypothesis of market equilibrium. This paper conducts such a test.

Rosen and Quandt (1978) tested and rejected the hypothesis of labor market equilibrium, and explicit disequilibrium models of the labor market have also been estimated by Broadberry (1983), Eaton and Quandt (1983), Sarantis (1981), and Sneesens (1983) among others. This paper differs from those models by incorporating potential information about the extent of labor market rationing in the estimation of the model. The standard disequilibrium equations of supply, demand, and the quantity min condition are augmented by a deterministic equation that indicates excess labor demand (or supply) by using data on unemployment, quits, layoffs, and help wanted advertising. Section II presents this disequilibrium model with exact excess demand indicators. This model is very easy to estimate and has certain structural advantages, in particular, improved dynamics and an endogenous wage. Section III describes the estimation procedure and the test for equilibrium. Since hypothesis tests are always conditional upon the assumed structural equations, we can provide a more substantial test for equilibrium with this model. The results of estimation are discussed in section IV.

II. The Model with Exact Indicators

The standard disequilibrium model consists of three equations, one each for demand, supply, and the observed quantity (which is the minimum of the demand and supply). The difficulties in estimating this model are well known, and include, for instance, the ill-behaved nature and potential unboundedness of the likelihood function and the very large computational burden (see Quandt (1982), Maddala (1983)). These estimation problems arise from the inability to observe directly demand and supply or to separate the sample into different regimes of rationing. An obvious solution is to add information to the model about excess demand that would aid in partitioning the sample. Therefore, a fourth equation, one that describes the nature of excess demand, will be added to the standard three equations of the simplest disequilibrium model.[2]

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[1] The main economic rationale for sluggish wage adjustment and incomplete labor market clearing is based on the long-term, idiosyncratic nature of the labor relationship. As recent research of principal-agent and contracting problems suggests, the optimal response of firms and workers to informational asymmetries, uncertainty, and job-specific capital is to form simple, non-contingent explicit and implicit contracts that insulate the wage. For references to the literature, see summaries by Solow (1980) and Schultze (1985).

[2] For other attempts to incorporate regime information into the estimation of disequilibrium models, see Lubrano (1985) and Kooiman (1984).

Labor Demand and Supply

The equations for demand and supply in this model can be derived from simple microeconomics; in particular, the derivation in Rosen and Quandt (1978) is applicable. The amount of labor demanded varies with the real wage rate and with the scale of production, as profit maximizing firms adjust the marginal productivity of labor. A time trend for possible productivity improvements will also be included. Assuming a log-linear formulation and an additive stochastic error u_{1t}, labor demand is

$$L_t^D = \alpha_0 + \alpha_1 WP_t + \alpha_2 Y_t + \alpha_3 t + u_{1t} \qquad (1)$$

where L_t^D is the log of the worker-hours demanded, WP_t is the log of the producer's real wage (the nominal wage divided by a production price index), Y_t is the log of output, and t is a time trend. Although equation (1) is a proper structural relationship, it should be noted that since output and the price of output are assumed to be exogenous the labor market is treated here in isolation from the rest of the economy. Such partial analysis is commonplace in single market studies, including Lucas and Rapping (1970) and Rosen and Quandt (1978).

This demand equation is also based on the assumption that labor is costlessly variable. Many writers have noted, however, the existence of adjustment costs in changing the amount of labor demanded, so past levels of labor will affect current desired levels. These costs lead firms to adjust gradually to the level given by the static labor demand equation rather than attempt to maintain it continually through time. To capture the effect of such partial adjustment, a lagged value of labor demand will be included as an explanatory variable (as in, for example, Lucas and Rapping (1970)), so labor demand is

$$L_t^D = \alpha_0 + \alpha_1 WP_t + \alpha_2 Y_t + \alpha_3 t + l_1 L_{t-1}^D + u_{1t}. \qquad (2)$$

For labor supply, microeconomic analysis of the work–leisure choice faced by a household identifies the real wage net of taxes and the amount of household real wealth as important influences on the decision to seek employment. Labor supply must also be scaled for changes in the size of the potential labor force as the population grows. Suppliers of labor may adjust slowly to attain these optimal levels because of habit or adjustment costs, so previous labor supply may be a factor in current labor supply. In log-linear form with error u_{2t}, labor supply is

$$L_t^S = \beta_0 + \beta_1 WC_t + \beta_2 A_t + \beta_3 TP_t + l_2 L_{t-1}^S + u_{2t} \qquad (3)$$

where all variables are in logarithms and WC_t is the consumer's real wage (the nominal wage net of taxes divided by a consumption deflator), A_t is household real wealth, and TP_t is the total population over 16 years of age.

The Min Condition

The above demand and supply functions are similar to those used in equilibrium models. It is the mechanism determining the actual quantity transacted in the market that permits quantity rationing or disequilibrium. The level of employment in the labor market is assumed to be determined as the minimum of demand and supply:

$$L_t = \min(L_t^D, L_t^S). \qquad (4)$$

The observed quantity of labor exchanged in the market, L_t, represents the short side of the market on the assumption that exchange is voluntary. Thus, if $L_t^D \geq L_t^S$, the quantity L_t is on the supply curve, and if $L_t^D \leq L_t^S$, the quantity is on the demand curve. Demand and supply are unobservable except insofar as they equal quantity. In contrast, the model of an equilibrium labor market replaces the min condition with

$$L_t = L_t^D = L_t^S. \qquad (5)$$

The equilibrium system, equations (2), (3), and (5), form a simultaneous equations system with two observable endogenous variables, the observed quantity L_t and the nominal wage W_t.

It would be desirable to model the labor market not as a single market switching between two regimes but as a smooth aggregation over many submarkets, a greater or lesser number of which are in excess demand or excess supply. Then, the aggregate L_t is less than the minimum of aggregate L_t^D or L_t^S. Such an explicitly aggregated disequilibrium model is formalized by Muellbauer (1978) and Malinvaud (1980) (though the concept is much older; see Hansen (1970)), and versions are estimated by Broadberry (1983) and Hajivassiliou (1984). The min condition above is also specified as deterministic. A third stochastic error could be added to equation (4), but this would only complicate estimation with little added economic significance (Quandt (1982)). .

The Indicator Equation

The final equation of the model incorporates information on the extent of excess demand. Let I_t be a statistic that measures or indicates excess demand in the labor market; an obvious example is (the inverse of) the unemployment rate. Let I_t^E be the equilibrium value of the indicator when labor demand equals labor supply. Then, the linear indicator equation is

$$L_t^D - L_t^S = \delta_0\left(I_t - I_t^E\right). \tag{6}$$

Assuming $\delta_0 \geq 0$ (i.e., I_t is, if anything, an indicator of excess demand not excess supply), when $I_t > I_t^E$, the market is in excess demand, so $L_t^D \geq L_t^S$ and $L_t = L_t^S$. The opposite is true during excess supply. Thus, this equation provides an exact partition of the sample and a quantitative measure of excess demand, effectively identifying the unobservable side of the market. We will discuss the usefulness of this equation for estimation and its nonstochastic nature in section III.

Equation (6) can be viewed as a generalization of a deterministic price or wage adjustment equation, which is found in several disequilibrium models starting with Fair and Jaffee (1972). The indicator equation reduces to a price adjustment equation if the indicator is the rate of wage inflation and the equilibrium inflation rate is assumed to be zero. However, instead of a price equation, equation (6) should be considered a measurement equation relating the unobservable excess demand to a labor market statistic. It is likely that there are other more direct and more informative indicators of excess labor demand than wage inflation.

The indicator of labor market tension I_t is a series correlated with excess demand but not necessarily causal, for it will be treated as an endogenous variable in estimation. The various labor statistics considered include the inverse of the rate of unemployment, the inverse of the rate of manufacturing layoffs, the index of help wanted advertising, the quit rate in manufacturing, and real and nominal wage inflation. These indicators of labor market excess demand are discussed in Baily (1982).

The equilibrium level I_t^E connotes a balance of pressure, given structural imperfections, between excess demand and excess supply.[3] Since no precise estimates of I_t^E exist for any of the series, the fitted quadratic trend of the series,[4] denoted I_t^T, will be used as a proxy. The indicators are given in logarithms; thus, the right-hand side of equation (6) takes the form of percentage deviations from trend. For unemployment, where some general notions of an equilibrium rate are available (e.g., Gordon (1977), Wachter (1976)), the quadratic trend matches these very closely. The sample separation that results from using the trend as an equilibrium level is also consistent with qualitative descriptions of the labor market. Figure 1 graphs the unemployment indicator with NBER business cycle *P*eaks and *T*roughs. This sample split is surprisingly similar across all indicators except wage inflation (which is extremely irregular). Besides providing a partitioning point to separate periods of excess supply from those of excess demand, the trend I_t^T also normalizes the indicator for long-term changes. For instance, the secular increase in the unemployment rate in the last thirty years, partly due to demographic changes in the labor force, will be matched by increases in the unemployment trend, so deviations from trend will remain a stable indicator of excess demand.

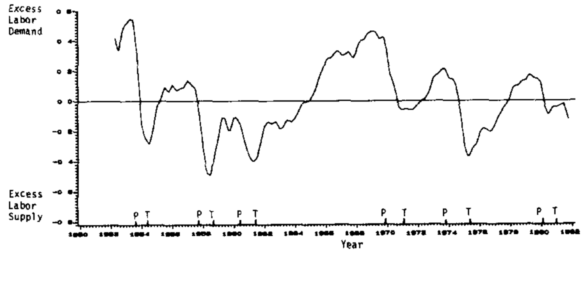
Besides using the individual statistics as indicators, the information contained in several indicators can be compressed prior to estimation[5] into a

[3] In this sense, I_t^E is a "natural rate" as defined by Friedman (p. 8, 1968), a level around which the market fluctuates. This is in contrast to the Keynesian "full employment" rate, which represents a ceiling or upper bound on economic fluctuations.

[4] The use of a linear or cubic trend made little difference in the estimation results.

[5] For discussion of an iterative technique to derive endogenous indicator weights, see Rudebusch (1985)

FIGURE 1.—THE UNEMPLOYMENT INDICATOR (PERCENTAGE DEVIATIONS FROM TREND OF THE INVERSE OF THE UNEMPLOYMENT RATE)



weighted average, which could then be used as a single indicator. One system of weights, which has a history of use in the construction of unobserved variables, is derived from principal component or factor analysis (see Johnston (1972, chapter 11)). The first principal component is a weighted average that accounts for a high percentage of the total variation contained in several indicators. This averaged measure of excess demand is less idiosyncratic than any single indicator and was also used in a disequilibrium estimation.

III. Estimation and Testing for Equilibrium

In this section, we describe the procedure for estimating the disequilibrium model with exact excess demand indicators and the construction of lagged dependent variables. Two very important topics are also discussed: the use of an endogenous wage and the test of the hypothesis of labor market equilibrium.

The Estimation Procedure

We restate the model in compact form as

$$L_t^D = \alpha' X_{1t} + l_1 L_{t-1}^D + u_{1t} \quad (7)$$
$$L_t^S = \beta' X_{2t} + l_2 L_{t-1}^S + u_{2t} \quad (8)$$
$$L_t = \min(L_t^D, L_t^S) \quad (9)$$
$$L_t^D - L_t^S = \delta_0 (I_t - I_t^E) \quad (10)$$

where

$$X_{1t} = (1, WP_t, Y_t, t)'$$

and

$$X_{2t} = (1, WC_t, A_t, TP_t)'.$$

This model can be estimated by least squares techniques. Since the indicator equation provides deterministic information about the type of regime and the difference between two unobservables $(L_t^D - L_t^S)$ can be replaced using the observable $(I_t - I_t^E)$, there are two cases to consider:

If $I_t - I_t^E > 0$, the market is in excess demand and

$$\begin{aligned} L_t &= L_t^D - (L_t^D - L_t^S) \\ &= \alpha' X_{1t} + l_1 L_{t-1}^D - \delta_0 (I_t - I_t^E) + u_{1t} \quad (11) \\ L_t &= L_t^S \\ &= \beta' X_{2t} + l_2 L_{t-1}^S + u_{2t}. \quad (12) \end{aligned}$$

If $I_t - I_t^E < 0$, the market is in excess supply and

$$\begin{aligned} L_t &= L_t^D \\ &= \alpha' X_{1t} + l_1 L_{t-1}^D + u_{1t} \quad (13) \\ L_t &= L_t^S + (L_t^D - L_t^S) \\ &= \beta' X_{2t} + l_2 L_{t-1}^S + \delta_0 (I_t - I_t^E) + u_{2t}. \quad (14) \end{aligned}$$

To implement this model, define partitioning variables:

$$\begin{aligned} ED_t^+ &= 1 \quad \text{if } I_t - I_t^E > 0 \text{ (excess demand)} \\ &= 0 \quad \text{otherwise.} \\ ED_t^- &= 1 \quad \text{if } I_t - I_t^E < 0 \text{ (excess supply)} \\ &= 0 \quad \text{otherwise.} \end{aligned}$$

Then form two equations,

$$L_t = \alpha' X_{1t} + l_1 L_{t-1}^D - \delta_0 ED_t^+ (I_t - I_t^E) + u_{1t} \quad (15)$$

$$L_t = \beta' X_{2t} + l_2 L_{t-1}^S + \delta_0 ED_t^- (I_t - I_t^E) + u_{2t}. \quad (16)$$

Three stage least squares is used to estimate these equations because of the presence of δ_0 in both equations, and because L_t, I_t and the nominal wage W_t (as discussed below) are considered endogenous to the system.

The key to estimation of the exact excess demand specification is the inclusion of outside information to indicate the nature of the regime. The one-to-one correspondence between unobservables (L_t^D, L_t^S) and observables (L_t, I_t) provides immense simplification in estimation as compared to the numerical maximum likelihood procedures necessary for the standard model. This simplification allows for a more complex structure of demand and supply. For example, a covariance between the demand and supply errors can be easily estimated.

In addition, since past unobservables (L_{t-1}^D, L_{t-1}^S) can be related to past observables (L_{t-1}, I_{t-1}), the exact excess demand model can include a dynamic structure with lagged dependent variables or autocorrelated errors. Dynamic links in the standard disequilibrium model are very different to estimate (see Laffont and Monfort (1979)). However, with the exact indicator equation, lagged values of supply and demand can be easily constructed. For instance, lagged demand equals the transacted quantity plus any positive excess demand,

$$L^D_{t-1} = L_{t-1} \quad \text{if } t-1 \text{ is excess supply}$$
$$= L_{t-1} + \delta_0(I_{t-1} - I^E_{t-1}) \quad \text{if } t-1 \text{ is excess demand.}$$

Using the partitioning variables, the lagged dependent variables can be compactly expressed as

$$L^D_{t-1} = L_{t-1} + \delta_0 ED^+_{t-1}(I_{t-1} - I^E_{t-1}) \qquad (17)$$
$$L^S_{t-1} = L_{t-1} - \delta_0 ED^-_{t-1}(I_{t-1} - I^E_{t-1}) \qquad (18)$$

and used in the estimation equations (15) and (16).

A limitation of this model is that the absence of a stochastic term in the excess demand equation may introduce a specification error. An additive stochastic error cannot be included, since an exact sample split is not then available, and the system must be estimated by maximum likelihood methods. The exact nature of the potential bias is unknown, but Goldfeld and Quandt (1981) provide some simulation results which show that for the purpose of testing for equilibrium (the parameter test to be discussed below) the deterministic indicator model is robust and provides correct results.[6] In addition, the possible increase in misspecification from the deterministic form of the indicator equation should also be considered with the large increase in estimation tractability. This tractability allows estimation with lagged dependent variables and an error covariance and, as shown below, a simple technique to endogenize the wage, all of which eliminates much larger sources of structural misspecification.

An Endogenous Wage

The endogeneity of the wage (or more generally the market price) is an important, sometimes misunderstood issue in discussing and testing market disequilibrium. Just as the classical model assumes the extreme version of complete price adjustment, the *simplest* disequilibrium model, the fix-price model in which the current price is exogenous, assumes complete quantity adjustment. The assumption of a fixed price is very common in both theoretical and econometric disequilibrium formulations, but it is by no means intrinsic to the paradigm. A disequilibrium model does not require that the price mechanism plays no role at all, only that there is *incomplete* price auctioneering or tâtonnement within the period, so prices fail to attain their equilibrium levels. A sophisticated disequilibrium model would allow for both current price adjustment and non-price quantity rationing. Price does respond to the demand–supply balance in the market, but this response is slow enough and weak enough that the market does not clear during the data period. Prices and quantities are both endogenous (jointly determined) and in disequilibrium. For instance, a sophisticated labor market model would allow for both simultaneous layoffs and wage adjustments. What is assumed by such a model is a sluggish adjustment of prices relative to the data period, not fixed prices.

For our estimations of the exact indicator model outlined above, the wage rate was treated as endogenous by a three stage least squares estimation, with the wage replaced by fitted values from a first stage regression of the wage on the exogenous variables. Thus, the wage rate is considered implicitly endogenous (endogenous but unexplained). This avoids explicit specification of wage determination, yet wages are still treated as econometrically endogenous to the system.

Testing for Equilibrium

For the simple standard disequilibrium model (e.g., equations (7)–(9) without lagged values), the wage is exogenous, and the hypothesis of disequilibrium is nonnested with respect to the alternative of equilibrium. Therefore, tests of equilibrium in such models are difficult to formulate (see Quandt (1982)).

The standard model is often augmented with a wage adjustment equation of the form

$$W_t - W_{t-1} = \gamma(L^D_t - L^S_t) + u_{3t}. \qquad (19)$$

In such a model, the wage is explicitly endogenous, and the equilibrium model is nested within the disequilibrium model (see Quandt (1982) and Gourieroux, Laffont, and Monfort (1980)). In particular, as $\gamma \to \infty$ (infinitely fast wage adjustment), $L^D_t = L^S_t = L_t$, and the disequilibrium model reduces exactly to the equilibrium model. Thus, a proper test of disequilibrium is the significance of $1/\gamma$. If it is significantly different from zero, equilibrium is rejected. Rosen and Quandt (1978) use a (real) wage adjustment equation similar to (19) to endogenize the wage in their labor market

[6] For further numerical results, see Rudebusch (1986); for some simple analysis, see Lee and Porter (1984).

model, and they apply this parameter test to reject the hypothesis of equilibrium.

Recall that the exact excess demand specification of this paper supplements the standard model with

$$L_t^D - L_t^S = \delta_0(I_t - I_t^E). \tag{10}$$

As discussed earlier, this can be considered a generalization of a deterministic price adjustment equation. In particular, with I_t equal to inflation (and I_t^E equal to 0) the significance of δ_0 provides a test for disequilibrium that is identical to the one for $1/\gamma$ given above. (The absence of a stochastic term does not matter.) However, this test can also be generalized to the case where other, non-inflation indicators are used. A key difference between equilibrium and disequilibrium in the standard model is the endogeneity or exogeneity of the wage. By considering the wage as endogenous through three stage least squares, we can eliminate this difference. The only remaining distinction between the two models is whether quantity is set by a min condition (equation (4)) or by equilibration (equation (5)), and equation (10) tests this directly regardless of the indicator chosen.

This can be shown by a comparison of the two sets of equations estimated under the equilibrium and disequilibrium hypotheses. With market clearing, supply always equals demand; $L_t = L_t^D = L_t^S$ for every t. With the supply and demand structure given as above, the two equilibrium equations estimated are

$$L_t = \alpha' X_{1t} + l_1 L_{t-1} + u_{1t} \tag{20}$$

$$L_t = \beta' X_{2t} + l_2 L_{t-1} + u_{2t}. \tag{21}$$

This model can be estimated by three stage least squares with L_t and the nominal wage W_t considered endogenous, and the exogenous variables serving as instruments.

The exact excess demand disequilibrium model estimated is

$$L_t = \alpha' X_{1t} + l_1 L_{t-1}^D - \delta_0 ED_t^+(I_t - I_t^E) + u_{1t} \tag{15}$$

$$L_t = \beta' X_{2t} + l_2 L_{t-1}^S + \delta_0 ED_t^-(I_t - I_t^E) + u_{2t}. \tag{16}$$

Again, three stage least squares is used with L_t, W_t, and I_t treated as endogenous by an initial regression on the exogenous variables. These two sets of equations estimate identical parameters except for δ_0, regardless of the nature of the indicator. When $\delta_0 = 0$, all indicator variables drop out (and $L_{t-1}^D = L_{t-1}^S = L_{t-1}$), so the disequilibrium equations (15) and (16) reduce exactly to the equilibrium equations (20) and (21). Therefore, if δ_0 is significantly different from zero, demand does not equal supply and disequilibrium is affirmed. If δ_0 is zero, then rationing is not present in the market or is not well reflected by the indicator.

IV. Results of Estimation

This section reports the results of estimation of the exact excess demand model given in equations (7) through (10). The data are quarterly observations on the United States labor market from 1952-II to 1981-IV. The dependent variable, L_t, is the total number of hours worked in the private nonfarm business sector, and other variables, such as wages and output, also pertain to this sector. A complete listing of the definitions of variables is given in the appendix. It is assumed that the disturbances u_{1t} and u_{2t} are serially independent and $(u_{1t}, u_{2t}) \sim N(0, \Sigma)$ where Σ is nonsingular but not necessarily diagonal. The indicator and the wage rate are assumed to be endogenous to the system; therefore, three stage least squares is used with the exogenous variables serving as first stage regressors.

The results of estimation of the disequilibrium model augmented by an equation of indication and the equilibrium model (equations (20) and (21)) are given in tables 1 and 2. The t-statistics given in parentheses are asymptotically distributed as Standard Normal except for those under the δ_0 estimates, where the significance levels are lower because of the non-negativity restrictions on the parameter set (see footnote 10 below). Durbin-Watson statistics for demand and supply (dw_D and dw_S) and the final value of the distance function that is minimized ($E'HH'E$, the sum of squared fitted residuals weighted by the covariances) are also provided. Six different variables (listed in section II) were considered as indicators for the disequilibrium model. In addition, the first principal component of the set of six indicators was also used.[7] This weighted average contains

[7] The use of principal components is legitimate because the variables averaged (percentage deviations) are dimensionless and an interpretation of the weights is not important for an interpretation of the model (see Johnston (1972)). The use of the first principal component formed from standardized indicators (also dimensionless) made no difference in the results

TABLE 1.—ESTIMATES WITHOUT LAGGED DEPENDENT VARIABLES

	Disequilibrium Model I = Unemployment	Disequilibrium Model I = 1st PC	Equilibrium Model
α_0	−4.05	−3.62	0.638
	(6.97)	(6.72)	(2.81)
α_1	−1.16	−1.04	−0.937
	(9.02)	(9.03)	(13.3)
α_2	1.61	1.52	0.790
	(15.2)	(15.6)	(18.9)
α_3	−0.0042	−0.0039	0.002
	(5.02)	(4.96)	(5.41)
l_1	—	—	—
β_0	0.428	0.817	1.76
	(1.42)	(2.50)	(2.59)
β_1	−0.123	−0.196	−0.087
	(3.18)	(4.71)	(1.10)
β_2	0.073	0.132	0.173
	(2.55)	(4.25)	(2.70)
β_3	0.947	0.928	0.734
	(20.0)	(18.2)	(7.13)
l_2	—	—	—
δ_0	0.247	0.53	—
	(19.0)	(17.3)	
$E'HH'E$	85.4	104.2	178.6
dw_D	0.184	0.242	0.140
dw_S	0.313	0.468	0.107

Note: Asymptotic t-statistics are in parentheses

TABLE 2.—ESTIMATES WITH LAGGED DEPENDENT VARIABLES

	Disequilibrium Model I = Unemployment	Disequilibrium Model I = 1st PC	Equilibrium Model
α_0	−2.42	−1.93	−0.456
	(6.77)	(3.25)	(5.39)
α_1	−0.451	−0.406	−0.138
	(5.97)	(4.62)	(4.77)
α_2	0.704	0.626	0.205
	(8.53)	(4.85)	(9.30)
α_3	−0.0026	−0.0021	−0.0005
	(5.52)	(2.65)	(3.55)
l_1	0.697	0.681	0.856
	(20.0)	(14.8)	(28.9)
β_0	−0.200	0.092	0.544
	(0.849)	(0.269)	(3.03)
β_1	−0.0002	−0.020	0.047
	(0.006)	(0.480)	(2.42)
β_2	−0.015	0.017	0.025
	(0.698)	(0.518)	(1.65)
β_3	0.173	0.018	−0.175
	(1.28)	(0.130)	(4.81)
l_2	0.850	0.980	1.08
	(7.02)	(6.98)	(34.3)
δ_0	0.276	0.055	—
	(9.23)	(3.01)	
$E'HH'E$	4.44	13.5	37.2
dw_D	0.960	1.21	1.02
dw_S	1.31	2.00	0.820

Note: Asymptotic t-statistics are in parentheses

61% of the total variation of all six pure indicators. Since the estimated coefficients are very similar across indicators, only the results of estimations using unemployment and the first principal component (1st PC) as indicators are reported. (See Rudebusch (1985) for further estimates.)

The results in table 1, which assume no lagged dependent variables, are given only to provide a comparison with previous studies that estimate a standard disequilibrium model of the labor market (e.g., Rosen and Quandt (1978) and Romer (1981)). It is extremely difficult to estimate the standard disequilibrium model with lagged dependent variables, and all reported studies exclude them. Without these lags, our disequilibrium results match the reported studies closely in sign and approximate magnitude.[8] This supports the exact indicator model as a viable econometric specification. Furthermore, by comparing table 2 with table 1, the effects of the misspecification resulting from the exclusion of lags are revealed. This dynamic misspecification is indicated by the extremely low Durbin-Watson statistics in table 1.[9]

In table 2, the demand coefficients are consistent with economic theory and are in general similar to those in table 1 and to those reported by other studies (also see Black and Kelejian (1970)). The elasticity of demand with respect to the real wage (α_1) is unambiguously negative, and the effect of real output on labor demand (α_2) is strongly positive. The coefficient of the time trend (α_3) also has the expected negative sign. The one period lagged dependent variable is always highly significant.

The estimates of the supply coefficients in table 2 are less satisfactory. There was some variation in the estimates across different indicators, but in general the estimates themselves were insignificant. The elasticity of supply with respect to the net wage (β_1) is small, negative, and insignificant. This result is also obtained in the papers listed

[8] For example, Rosen and Quandt (1978) estimate a model that has similar structure and variables. They report (table 1, column 2, p. 376):

$$\alpha_1 = -.982;\ \alpha_2 = 1.11;\ \alpha_3 = -.003;$$
$$\beta_1 = -.019;\ \beta_2 = .610;\ \beta_3 = .347$$

[9] The Durbin-Watson statistics in table 2 are not strictly correct because they are biased by the presence of lagged dependent variables. The correct test, Durbin's h-statistic, cannot be applied since the lagged variable is constructed, but for a regression-based test see Rudebusch (1986).

above and in most labor supply studies (e.g., Lucas and Rapping (1969)). Two explanations can be given for the lack of an aggregate labor supply response to the real wage: first, income and substitution effects could offset each other to produce a small net effect; second, the wage elasticities of various labor subgroups could be significant but of opposite sign, so that the aggregate elasticity is insignificant. The elasticity of labor supply with respect to real wealth (β_2) is insignificant as Rosen and Quandt (1978) reported. Finally, β_3, the elasticity of the worker-hours supplied with respect to the total population, is weakly positive. It appears that lagged labor supply, which is highly significant, has accounted for much of the explanatory power that the population variable had in the static model.

The most interesting result from this model is the information provided on the question of whether the labor market clears within the quarter. The weighted residuals ($E'HH'E$), which are inversely related to the value of the likelihood function, show a much better fit for the disequilibrium structure. A formal statistical test can be constructed by considering the significance of the excess demand coefficient δ_0, as discussed in section III.[10] The excess demand coefficient was significant at the 1% level for four pure indicators (unemployment, help-wanted advertising, real wage inflation, and quits), and it is also significant for the first principal component. This significance signals rejection of the equilibrium model. The presence of disequilibrium has some effect on the structural coefficients as a comparison of the disequilibrium and equilibrium estimates shows. On the demand side, none of the disequilibrium estimates change sign or significance, but they are at least twice as large in absolute value. On the supply side, the changes are not uniform but in general the coefficients of the disequilibrium model are less significant.

[10] There is a slight statistical correction to be applied to this significance test since it is a test of a hypothesis (H_0: $\delta_0 = 0$) that lies on the boundary of the parameter set ($\delta_0 \geq 0$). This problem was originally considered by Chernoff (1954). For hypothesis testing in disequilibrium models, it is discussed by Gourieroux, Holly, and Monfort (1980) and Monfort (1982). The result for this single parameter test is that the likelihood ratio is asymptotically distributed $\frac{1}{2}\chi_1^2$ instead of χ_1^2. The squared t-statistic is asymptotically a likelihood ratio test; thus, the t-statistics given in parentheses below the estimates of δ_0 are asymptotically distributed $\sqrt{\frac{1}{2}\chi_1^2}$. The 5% significance level is 1.64; the 1% level is 2.33

V. Conclusion

The empirical results from the estimations of this labor market disequilibrium model support two major conclusions. First, the hypothesis of a labor market in equilibrium is rejected, although it should be noted that, as always, this conclusion is conditional upon the structural form of labor supply and demand. In addition, the importance of dynamics is affirmed by the strong significance of the lagged endogenous variables. This suggests that previous static disequilibrium models of the labor market may be seriously misspecified.

Further research should include refining the structural model, especially by integrating other markets to endogenize output and account for spillover effects. The use of tension indicators and rationing information in the estimation of disequilibrium models should also be pursued. Work on determining sample split information and developing measures of excess demand would be especially productive.

APPENDIX

Data are taken from the MPS databank and are listed with their numerical label. All of the series are seasonally adjusted

Series	Description
L	Log of hours of employees in the nonfarm business sector; ln(MPS139).
W	Nominal employee compensation in the nonfarm business sector, cents/hour; (MPS152).
PP	Implicit deflator for nonfarm private output, = 100 in 1972; (MPS156).
WP	$\ln(W/PP)$
Y	Log of output of employees in the nonfarm business sector; ln(MPS263 * (MPS139 + MPS142)/100).
t	Time trend.
CP	Price deflator for consumption expenditure, = 100 in 1972; (MPS132).
θ	Effective average rate of personal income taxation; (MPS516/100).
WC	$\ln((1-\theta)W/CP)$.
A	Log of net worth of households deflated by consumption deflator, beginning of quarter; ln(MPS138/MPS132).
TP	Log of non-institutional population 16 years and older; ln(MPS458).

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