Econ. J. of Hokkaido Univ.,
Vol.21 (1992), pp.97～110.

Estimation of the Japanese Aggregate Labor Market: Disequilibrium Approach

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1. Introduction

Since Fair and Jaffee (1972) first proposed systematically the estimation methods for a market in disequilibrium, many research efforts have been piled up by many authors and have formed a new interesting area which is called "Disequilibrium Econometrics". Major theoretical breakthroughs which followed Fair and Jaffee were found by Maddala and Nelson (1974) and Amemiya (1974), who formulated the exact maximum likelihood (ML) methods for the Fair-Jaffee models. Further, the extension applicable to a multi-market situation was accomplished by Ito (1980), in line with the progress of the general equilibrium theory under quantity rationing. On the other hand, these invented techniques have been put to use in various empirical studies. To name a few, Rosen and Quandt (1978) examined the problem of which of the two regimes, equilibrium and disequilibrium, was responsible for generating the past U.S. aggregate labor market data, and Artus, Laroque, and Michel (1984) eatimated the two-market macroeconomic model which allows for a spill-over effect between the labor and goods market, using French macroeconomic data.

In Japan, though there are some famous research examples concerning the extent of flexibility of interest rate in the loanable fund market by Ito and Ueda (1981), Tsutsui (1988), and others, the direct application of disequilibrium econometrics has not become so common a practice in macroeconometrics or labor economics. Instead, the standard macroeconomic approach in the empirical study of wage and employment has been mainly to use Phillips relations or Okun's law.[1] Some unpopularity or reluctance to the application of disequilibrium econometrics, to some extent, comes from difficulties in identifying state of the labor market only from the observed ex-post movements of real wage. For example, Ito (1985) showed in his framework of the disequilibrium growth model that when technology becomes more labor-intensive, an increase in real wage equal to the same amount of productivity growth is not inconsistent with continuation of equilibrium in the labor market. Though a solution to this kind of problem has not been well formulated, it is interesting to test the performance of today's standard disequilibirum econometric model to estimation and prediction concerning the Japanese labor market.

Motivated by Rosen and Quandt's paper, the author tried an estimation using

one variant of Fair-Jaffee models (which corresponds to their 'Quantitative Method') and annual Japanese macroeconomic data. Below, estimated coefficients, predicted aggregate notional labor demand and supply, and predicted unemployment rate are reported. The results show that although numerical values of the predicted series are great in magnitude relative to observed and official ones, they appear to have captured demand-supply relations in the aggregate labor market observed for these three decades. The estimation results also suggest that the relative downward stickiness exists in real wage adjustment. Furthermore, although the current study is nothing but an application of disequilibrium econometrics to unemployment phenomenon and dismisses considerations about inherent features of the labor market, e.g., heterogeneity of labor services, market segregation, long-term and implicit properties of contracts, and so on, it also gives some evidences consistent with the extensively discussed facts of low unemployment and long working hours in the Japanese economy.

2. The Model and Estimation Method

The disequilibrium model to be estimated consists of the following four equations which are obtained by modifying the Rosen-Quandt model so as to enable the application of the two-stage least squares method (2SLS):

$$lnL_t^D = \alpha_0 + \alpha_1 lnw_t + \alpha_2 lnQ_t + \alpha_3 t + \varepsilon_{1t} \tag{1}$$

$$lnL_t^S = \beta_0 + \beta_1 lnw_t + \beta_2 lnA_t + \beta_3 lnP_t + \varepsilon_{2t} \tag{2}$$

$$lnL_t = min(lnL_t^S,\ lnL_t^D) \tag{3}$$

$$\Delta lnw_t = \begin{cases} \gamma_1(lnL_t^D - lnL_t^S), \text{ if } lnL_t^D > lnL_t^S,\ \gamma_1 > 0 \\ \gamma(lnL_t^D - lnL_t^S), \text{ if } lnL_t^D < lnL_t^S,\ \gamma_2 > 0 \end{cases} \tag{4}$$

All variables are converted to natural logarithmic values except for the time trend term t in (1). (1) is the labor demand equation or, to be more precise, 'the marginal productivity condition for labor', which means that the notional demand for labor L_t^D given output Q_t is a function of the current wage w_t, allowing for the state of technical progress represented by t. The notional supply of labor L_t^S is determined by w_t and unearned income A_t. In addition to these determinants, (2) includes another variable P_t which reflects changes in the size of the potential labor force. Also here, the likely endogeneity of A_t and P_t is tentatively ignored. (3) represents the short-side rule according to which the observed quantity of labor actually traded is determined to the minimum of demand and supply at the current wage. (4) is the standard Walrasian adjustment equation and allows for a difference in the speed of adjustment between upward and downward directions. Finally, ε_{1t} and ε_{2t} are random error terms and assumed to be serially and contemporaneously independent with the distribution $N(0, \sigma_1^2)$ and $N(0, \sigma_2^2)$ respectively.

The original Rosen-Quandt model consists of (1), (2), (3), and

$$\Delta lnw_t = \delta_1(lnL_t^D - lnL_t^S) + \delta_2 lnP_t + \varepsilon_{3t} \tag{4'}$$

where $\varepsilon_{3t} \sim N(0, \sigma_3^2)$. Under the specification (1) through (4′) and assumed stochastic structures of ε's, they estimated parameters using the full information maximum likelihood method (FIML). This Rosen-Quandt specification takes the form of the 'Generalized Model' of Fair and Kelejian (1974), where the price equation is generalized to be a multivariate and stochastic function. While their estimation technique is more advanced than ours, one merit lies in our specification that it can estimate two distinguished parameters representing the adjustment speed of real wage.

Before considering estimation procedure, there is more to be said about (4), because specification of Δlnw_t determines whether lnw_t is endogenous or not in the system. Wage movement Δlnw_t can be specified in two ways. The formulation such that $\Delta lnw_t = lnw_t - lnw_{t-1}$ is appropriate, when current wage w_t is adjusted during current period t, reflecting a discrepancy between L_t^D and L_t^S. In this case, lnw_t is a current endogenous variable. On the other hand, if w_t is kept constant for one year at the level set at the end of the previous period, we have $\Delta lnw_t = lnw_{t+1} - lnw_t$ and lnw_t becomes exogenous.[2]

Estimation of the model (1) through (4) proceeds as follows: first, on the basis of observations of Δlnw_t, we have a sample separation according to (4) which classifies the entire sample periods into those with either excess demand, excess supply, or equilibrium. Define subsets of the entire sample periods, Ψ_1, Ψ_2, and Ψ_3 such that $\Psi_1 = \{i \mid L_i^D > L_i^S\}$, $\Psi_2 = \{i \mid L_i^D < L_i^S\}$ and $\Psi_3 = \{i \mid L_i^D = L_i^S\}$.

If $t \in \Psi_1 \cup \Psi_3$, from the short-side rule (3) we have $L_t = L_t^S$ and (4) can be rewritten as

$$\Delta lnw_t = \gamma_1 (lnL_t^D - lnL_t^S).$$

Therefore, we have for $t \in \Psi_1 \cup \Psi_3$

$$lnL_t = lnL_t^D - \frac{1}{\gamma_1} \Delta lnw_t \tag{5}$$

$$lnL_t = lnL_t^S \tag{6}$$

Similarly, for $t \in \Psi_2 \cup \Psi_3$, we have

$$lnL_t = lnL_t^S + \frac{1}{\gamma_2} \Delta lnw_t \tag{7}$$

$$lnL_t = lnL_t^D \tag{8}$$

Combining (5) and (8), and (6) and (7), respectively, the whole system (1) through (4) is transformed to the following two equations:

$$lnL_t = \alpha_0 + \alpha_1 lnw_t + \alpha_2 lnQ_t + \alpha_{3t} - \frac{1}{\gamma_1} g_t + \varepsilon_{1t} \tag{9}$$

where

$$g_t = \begin{cases} \Delta lnw_t & \text{if } \Delta lnw_t > 0, \\ 0 & \text{otherwise,} \end{cases}$$

and

$$lnL_t = \beta_0 + \beta_1 lnw_t + \beta_2 lnA_t + \beta_3 lnP_t - \frac{1}{\gamma_2} h_t + \varepsilon_{2t} \tag{10}$$

where

$$h_t = \begin{cases} -\Delta lnw_t & \text{if } \Delta lnw_t < 0, \\ 0 & \text{otherwise.} \end{cases}$$

In order to obtain consistent estimates of parameters, α's, β's, and $\frac{1}{\gamma}$'s, 2SLS must be applied to each of these two equations over all sample periods. This statement means that in carrying out estimation, it is important to take account of truncation bias which comes from sample separation, as well as simultaneous equation bias. This point is clarified by arguing as follows. For example, consider estimation of (9) with $\Delta lnw_t = lnw_{t+1} - lnw_t$. In this case, lnL_t and g_t are endogenous. Now suppose that (as Fair and Jaffee proposed) on account of the singular property of the g_t series like step function, predictors of g_t, $\hat{g}_t$, are constructed by regression g_t only over those sample periods in which $g_t > 0$ (i.e., Ψ_1) in the first regression, and putting $\hat{g}_t = 0$ whenever $g_t = 0$. For notational simplicity, denote (9) using matrix form as follows:

$$\mathbf{L} = (\mathbf{X}\ \hat{\mathbf{g}})\left(\boldsymbol{\alpha} - \frac{1}{\gamma_1}\right) + \boldsymbol{\varepsilon}_1, \tag{9'}$$

where $\mathbf{L}' = (\ln L_1 \cdots)$, $\hat{\mathbf{g}}' = (\hat{g}_1 \cdots)$, $\boldsymbol{\alpha}' = (\alpha_0 \alpha_1 \alpha_2 \alpha_3)$, $\boldsymbol{\varepsilon}_1' = (\boldsymbol{\varepsilon}_{11} \cdots)$, and

$$\mathbf{X} = \begin{pmatrix} 1 & lnw_1 & lnQ_1 & 1 \\ \vdots & \vdots & \vdots & \vdots \\ 1 & lnw_t & lnQ_t & t \\ \vdots & \vdots & \vdots & \vdots \end{pmatrix}$$

Then, the second regression yields the following relationship:

$$\begin{pmatrix} \hat{\boldsymbol{\alpha}} \\ -\frac{\hat{1}}{\gamma_1} \end{pmatrix} = \begin{pmatrix} \boldsymbol{\alpha} \\ -\frac{1}{\gamma_1} \end{pmatrix} + \begin{pmatrix} \mathbf{X}'\mathbf{X} & \mathbf{X}'\hat{\mathbf{g}} \\ \hat{\mathbf{g}}'\mathbf{X} & \hat{\mathbf{g}}'\hat{\mathbf{g}} \end{pmatrix}^{-1} \begin{pmatrix} \mathbf{X}'\boldsymbol{\varepsilon}_1 \\ \hat{\mathbf{g}}'\boldsymbol{\varepsilon}_1 \end{pmatrix}$$

where hat means parameter estimates. Note that $\hat{\mathbf{g}}'\boldsymbol{\varepsilon}_1 = \sum_{t \in \Psi_1} \hat{g}_t \varepsilon_{1t}$ and $E(\varepsilon_{1t} | t \in \Psi_1) \neq 0$. The latter holds because the distribution of ε_{1t} is truncated over Ψ_1. Therefore estimators derived above are not consistent. In order to obtain consistency, it is necessary to regress g_t on exogenous variables over all sample periods in the first regression.[3]

As was already mentioned in the preceding paragraphs, whether lnw_t is endogenous or not depends on the specification of Δlnw_t. If $\Delta lnw_t = lnw_t - lnw_{t-1}$,

$\ln w_t$ should be a current endogenous variable. But, it must be considered to be a predetermined variable inherited from the previous period if we assume $\Delta lnw_t = lnw_{t+1} - lnw_t$. The model (1) through (4) where the former definition is embedded will be called 'Model I' and another model with the latter definition will be called 'Model II', respectively, in the following passages.

The data are annual observations on the Japanese economy for the year 1955 through 1989. L_t is total hours worked per year expressed in billions. It is the product of domestic hours per person and the number of persons engaged in production. w_t is total wages and salaries in 1980 price, divided by the number of hours worked. Q_t is gross national product expressed in billions of the 1980 price. A_t is the sum of rent, dividends, and interest in the 1980 price, divided by the number of workers. P_t is the potential number of hours available in year t expressed in billions. It is calculated by multiplying labor force population by the average number of hours worked per year.

3. The Estimation Result and Its Examination

In this section, the estimation and prediction results are examined from the viewpoint of how reasonable the estimates are, and to what extent the prediction captures the observed chronology of the labor market and matches with offical unemployment rates. Additionally, the results are compared with those of Rosen and Quandt, and also with notes and comments of Romer (1981), who tried to correct the anomalous prediction results derived from the Rosen-Quandt model.

The parameter estimates are shown in Table 1. This table also shows estimates of the equilibrium counterpart just for reference, which is simply obtained by setting $L_t = L_t^D = L_t^S$ over all sample periods and deleting (3) and (4) from the model (1) through (4).

Apart from a constant term, β_0, all estimates are statistically significantly different from 0 in the case of Model I. However, Model II failed in meeting the sign condition on γ_2, and six estimates out of ten are not significantly different from 0. Therefore, we will focus on the results from Model I below.

In column 1 of Table 1, coefficients on the demand side, α's, are reasonable in sign. The minus sign on α_3 suggests that technical progress has had a tendency to become more labor-saving.

If the underlying production function is CES, (1) is written as

$$lnL_t^D = C - \sigma lnw_t + \frac{h\sigma + 1 - \sigma}{h} lnQ_t - \frac{\lambda(1-\sigma)}{h\sigma} t + \varepsilon_{1t} \qquad (1')$$

where C is some constant, σ is the elasticity of substitution between labor and capital, h is the degree of homogeneity, and λ is the rate of Hicks-neutral technological change. The common assumptions on σ and h (Cobb-Douglas case) imply that $\alpha_1 = -1$, $\alpha_2 = 1$, and $\alpha_3 = 0$. Therefore, under the assumptions of CES and typical

Table 1. — Parameter Estimates
(Standard errors are in parentheses)

	Model I 1956-89	Model II 1955-88	Equilibrium 1955-89
α_0	− 7.346 (1.106)	−8.090(a) (4.404)	−2.148 (0.512)
α_1	− 1.022 (0.108)	−1.263 (0.554)	−0.552 (0.077)
α_2	1.644 (0.166)	1.852 (0.734)	0.878 (0.083)
α_3	− 0.044 (0.007)	−0.047(a) (0.026)	−0.011 (0.003)
$-1/\gamma_1$	− 2.756 (0.492)	−2.820(a) (1.957)	− (−)
R^2	0.995	0.947	0.982
D. W.	0.588	1.341	0.496
β_0	0.999(a) (0.724)	−0.987(a) (0.934)	−1.133 (0.496)
β_1	− 0.151 (0.040)	−0.169(a) (0.104)	−0.104 (0.036)
β_2	0.296 (0.034)	0.255 (0.057)	0.225 (0.024)
β_3	0.337 (0.168)	0.856 (0.210)	0.854 (0.110)
$-1/\gamma_2$	−21.553 (5.591)	7.576(a) (9.065)	− (−)
R^2	0.995	0.980	0.993
D. W.	0.588	1.575	0.525

a) The absolute value of t-value is less than 2.

parameter values, the estimated numerical value of α_2 is considered to be rather large.

Coefficients on the supply side have intuitively or micro-theoretically less satisfactory features. The elasticity of labor supply with respect to real wage, β_1, appears as a minus sign. Furthermore, the elasticity with respect to unearned income, β_2, appears as a plus sign. These features are shown also in Model II and the Equilibrium Model. As for negative real wage elasticity, it is hard to identify its sources from the aggregate viewpoint on which the current study stands. Nevertheless, one likely channel is that a secondary earner in the family, who may belong to a peripheral group of workers in most cases, will exit from the labor force, whenever the real wage of a primary earner increases enough. In order to explain the reason for this negativity, we need to take a closer look at the behavior of such

Figure 1. The Official Unemployment Rates of Japan, 1956-1989

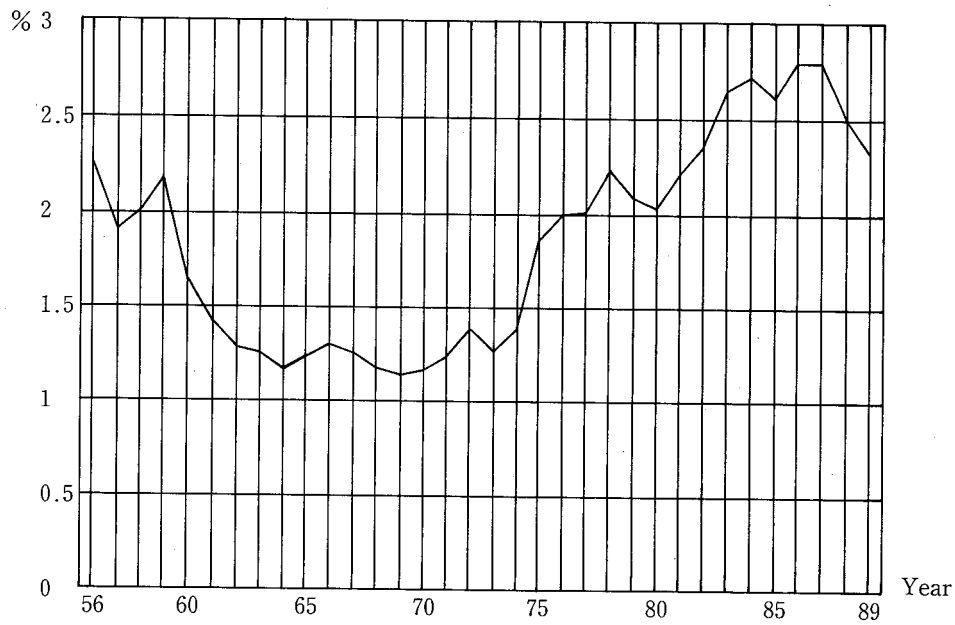
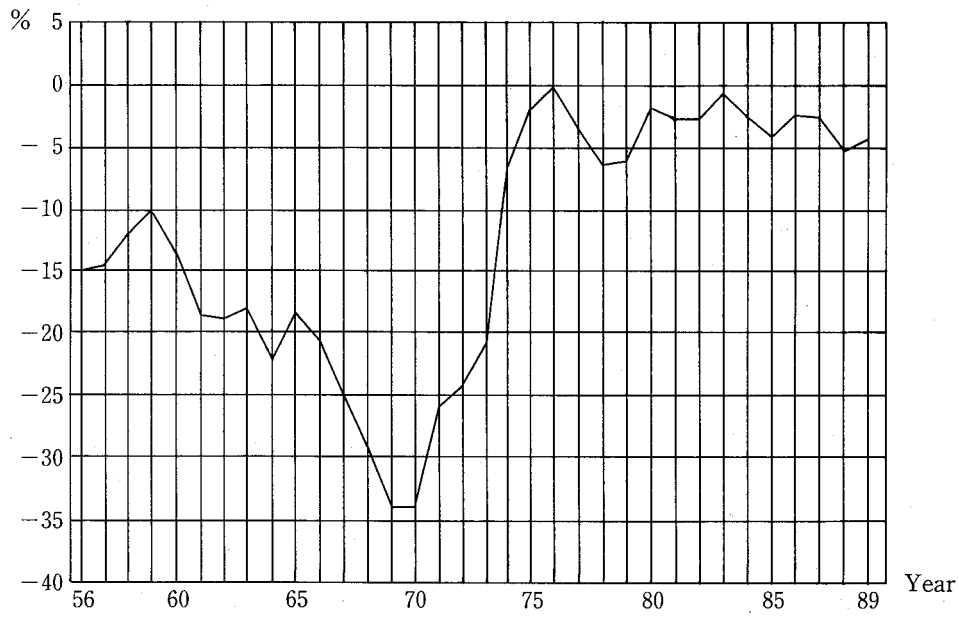


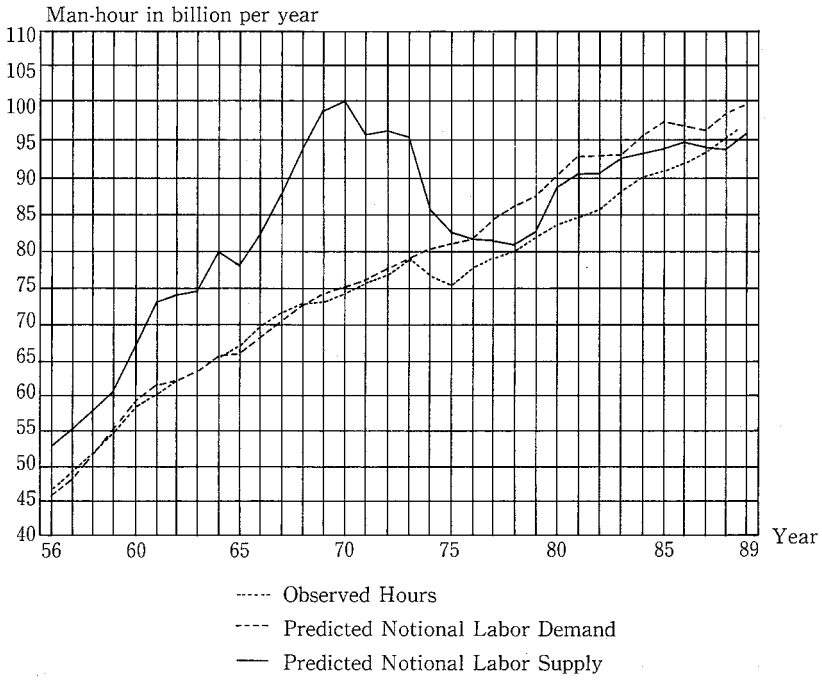
Figure 2. The Unemployment (Underemployment) Rates Generated by Model I, 1956-1989



workers who react more sensitively to real wage movement. On the other hand, as for positive unearned income elasticity, we will revert to this problem when we discuss Romer's comments on prediction results by Rosen and Quandt below.

Concerning the speed of adjustment, Model I yields fairly plausible results.

Figure 3. The Observed Hours Worked, and the Notional Demand and Supply Predicted from Model I, 1956-1989



We have the implied values of γ's as $\gamma_1 = 0.363$ and $\gamma_2 = 0.046$, respectively. This means wage stickiness to downward direction, which accords with the almost unceasing growth of real wage observed from the data. Only twice did real wage reduction occur (1976 and 1980) for the years 1955 through 1989, according to our data.

Figure 1, 2, and 3 show the time series of the official unemployment rate, the predicted unemployment rate from Model I, and the predicted notional labor demand and supply, respectively. The predicted unemployment rate is calculated as

$$100 \times \frac{\hat{L}_t^s - \hat{L}_t^D}{\hat{L}_t^s} \tag{11}$$

where $\hat{L}_t^D$ and $\hat{L}_t^s$ are predicted notional labor demand and supply, respectively.[4]

We first recognize that the prediction from Model I amplifies or exaggerates the movement of the official rate rather drastically and suggests the existence of permanent excess demand except for a few periods (1976 and 1983). Though numerical values in Figures 2 and 3 obtained from prediction seem far from realistic, as compared with official statistics, it may be safe to say that the predicted series captures fairly well the chronological pattern of actual movements in the labor market. From Figures 2 and 3, we can see the following points:

(a) The magnitude of excess demand had been much larger in the 1960's and until the recession caused by the first oil crisis. This fits well the fact that rapid economic growth continued during these periods, but the first oil crisis put an end to

it.

(b) Since 1974, the magnitude of excess demand has stayed much lower than previous levels. At the same time, the predicted unemployument rate dramatically increased, reflecting this movement. Furthermore, it shows that excess demand declined to minimum levels in 1976 and 1983 which correspond to recession periods after the first and second oil crises, respectively.

As we have just seen above, the disequilibrium approach suggests that potentially the Japanese economy has had a large amount of excess demand for labor and therefore effective demand enough to realize full employment. On the basis of the results examined so far, let us try to derive possible implications of the two major questions which have often been posed internationally as well as in Japan: (a) why the official unemployment rate of Japan is very low relative to the international standards; (b) why working hours of the Japanese are so long relative to those in other advanced countries. Concerning these questions, we should note the following statistical facts pointed out by Hamada and Kurosaka (1986): first, 'low unemployment is a distinct feature of the Japanese econmy only after the 1970's—during the 1960's unemployment rates in most industrial countries, for example, West Germany, were also quite low' and 'unemployment rates have a long-run upward trend in the past 15 years' in their accounts; second, 'the number of hours worked per week in Japan is much longer than that in other countries but only since the middle of the 1970's' and 'while working hours declined quite sharply in most countries after the first oil crisis, they went up in Japan during the five years between 1975 and 1980'.

Although international comparison itself is beyond the scope of the current study, Figure 3 makes us think that the unemployment rate in Japan should be very low during these three decades. Furthermore, Figure 2 shows that change in trend occurred in the middle of the 1970's. We have nothing contradictory to say about the first point made by Hamada and Kurosaka so far. Concerning the second question, we can say that though excess demand declined and the trend of unemployment rate moved upward after the mid-1970's, the Japanese economy still retained potentially full employment, and therefore reduction in working hours comparable to other countries did not occur.

Finally, we compare the above estimation and prediction results with those of Rosen and Quandt, and also with notes and comments by Romer, in order to consider problems suggesting the need of further research. Table 2 shows their estimation results, and Figures 4 and 5 show the predicted unemployment rate series by Rosen and Quandt, and Romer, respectively. As is shown in column 1 in Table 2, parameter estimates obtained by Rosen and Quandt are reasonable, and comparison of *logL* (log-likelihood) between columns 1 and 2 suggests that the disequilibrium hypothesis is the more favored one. However, Figure 4 shows some anomalous features which apparently contradict the facts in US economic history. Namely, the model pre-

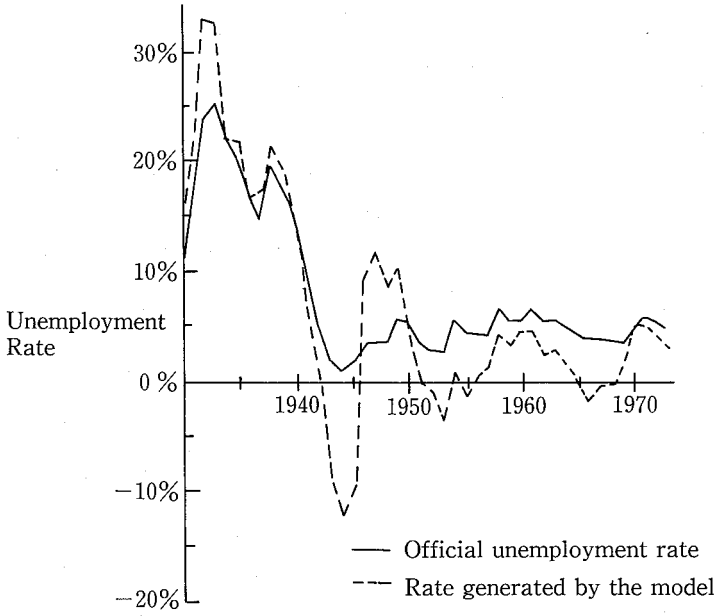
Table 2. Parameter Estimates by Rosen and Quandt (1978) and Romer (1981)
(Standard errors are in parentheses)

	Rosen-Quandt (1978)		Romer(1981)
	Disequilibrium 1930-1973	Equilibrium 1930-1973	Disequilibrium 1930-1973
α_0	−1.330 (0.199)	−2.442 (0.985)	−0.455 (0.066)
α_1	−0.984 (0.105)	−1.480 (0.452)	−0.477 (0.070)
α_2	1.095 (0.038)	1.241 (0.196)	0.948 (0.010)
α_3	−0.003 (0.003)	0.012 (0.019)	−0.011 (0.002)
β_0	0.209 (0.496)	3.616 (0.904)	−1.608 (0.033)
β_1	0.008 (0.040)	0.015 (0.075)	−0.189 (0.021)
β_2	0.490 (0.046)	0.526 (0.075)	— —
β_3	0.871 (0.091)	0.216 (0.168)	1.175 (0.006)
δ_1	0.182 (0.058)	— —	0.097 (0.050)
δ_2	0.002 (0.003)	— —	0.036 (0.007)
logL	202.64	178.3	—

dicts excess demand for labor from 1930 to 1945, excess demand and little excess supply from 1946 to 1953, and excess supply from 1954 to 1973. 'It is disappointing that the years of the Great Depression do not show up more unambiguously on the excess supply side, although excess demand during World War II and the Korean War as well as excess supply in the last decade do make sense.'[5]

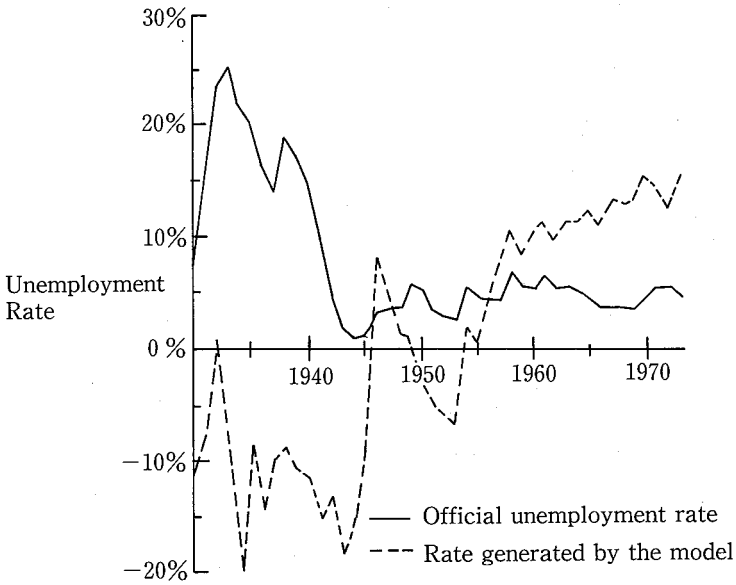
Romer pointed out that the above unlikely results come from the presence of non-labor income in the labor supply equation, in a manner of static labor-leisure choice theory: because unearned income depends on past hours of work in a life-cycle framework, it is inherently endogenous. When hours of work are high, people accumulate assets and thereby increase their non-labor incomes and vice versa. Thus, positive correlation exists between hours worked and unearned income. To be more specific, during the Great Depression, people decumulated their assets to maintain consumption and as a result, non-labor income fell. By construction, the model predicts a relatively low labor supply and therefore high excess demand

Figure 4. Comparison of Unemployment Rates Generated by the Rosen-Quandt Model with Official Rates, 1930-1973[1]



1) This figure is cited from Romer (1981).

Fegure5. Comparison of Unemployment Rates Generared by the Revised Model with Official Rates, 1930-1973[1]



1) This figure is cited from Romer (1981).

during these periods. On this recognition, Romer deleted the unearned income term InA_t from labor supply equation (2) and re-estimated the revised model to get parameter estimates in column 3 of Table 2, and predicted the unemployment rate series in Figure 5.

It is readily seen that the prediction is improved dramatically, though deleting unearned income is not a theoretically satisfactory solution. As we noted before, our estimation result concerning β_2 also suffers the same problem that confronted Rosen and Quandt. Besides, our prediction from Model I failed in generating positive unemployment rates. However, it exhibits movement similar to that of the official rate. One likely reason for this is that the Japanese economy has not been subject to such depressions that cause sharp reductions in unearned income for about these three decades.

4. Concluding Comments

We have seen that as far as parameter estimation is concerned, the aggregate disequilibrium model can give fairly reasonable estimates. But, when it comes to prediction, the performance is more fragile, as was made clear when the Rosen-Quandt result was discussed above. However, as Romer pointed out, it is not true that all of its sources are attributed to the structure of the disequilibrium model in general. In cases involving both the Rosen-Quandt and our models, the problem is not so much disequilibrium formulation itself as the use of static labor-leisure choice theory. Incorporation of life-cycle theory into disequilibirum models is considered to be an important future research.

Another difficult question pertaining to disequilibrium econometrics is about methods for testing the equilibrium vs. disequilibrium hypotheses. Because these two are not in nested relations with each other, generally there is no strictly proper testing method. Although some alternatives have been ingeniously devised case by case so far, formulation of a general way remains as one of the open questions on the frontier of today's econometrics.

Endnotes

1. As an up-to-date literature including contributions through the standard approach, one can refer to Kurosaka's work(1988).
2. Superficially, the latter specification seems more plausible in the case of the Japanese labor market, because the Shunto is considered to exert great influence on the course of wage payment through the whole year. However, the assumption that wage adjustment takes place only once a year appears less satisfactory, when we take into account Odaka and Minami's (1971) notes. In their classical work concerning wage adjustment, they insist that the assumption of once-and-for-all wage adjustment annually should be unreasonable, because: (a) not only the Shunto has a

significant effect on wage movement, where base-up negotiation takes place, but also management discretion to pay a bonus at the end of the year, and (b) wage is adjusted taking account of persons already employed who change their current jobs, as well as graduates who newly enter on careers in the spring. Therefore, the former specification which says that current wage reacts to current excess demand has a rationale that needs to be supported more firmly.

3. The exact application of 2SLS to the quantitative method of Fair and Jaffee was formulated by Amemiya (1974).

4. The prediction was carried out using reduced form equations concerning lnL_t^D and lnL_t^S.

5. Rosen and Quandt (1978).

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