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TESTING BETWEEN COMPETING MODELS OF BUSINESS CYCLES: THE EFFICIENT LONG-TERM CONTRACT HYPOTHESIS VERSUS THE INTERTEMPORAL SUBSTITUTION HYPOTHESIS

by

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Abstract

This paper tests the efficient long-term contract model against the intertemporal substitution model using Japanese aggregate data. From the former model, employment and wages are arranged by bilateral dynamic bargaining between firms and workers. From the latter model, employment and wages are determined by the dynamic optimization of households within the competitive market framework. The theoretical argument shows that these two hypotheses are nested if labor input adjustments are made by means of worksharing alone. The estimation results are consistent with the efficient long-term contract model, but are inconsistent with the intertemporal substitution model. This finding implies that observed movements in employment and real wages do not arise from strong intertemporal substitution in labor supply but from risk sharing or bilateral bargaining arrangements between firms and workers. Furthermore, the empirical evidence suggests that systematic expansionary policies have no effects on consumption or employment even though unexpected expansionary policies can increase the long-run level of employment.

1. Introduction

A business cycle phenomenon is typically found in time-series data on employment and real wages. According to the data of almost all developed countries, employment fluctuation is considerably greater than wage fluctuation. Many recent economic researches have attempted to explain this kind of phenomenon. Most of these studies fall into one of two categories: the intertemporal substitution theory and the long-term wage contract theory.

The first, often called the equilibrium business cycle theory, stems from the fundamental contribution of Lucas and Rapping (1968). The basic hypothesis of the intertemporal substitution theory is that leisure is easily substitutable across periods. In this view, individuals supply great labor effort in periods of high transitory wages, so that small transitory movements in perceived real wages can have large effects on the path of labor supply. If the deviation of labor supply from its trend level is regarded as a measure of individual unemployment, cyclical movements in labor supply or unemployment can mainly be attributed to (potentially misperceived) changes in real wages. Wage stickiness and unemployment are then interpreted within the competitive equilibrium framework as the outcome of the strong intertemporal substitution in labor supply or erroneous expectation.

The policy implications of the intertemporal substitution theory are summarized in two respects. First, since consumption follows the rule of the permanent income hypothesis, systematic expansionary policies have no effects on consumption. Second, if trade unions prevent the adjustment of wages, the theory recommends policies which weaken the power of trade unions.

The ability of the intertemporal substitution theory for explaining fluctuations in employment and real wages depends on the presence of strong substitutability in labor supply across periods. Observed small fluctuations in real wages could not cause observed large fluctuations in labor supply unless leisure is very substitutable across periods. Thus the empirical literature on the intertemporal substitution theory has focused on the estimation of the elasticity of intertemporal substitution in labor supply. However, almost all of these researches suggest that the estimated results provide strong evidence against the intertemporal substitution theory or that the elasticity of intertemporal substitution in labor supply is substantially low.[1] This finding implies that the intertemporal substitution theory has difficulty in explaining observed fluctuations in employment and real wages.

For the purpose of discussing cyclical fluctuations in aggregate employment and real wages, models with sticky wages or prices are the leading alternative theory to the intertemporal substitution framework. In particular, models with long-term wage contracts have some plausibilities which are based on the observation of the apparant existence of such contracts (see Fischer (1977) and Taylor (1980)). The point of departures is the recognition that many workers have formal contracts with predetermined wages and let firms choose employment on the labor demand curve in accordance with the predetermined wages. In this setting, the labor market is adjusted to the predetermined wages by means of the level of employment; and changes in employment and real output are caused by systematic expansionary policies. This argument indicates that long-term wage contracts give a role to systematic expansionary policies. Unfortunately, the recent empirical researches have doubted the ability of the long-term wage contract theory for explaining observed business cycles.[2]

Within the framework of the Fischer-Taylor contract theory, long-term wage contracts are viewed as setting wages that have an allocational role.

Once a long-term wage contract determines the wage rate, the firm which enters into the long-term wage contract chooses the level of employment by equating the marginal revenue product of labor to the wage rate. Criticizing this assumption, Barro (1977) argues that rational contracting parties must consider not only wage but also employment determination in the contract negotiation. Barro's theoretical criticism of the Fischer-Taylor contract theory has recently been supported by the empirical studies of the US unionized market.[3] These studies find much evidence for the so-called 'efficient contract hypothesis' that employment and wages are simultaneously determined by bilateral bargaining between firms and workers.

The foregoing arguments suggest that we proceed to develop other lines of research for explaining cyclical fluctuations in aggregate employment and real wages. The purpose of this paper is to consider the efficient long-term contract theory—an extension of the static efficient contracing model to a macroeconomic, dynamic one—as an alternative to the intertemporal substitution or to the Fischer-Taylor contract theory.[4] Efficient long-term contracts consist of those intertemporal arrangements on employment and wages which are made by dynamic bargaining between firms and workers.[5] The main difference between the Fischer-Taylor and the efficient long-term contract stems from the presumption that in the contract negotiation employment determination is not considered by the former but by the latter.

The basic idea of the efficient long-term contract theory is such that employment is long-term and that current wages are nothing more than installment payments on a long-term obligation. This idea is concerned with the following two aspects of the contractual relation between firms and workers. First, as argued by Baily (1974) and Azariadis (1975), firms are usually less risk averse than workers and thus have an incentive to insure workers against wage fluctuations by means of intertemporal risk-sharing arrangements. Second, as pointed out by McDonald and Solow (1981), firms and workers make bargaining over present, future wages and employment on the grounds of the presence of high separation costs, search costs, and training costs. Wages then have a role as an internal distribution parameter according to which organizational rents are distributed. This finding suggests that, within the bilateral bargaining situations, wages do not necessarily vary with employment. These two aspects imply that wage stickiness arises from risk-sharing or bilateral bargaining arrangements between firms and workers under the efficient long-term contract hypothesis.[6]

The efficient long-term contract theory tells us that some of the main propositions of the intertemporal substitution theory are consistent with the observed cyclical fluctuations in employment and real wages even if the capital market is imperfect or even if the intertemporal substitution elasticity in labor supply is low. First, systematic expansionary policies have no effects on consumption, because the consumption path in the efficient long-term contract model duplicates that of the permanent income hypothesis. Second, a rise in the worker's bargaining power decreases employment in the present, future periods if the firm adjusts the labor input by work-sharing alone; thus public policies that weaken trade unions may increase employment, as recommended by the intertemporal substitution theory.

However, the efficient long-term contract theory does not necessarily expect the same world as the intertemporal substitution theory. This aspect can be explained using the timing and the persistence effect of Clark and Summers (1982). The timing effect is identical with the effect which is attributed to the intertemporal substitution in labor supply. The persistence effect is due to frictions and specificity of employment relationship, thus generating persistence of employment. Since the same presumptions underlie the efficient long-term contract model, the presence of efficient long-term contracts involves the persistence effect. Clark and Summers suppose an economy in which the government undertakes unexpected expansionary policies. The initial impact of the change is an increase in employment irrespective of whether the timing or the persistence effect predominates. However, these two effects exactly have the opposite implications for the long-run effects of unexpected expansionary policies. If the timing effect is predominant, employment after the shock will be less than it would have been had the shock never occurred. This is because individuals wish that a large proportion of their lives in the labor force is scheduled to coincide with periods of maximum opportunity. In contrast, if the persistence effect prevails, short-run increases in employment will tend to persist because of the factors such as habit formation, adjustment costs, or human capital accumulation.

In this paper, using aggregate Japanese data, we test the efficient long-term contract model against the intertemporal substitution model. The theoretical argument reveals that these two models are nested if labor input is adjusted by means of work-sharing alone. The testing results unambiguously show that the efficient long-term contract model is supported, whereas the intertemporal substitution model is rejected.

The paper is organized as follows. The next section first reviews the intertemporal substitution theory based on a standard model of life-cycle labor supply and then considers the alternative theory built on an efficient long-term contract model. Section 3 develops a testing method for distinguishing between these two theories. Section 4 offers the estimation results and appraises them. The final section summarizes the test results and discusses their implications.

2. Theory

In this section, we discuss the formal relation between the intertemporal substitution model and the efficient long-term contract model. For this purpose, we start with presenting the basic structure of the two models.

Let us first consider a representative household who derives pleasure from consumption and leisure, and whose utility function is stationary and additively separable over time. The present value of stream of expected utility at the initial period, V_0, is

$$V_0 = E_0[\sum_{t=0}^{t=T} \rho^t \cdot U(C_t, L_t)]. \quad (1)$$

Here, E_0 is an expectation operator conditional on information available at the initial period; ρ is a constant discount factor; C_t is real consumption at t; L_t is labor effort at t; and U is a function that is increasing in C_t, decreasing in L_t, and concave in C_t and L_t.

We next describe the per capita production function of a representative firm at period t:

$$Y_t = F_t(L_t, K_t, u_t), \quad (2)$$

where L_t is per capita labor supply to the firm at t, K_t the per capita real stock of capital at t, and u_t a random variable at t. It is assumed that F_t is increasing and concave in L_t and K_t. The per capita expected profit of the firm prior to the payment to capital owners at period t is

$$\pi_t = E_t[P_tF_t(L_t, K_t, u_t) - W_tL_t], \quad (3)$$

where P_t is the product price of the firm at t and W_t the nominal wage rate at t. In the analysis that follows, we assume that the product price, P_t, and the per capita real capital stock, K_t, are exogenously determined.

We now present the intertemporal substitution and the efficient long-term contract model by concentrating upon the labor market. From now on, we designate the former as the ITS model and the latter as the ELC model.

To formulate the ITS model, we need to discuss the demand for labor by the firm and the supply of labor given by the dynamic optimization of the household. We begin with examining the demand for labor by the firm. Within the framework of the intertemporal substitution theory, the labor market is competitive; and the firm continuously maximizes its single-period profits. Then the demand for labor by the firm is determined from the marginal productivity condition:

$$W_t = P_t \cdot \partial F_t / \partial L_t. \tag{4}$$

Dividing W_{t+1} by W_t and taking expectations of it, we have the following dynamic marginal productivity condition for the later analysis:[7]

$$E_t\left[\frac{W_{t+1}/P_{t+1}}{W_t/P_t} - \frac{\partial F_{t+1}/\partial L_{t+1}}{\partial F_t/\partial L_t}\right] = 0, \tag{5}$$

where E_t is an expectation operator conditional on information available at period t.

We next scrutinize the dynamic optimization of the household. To this end, we must introduce the budget constraint of the household. It is assumed that the household has access to some financial assets which can be both bought and sold, and that the household faces no quantity constraints in the labor and the product market. With these assumptions, the budget constraint of the household at period t is

$$P_tC_t + A_t \leqq W_tL_t + (1 + R_t)A_{t-1}. \qquad (6)$$

Here, R_t is the price of capital which is equal to the nominal return from holding a security between t-1 and t; and A_t is the nominal value of assets possessed by the household at the end of t. Given initial assets A_0, predicted future prices P_t, and predicted future nominal rates of return R_t, the household maximizes V_0 of (1) subject to budget constraint (6) with respect to $[C_t, L_t : 0 \leqq t \leqq T]$.

Solving the maximization problem of the household, we obtain the first-order conditions and rewrite them in the following form:[8]

$$\frac{W_t}{P_t} \cdot \frac{\partial U/\partial C_t}{\partial U/\partial L_t} = -1, \qquad (7)$$

$$E_t[\rho \frac{\partial U/\partial C_{t+1}}{\partial U/\partial C_t} \frac{P_t(1 + R_{t+1})}{P_{t+1}}] - 1 = 0, \qquad (8)$$

$$E_t[\rho \frac{\partial U/\partial L_{t+1}}{\partial U/\partial L_t} \frac{W_t(1 + R_{t+1})}{W_{t+1}}] - 1 = 0. \qquad (9)$$

Equation (7) represents the static substitutable relation of consumption to labor supply at period t. The Euler equation for consumption, (8), states the substitutable relation of consumption between period t and period t+1. The Euler equation for labor supply, (9), expresses the substitutable relation of labor supply between period t and period t+1. Note that either Euler equation (8) or (9) is redundant if (7) holds exactly in all periods.

For convenience of later analysis, dividing both sides of (7) at t+1 by those at t and taking expectations of them, we replace (7) with the following

Euler equation:[9]

$$E_t\left[\frac{W_{t+1}}{W_t}\frac{P_t}{P_{t+1}}\frac{\partial U/\partial C_{t+1}}{\partial U/\partial C_t}\frac{\partial U/\partial L_t}{\partial U/\partial L_{t+1}}\right] - 1 = 0. \quad (10)$$

The ITS model is now described by the dynamic marginal productivity condition, (5), and the Euler equations derived from the dynamic optimization of the household, (8), (9) and (10).

We next turn to characterizing the ELC model. For this purpose, we must consider a model in which the firm offers a multi-period contract to a set of homogeneous workers that cannot borrow or lend. The multi-period contract of the firm, drawn up on the initial period when the states of nature in the present and future periods are unknown, stipulates wage-employment policies conditional on the set of available information at t, I_t; that is, $[W_t(I_t), L_t(I_t);\ 0 \leqq t \leqq T]$, where $W_t(I_t)$ is a nominal wage rate at t conditional on I_t and $L_t(I_t)$ a per worker labor input at t conditional on I_t. To avoid complexity, we simply write W_t and L_t rather than $W_t(I_t)$ and $L_t(I_t)$.

The firm of the ELC model desires to maximize the expected value of the discounted sum of profits subject to a worker's minimum expected discounted utility level, V^*. In general, V^* is determined by dynamic bilateral bargaining between the firm and the trade union or from alternative wages available to the workers. However, it is rather complicated to discuss the determination process of V^*, so that V^* is regarded as exogenously given. The dynamic maximization problem of the firm with respect to $[L_t, W_t;\ 0 \leqq t \leqq T]$ is formally represented as follows:[10]

$$\text{Max } E_0\sum_{t=0}^{t=T}\left\{\left[\prod_{i=0}^{i=t}\frac{1}{1+R_i}\right][P_tF_t(L_t, K_t, u_t) - W_tL_t]\right\}, \quad (11)$$

$$\text{sub. to} \quad E_0 \sum_{t=0}^{t=T} \rho^{t} \cdot U(W_t L_t / P_t,\ L_t) \geqq V^*. \tag{12}$$

Solving the maximization problem and rearranging the first-order conditions with the relation $P_t C_t = W_t L_t$, we have

$$\frac{\partial U/\partial C_t}{\partial U/\partial L_t} \partial F_t/\partial L_t + 1 = 0, \tag{13}$$

$$E_t[\rho \cdot \frac{\partial U/\partial C_{t+1}}{\partial U/\partial C_t} \frac{P_t(1 + R_{t+1})}{P_{t+1}}] - 1 = 0, \tag{14}$$

$$E_t[\rho \cdot \frac{\partial U/\partial L_{t+1}}{\partial U/\partial L_t} \frac{\partial F_t/\partial L_t}{\partial F_{t+1}/\partial L_{t+1}} \frac{P_t(1 + R_{t+1})}{P_{t+1}}] - 1 = 0. \tag{15}$$

Note that either (14) or (15) is redundant if condition (13) holds. As has been shown in the ITS model, the static equation, (13), expresses the substitutable relation of consumption to labor input at period t. The Euler equation for consumption, (14), implies the substitutable relation of consumption between period t and t+1. The Euler equation for labor input, (15), states the substitutable relation of labor input between period t and t+1.

For the later analysis, the following Euler equation is derived from rearrangement of (13):11/

$$E_t[\frac{\partial U/\partial C_{t+1}}{\partial U/\partial C_t} \frac{\partial U/\partial L_t}{\partial U/\partial L_{t+1}} \frac{\partial F_{t+1}/\partial L_{t+1}}{\partial F_t/\partial L_t}] - 1 = 0. \tag{16}$$

The ELC model now consists of the system of equations (14), (15), and (16).

In the ELC model, wages do not equal the marginal product of labor, because dynamic marginal productivity condition (5) need not be satisfied.

However, the ELC and the ITS model share some implications for the effectiveness of the macroeconomic and the labor policies. First, systematic expansionary policies cause no effects on consumption in the ELC model nor in the ITS model, since the Euler equation for consumption in the ELC model, (14), is identical with that in the ITS model, (8). Second, as proved in Appendix A, a rise in the worker's minimum expected discounted utility level decreases employment in the present and future periods unless the firm faces production uncertainty. Thus public policies that weaken trade unions can increase employment.

Needless to say, these two conclusions depend on several restrictive assumptions. First, in the ELC model, consumption can be viewed as consumption from wages and not as consumption from profit income. Systematic expansionary policies may affect total consumption if consumption from profit income is sensitive to systematic expansionary policies. Second, the proposition on labor supply cannot hold any longer in the ELC model if the firm adjusts the labor input through layoffs or if the firm faces uncertain environments. In fact, an increase in the bargaining power of workers leads to a higher wage and a greater level of employment within the one-period, layoff model such as McDonald and Solow (1981). Thus we need to recognize such factors when discussing the implications of the ELC model.

We now explore the formal relation between the ITS model and the ELC model. For this purpose, we rearrange the ITS model by substituting dynamic marginal productivity condition (5) into (9) and (10):

$$E_t[\rho \frac{\partial U/\partial L_{t+1}}{\partial U/\partial L_t} \frac{\partial F_t/\partial L_t}{\partial F_{t+1}/\partial L_{t+1}} \frac{P_t(1 + R_{t+1})}{P_{t+1}}] - 1 = 0, \qquad (9')$$

$$E_t\left[\frac{\partial U/\partial C_{t+1}}{\partial U/\partial C_t} \frac{\partial U/\partial L_t}{\partial U/\partial L_{t+1}} \frac{\partial F_{t+1}/\partial L_{t+1}}{\partial F_t/\partial L_t} \right] - 1 = 0. \tag{10'}$$

Note that (9′) and (10′) are identical with (15) and (16), respectively. Furthermore, as has been proved, equation (8) is also identical with equation (14). These findings show that the system of equations (5), (14), (15), and (16) describes the ITS model.[12] Thus the ITS and the ELC model turn out to be nested if the ITS model is characterized by (5), (14), (15) and (16). The parameters of the ITS model therefore lie in a subset of the parameter space of the ELC model.

3. Estimation Framework

In this section, we first present the nonlinear regression equations of the ELC and the ITS model by specifying preferences of the worker and production technology of the firm. We then develop a testing method for these nonlinear regression equations.

The utility function we use is an additively separable one in consumption and labor supply:

$$U(C_t, L_t) = \alpha^{-1} \cdot (C_t)^{\alpha} - \beta^{-1} \cdot (L_t)^{\beta}. \tag{17}$$

The functional form provides for the possibility of differential degrees of intertemporal substitution in consumption and labor supply: $(1-\alpha)^{-1}$ and $(\beta - 1)^{-1}$ represent the elasticity of intertemporal substitution in consumption and in labor supply, respectively. These two indexes reflect how the worker adjusts consumption and labor supply in response to anticipated changes in wages over the life-cycle. It is assumed that $0 < \alpha < 1$ and $1 < \beta$ because U is increasing in C, decreasing in L, and concave in C and L.

We next give production technology of the firm by the following simple Cobb-Douglas form:

$$F_t(L_t, K_t, u_t) = A_0 \cdot \exp(\delta t + u_t)(L_t)^{\sigma} \cdot (K_t)^{1-\sigma} . \tag{18}$$

Here, A_0 is a constant term, δ the rate of technical progress, σ the substitution rate between capital and labor, and u_t real shocks in production technology of the firm. Since F_t is increasing and concave in L_t and K_t, it is assumed that $0 < \sigma < 1$.

We now rearrange the ITS and the ELC model using specific functional forms (17) and (18). We first reformulate the ELC model by substituting (17) and (18) into (14), (15), and (16). Taking natural logarithms of both sides of these equations yields

$$\Delta \ln C_{t+1} + \frac{1}{\alpha - 1} \ln (1 + R_{t+1}) - \frac{1}{\alpha - 1} \Delta \ln P_{t+1} + \frac{\ln \rho}{\alpha - 1} = \xi_{1,t+1}, \tag{19}$$

$$\Delta \ln L_{t+1} + \frac{1-\sigma}{\sigma - \beta} \Delta \ln K_{t+1} - \frac{1}{\sigma - \beta} \ln (1 + R_{t+1})$$

$$+ \frac{1}{\sigma - \beta} \Delta \ln P_{t+1} - \frac{-\delta + \ln \rho}{\sigma - \beta} = \xi_{2,t+1}, \tag{20}$$

$$\Delta \ln L_{t+1} + \frac{\alpha - 1}{\sigma - \beta} \Delta \ln C_{t+1} + \frac{1-\sigma}{\sigma - \beta} \Delta \ln K_{t+1} + \frac{\delta}{\sigma - \beta} = \xi_{3,t+1}. \tag{21}$$

Here, Δ denotes the difference operator, that is, $\Delta \ln C_{t+1} = \ln C_{t+1} - \ln C_t$; $\xi_{i,t+1} = \varepsilon_{i,t+1} - [1/(\sigma - \beta)] \cdot \Delta u_{t+1}$ $(i = 2, 3)$; and $\varepsilon_{i,t+1}$ is a random variable $(i = 1, 2, 3)$.

We next rewrite the ITS model by substituting (17) and (18) into (5), (14), (15), and (16), and by taking natural logarithms of both sides of these equations. Then the ITS model is represented by (19), (20) and (21) plus the following equation:

$$\Delta \ln \frac{W_{t+1}}{P_{t+1}} + (1-\sigma)\, \Delta \ln L_{t+1} - (1-\sigma) \Delta \ln K_{t+1} - \delta = \xi_{4,t+1}, \tag{22}$$

where $\xi_{4,t+1} = \varepsilon_{4,t+1} + \Delta u_{t+1}$ and $\varepsilon_{4,t+1}$ is a random variable.

Some comments on these two equation systems are in order. First, they have nonlinear parametric restrictions across the equations. In other words, α, β, ρ, δ, and σ appear several times across the equations of each system. Second, the "error terms" $(\xi_{1,t+1}, \ldots, \xi_{4,t+1})$ are made up of (i) prediction errors due to the fact that only a limited subset of information is available,[13/] (ii) measurement errors in consumption, labor supply, and real wages, and (iii) real shocks in production technology of the firm. The final factor arises from the logarithm of production uncertainty, u_{t+1}, which is assumed to follow a martingale: $\Delta u_{t+1} = v_{t+1}$, where v_{t+1} is independently and identically distributed. Since these three errors are assumed to be serially uncorrelated and uncorrelated with the included instrumental variables, the whole error terms $(\xi_{1,t+1}, \ldots, \xi_{4,t+1})$ are also serially uncorrelated and uncorrelated with the included instrumental variables.

We are now in a position to develop a method for testing the ELC and the

ITS model. The testing procedure is divided into three parts.

We start by discussing a single-equation test of the ELC model on the basis of the Euler equation in labor supply. This single-equation test can be justified as follows. As has been proved in the previous section, the Euler equation in consumption, (19), is redundant in every period because it can be derived from (20) and (21). Furthermore, dynamic form (16) (or its specific dynamic form (21)) is always satisfied if its static substitutable relation (13) is assumed to hold exactly at the ex-post date in every period. These arguments permit us to delete (19) and (21) from the system of equations of the ELC model and to estimate (20) alone for the purpose of testing the ELC model.

Since (20) belongs to the simultaneous equation system and has nonlinear parametric restrictions, we use the nonlinear two-stage least squares (NL2SLS) to estimate (20). The NL2SLS estimator is obtained from minimization of the following quadratic form with respect to (β, ln ρ, σ) subject to the nonlinear parametric restrictions of (20):

$$S_0 = \xi_2'[Z(Z'Z)^{-1}Z']\xi_2, \tag{23}$$

where $\xi_2 = (\xi_{2,1}, \ldots, \xi_{2,T})$ is a vector made up of the error term in (20) at each sampling period, T a sample size, and Z a matrix whose t-th row is a vector of instrumental variables at t, z_t.

Unfortunately, we cannot distinguish the ELC model from the ITS model by the method described above, because both of these models have the same Euler equation in labor supply. To test which model is fitted to actual data, we must use the fact that the ITS model consists of the equations of the ELC model plus dynamic marginal productivity condition (22). It is easily understood from this fact that the estimation of the system of equations (20) and (22) must yield favorable results if the ITS model really holds. We therefore carry out as a second step of our testing procedure a simultaneous-equation test of equations (20) and (22) so as to verify the empirical fitness of the ITS model.

Given that equations (20) and (22) have nonlinear parametric restrictions across them, we estimate (20) and (22) by the nonlinear three stage least squares (NL3SLS) in order to obtain consistent and asymptotically efficient estimates. More specifically, the NL3SLS estimator is derived from minimization of the following quadratic form with respect to the parameters (β, $\ln \rho$, δ, σ) subject to the nonlinear parametric restrictions across (20) and (21):

$$S_1 = (\xi_2, \xi_4)'[\hat{\Sigma}_1^{-1} \otimes Z(Z'Z)^{-1}Z'](\xi_2, \xi_4). \qquad (24)$$

Here, $\xi_4 = (\xi_{4,1}, \ldots, \xi_{4,T})$ is a vector made up of the error term in (22) at each sampling period; and $\hat{\Sigma}_1$ is any consistent estimate of the variance-covariance matrix of (ξ_2, ξ_4).14/

As a final step, we consider the whole equation systems to estimate the ELC or the ITS model. We first carry out the estimation of both the ELC and the ITS model by excluding the Euler equation in consumption ((19)) from their equation systems, for we can obtain (19) from (20) and (21). However, it seems unlikely that equation (19) holds exactly in every period. Thus we also estimate both the ELC and the ITS model inclusive of the Euler equation in consumption, (19).

For the estimation of the whole equation systems, we use the nonlinear three-stage least squares (NL3SLS) because the ELC or the ITS model consists of the simultaneous equations with nonlinear parametric restrictions across the equations. As shown in (24), the NL3SLS estimator for each model is derived from minimization of the following quadratic form with respect to the parameters (α , β , ln ρ , δ , σ) subject to the nonlinear parametric restrictions across the equations of each model:

$$S_2 = \xi'[\hat{\Sigma}_2^{-1} \otimes Z(Z'Z)^{-1}Z']\xi, \tag{25}$$

where ξ is a vector made up of the error terms in the equations of each model throughout the sampling period and $\hat{\Sigma}_2$ is any consistent estimate of the variance-covariance matrix of ξ.

Our estimated results can be evaluated in the following two ways. First, we check whether the estimates have plausible standard errors and obey the well-behaved properties of the utility and the production function; that is, $0 < \alpha < 1$, $1 < \beta$, $0 < \rho < 1$ ($\ln \rho < 0$), $\delta > 0$ and $0 < \sigma < 1$.

Second, we test the nonlinear parametric restrictions across the equations of both the ELC and the ITS model using the J-test of the overidentifying restrictions implied by these models. Since these two models are nested, the empirical fitness of the ELC model is compared with that of the ITS model on the basis of their J-statistic.

The J-statistic in each estimation, J_i, is basically defined as the difference between the minimized values of the quadratic form S_i—expressed in terms of (23)-(25)—with and without the set of parametric restrictions (i = 0, 1, 2). To give J_i more precisely, let $S_i{}^*$ denote the minimized value of the quadratic form S_i with the set of parametric restrictions and $S_i{}^{**}$ the minimized value of the quadratic form S_i without the set of parametric restrictions (i = 0, 1, 2). The J-statistic in each estimation, J_i(i = 0, 1, 2), is then represented by

$$J_i = T \cdot S_i{}^* - T \cdot S_i{}^{**}. \tag{26}$$

Here, T is the number of a sample size. As shown in Gallant and Jorgenson (1979), under the null hypothesis, the J-statistic is distributed asymptotically as a chi-square with (qm− r), where r is the number of estimated parameters, q the number of estimated equations, and m the number of instrumental variables.[15] If the sample is in accord with the null hypothesis, J will be near zero; but, if the sample is not, J will be large. Thus an asymptotically level α test of the null hypothesis is: reject the null hypothesis if J exceeds the upper $\alpha \times 100$ percentage point of the chi-square distribution with qm− r degrees of freedom.

4. Empirical Results

In this section, we report the results of the ELC and the ITS model estimated with the same set of instruments.

In conducting empirical investigation, we mainly use Japanese quarterly data for the sample period from 1965:Q3 to 1985:Q3. The definitions of data variables are summarized in Appendix B. The set of the instruments includes the constant unity, the logarithm of the nominal rate of return on the security, the first differences of the logarithms of general consumer price index and real per capita capital stock,[16] and the first lagged values of the first differences of the logarithms of real per capita wage payments, real per capita consumption, and per capita labor hours:

$$z_{t+1} = [1,\ \ln(1 + R_{t+1}),\ \Delta \ln P_{t+1},\ \Delta K_{t+1},\ \Delta \ln \frac{W_t}{P_t},\ \Delta \ln C_t,\ \Delta \ln L_t]. \quad (27)$$

Some comments on several choices about the data are in order. First, the yields of Telephone and Telegram Bonds or the yields of *Gensaki* (bond trading with repurchase agreement) are used as a proxy of the interest rate, R_{t+1}. Second, bonus payments are excluded from the series of wage payments although our empirical results are not modified by inclusion of bonus payments.[17] Third, two series of labor hours are used: the total working and the overtime working hours of regular workers in all manufacturing industries. Fourth, the general consumer price index is used as a proxy of the price P_t because our empirical results are not modified by using the wholesale price index. Fifth, the series of expenditures on durables as well as on nondurables and services are included in our consumption series because of the data restriction placed on the Japanese *quarterly* data series of aggregate consumption of *worker's households*.[18] However, we do not suffer from this data restriction when estimating equation (20) alone or estimating combined subsystem (20) and (21).

Our empirical arguments are proceeded as follows. We first discuss the results of the single-equation test for the ELC model which are estimated by the NL2SLS method. However, as has already been shown, the ITS and the ELC model share equation (20) if dynamic marginal productivity condition (22) holds. To explore which hypothesis is more fitted to actual data, we estimate the combined subsystem of (20) and (22) by the NL3SLS method. Finally, we test the whole equation systems of both the ELC and the ITS model on the basis of the NL3SLS method.

The estimates of the single-equation test for the ELC model are summarized in Table 1. The term, $-\delta + \ln \rho$, is listed in Table 1 because neither $\ln \rho$ nor δ can be identified separately from (20) alone. The first column reports the estimated values when total working hours are used as per capita labor hours and the yields of Telephone and Telegram Bonds (TTB rate) as the interest rate. The second column presents the estimates when the yields of Telephone and Telegram Bonds are replaced with the yields of *Gensaki*. The coefficient estimates in these two columns are very similar. The parameter estimates of β (the taste parameter of workers in labor supply) and σ (the substitution rate between capital and labor) are economically plausible and highly significant. However, the parameter value of $-\delta + \ln \rho$, estimated from the constant term, is inconsistent with the theoretical restrictions on the signs of ρ and δ although the standard errors are large.

The failure of estimating $-\delta + \ln \rho$ seems to arise from that negative trend in the series of total working hours which is not explained by the model under investigation.[19] To verify this point, we estimate the Euler equation in labor supply with overtime working hours because the series of overtime working hours have no secular trend. The estimated results are provided in the third column of Table 1. All of the parameter estimates are economically plausible although the standard errors of $-\delta + \ln \rho$ are large.

The bottom row of Table 1 gives a test statistic for the hypothesis of whether the restrictions on the parameters in the Euler equation in labor supply apply to the system of regression in Table 1. All the results show that the restrictions of the Euler equation in labor supply cannot be rejected at any significant level.

We next turn to testing the ITS model represented by the subsystem of (20) and (22). For the preliminary purpose, dynamic marginal productivity condition (22) is separately estimated from the subsystem of (20) and (22) using the NL2SLS method. The estimated results are reported in the top half of Table 2. The first column contains the estimated values for total working hours whereas the second column lists the estimates for overtime working hours. Both of these estimates show that the production-substitutability parameter σ is significantly greater than unity, thus contradicting the theoretical restriction of the production function.

The estimated results of dynamic marginal productivity condition (22) lead us to expect that the ITS model consisting of the subsystem of (20) and (22) has trouble explaining the cyclical movements of employment and real wages. This conjecture can really be verified in the bottom half of Table 2. For any combination of working hours and the interest rate, the production-substitutability parameter σ is highly significant and greater than unity, which contradicts the theoretical restriction of the production function. Furthermore, the overidentifying restrictions of the ITS model are rejected at the 0.5 % level in all cases.

To summarize, the ELC model cannot be rejected by the single equation test of the Euler equation in labor supply. In contrast, the testing results of the subsystem of (20) and (22) provide substantial evidence against the ITS model.

We now consider the testing results of the whole equation systems of the ELC or the ITS model on the basis of the NL3SLS method. We first estimate the equation systems exclusive of (19) because we can derive (19) from (20) and (21). However, even though the other two equations are well fitted to actual data, it seems unlikely that (19) holds exactly at every period. Thus we next estimate the whole equation systems of both the ELC and the ITS model inclusive of (19). In the following estimation, we restrict our attention to the case in which total working hours are used as labor hours and the yields of Telephone and Telegram Bonds as the interest rate.

Table 3 displays the computed values of the whole equation systems exclusive of (19). The first column presents the estimates of the ELC model whereas the second column reports the estimates of the ITS model.

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Table 3 displays the computed values of the whole equation systems exclusive of (19). The first column presents the estimates of the ELC model whereas the second column reports the estimates of the ITS model.

Inspecting the results of the ELC model shows that all of the parameter estimates except δ are economically plausible. The estimates of the taste parameters of workers, α and β, ensure the well-behaved properties of utility function (17). Furthermore, the estimated value of α is significant at the 1 % level. The estimated discount rate per quarter, ρ, and the estimated substitution rate between capital and labor, σ, also accord with their theoretical restrictions although their standard errors are large. The only undesirable result appears in the estimate of the rate of technical progress, δ. However, this undesirable outcome is not surprising, because δ is estimated from the constant term impinged strongly by the negative trend in the series of total working hours; and the negative trend is not incorporated into the ELC model.

The J-statistic for a test of the overidentifying restrictions of the ELC model, J(16), does not provide strong evidence against the ELC model. In fact, the overidentifying restrictions of the ELC model are not rejected at the 2.5% level.

We next examine the estimates of the ITS model in the second column of Table 3. As shown in the test of the ITS model consisting of the subsystem of (20) and (22), the empirical results contradict the theoretical restriction of the production function because the parameter estimate of σ is significant and greater than unity. Furthermore, the overidentifying restrictions of the ITS model are strongly rejected at the 0.5% level.

Table 4 gives the estimated results of both the ELC and the ITS model inclusive of the Euler equation in consumption. The parameter estimates of the ELC model except $\ln \rho$ in Table 4 are economically plausible. Note that the parameter estimates of the ELC model in Table 3 are consistent with the theoretical requirement of the sign of $\ln \rho$ but inconsistent with that of the sign of δ . These findings imply that the parameters estimated from the constant term are rather unstable because of the negative trend which is found in the series of total working hours and unexplained in the theoretical models.

The estimates in Table 4 also show that even in the ITS model the production-substitution parameter, σ , does not violate the theoretical restriction of the production function. Thus the parameter estimates do not provide substantial evidence against the ITS model. However, the overidentifying restrictions of the ITS model are strongly rejected at the 0.5% level; on the other hand, the overidentifying restrictions of the ELC model are not rejected at the 2.5% level. The highly significant value of the overidentifying restricitons of the ITS model constitutes a resounding rejection of the ITS model.

The rejection of the overidentifying restrictions of the ITS model leads us to expect that the parameter values of the NL3SLS estimators of the ELC model in Tables 3 and 4 are totally inconsistent with those of the NL2SLS estimator of dynamic marginal productivity condition (22) in the first column of the top half of Table 2. Comparing the estimated outcome in the first column of Tables 3 and 4 with that in the first column of the top half of Table 2 completely verifies our conjecture.

The averaging involved in seasonal adjustment might disturb our basic estimated results. To check this point, we estimate both the ELC and the ITS model with fiscal half year data because Japanese fiscal half year data are free from some of the main causes of seasonal adjustment. The estimates can verify the basic tendency found in the results estimated with quarterly data.[20]

One might also think that the estimation of the ITS model does not provide strong evidence against the ITS model if we use the 'structural' ITS model based on (8)-(10). In Table 5, the estimated results of the ITS model based on (8)-(10) are presented to clarify this matter. The first column of Table 5 reports the estimates of the single equation test using the Euler equation in labor supply, (9). The second column lists the estimates of the subsystem made up of (9) plus dynamic marginal productivity condition, (5). The third and the fourth column contain the estimated results using the whole equation systems exclusive of and inclusive of the Euler equation in consumption, (8). All of these estimates except those in the first column of Table 5 show that the taste parameter of workers in consumption, α , or the production-substitution parameter, σ , does not accord with the theoretical restriction of the utility function or the production function, respectively. The overidentifying restrictions of these testing hypotheses except the first column of Table 5 are also rejected at the 0.5% level. Only the estimates of the single equation test in the first column of Table 5 are consistent with the restrictions of the ITS model although the elasticity of intertemporal labor supply, $1/(1-\beta)$, is very low and the negative trend in the series of total working hours distorts the sign of the discount factor, ρ . However, the single equation test of the ITS model is not much meaningful, because the wage determination is not accounted for by means of (9) alone.

To sum up, we conclude from our estimated results that the Japanese aggregate employment and real wages are characterized by the efficient long-term contract model, but not by the intertemporal substitution model.

5. Concluding Remarks

This paper has tested the efficient long-term contract model against the intertemporal substitution model using Japanese aggregate data. The empirical results are consistent with the efficient long-term contract model, but are inconsistent with the intertemporal substitution model. This finding suggests that cyclical movements of employment and real wages in the Japanese economy do not arise from intertemporal substitution in labor supply but from risk sharing or bilateral bargaining arrangements between firms and workers. Our observation also indicates that systematic expansionary policies have no effects on consumption or employment even though unexpected expansionary policies can increase the long-run level of employment.

This paper has only begun to touch on the implications of the dynamic efficient contracting model for macroeconomic questions. Both the empirical and the theoretical work developed in this paper could be extended in several directions. First, systematic expansionary policies can cause some effects on total consumption through consumption from profit income although they have no effects on worker's consumption under the efficient long-term contract model. Thus it would be interesting to extend our analysis into a framework including the dynamic behavior of capital owners. Second, the efficient long-term contract model of this paper does not allow the firm to lay off the workers. However, if the firm can adjust the workers by layoffs, a rise in the bargaining power of workers does not necessarily decrease labor supply in the present and future periods. On the contrary, within the one-period, layoff model such as McDonald and Solow (1981), a rise in the bargaining power of workers leads to a higher wage and a greater level of employment. Thus it would be valuable to examine a dynamic efficient contracting model in which the firm is permitted to layoff the workers.

Appendix A

This appendix provides a proof for the following proposition:

Proposition: Let us assume that $U(C_t, L_t) = V(C_t) + H(L_t)$. Under the ELC model, a rise in the minimum expected utility level V^* decreases labor supply in the current and future periods if the firm faces no production uncertainty.

Proof.

We begin with showing that consumption at t, C_t, is expressed in terms of a function in labor supply at t, L_t. Rearranging (13) with $U(C_t, L_t) = V(C_t) + H(L_t)$ yields

$$C_t = G\left(-\frac{H'(L_t)}{\partial F_t/\partial L_t}\right), \tag{A1}$$

where G is an inverse function of V' ($= dV/dC_t$) with respect to C_t, and $H' = dH/dL_t$. Note that $G'(L_t) = [V''(L_t)]^{-1} < 0$.

We next discuss how labor supply at period t, L_t, is related with labor supply at the initial period, L_0. Given that $U(C_t) = V(C_t) + H(L_t)$, it follows from (15) that in the absence of production uncertainty

$$\frac{H'(L_t)}{\partial F_t/\partial L_t} = \frac{P_t}{P_{t-1}(1 + R_t)} \frac{H'(L_{t-1})}{\partial F_{t-1}/\partial L_{t-1}} \frac{1}{\rho}$$

$$= \frac{P_t}{P_0}\left[\prod_{i=1}^{i=t} \frac{1}{(1 + R_i)}\right] \frac{H'(L_0)}{\partial F_0/\partial L_0} \frac{1}{\rho^t}. \tag{A2}$$

Totally differentiating (A2) with respect to L_t and L_0 generates

$$\frac{dL_t}{dL_0} = \frac{P_t}{P_0}\left[\prod_{i=1}^{i=t} \frac{1}{(1+R_i)}\right]\frac{D_0}{D_t}\frac{1}{\rho^t} > 0, \tag{A3}$$

where

$$D_t = \frac{H''(L_t)\cdot\partial F_t/\partial L_t - \partial^2 F_t/\partial L_t^2\cdot H'(L_t)}{(\partial F_t/\partial L_t)^2} < 0. \tag{A4}$$

The final inequality derives from the assumptions that $H' < 0$, $H'' < 0$, $\partial F_t/\partial L_t > 0$ and $\partial^2 F_t/\partial L_t^2 < 0$.

We now examine the effects of a change in the minimum expected utility level V^* on L_0. Substituting (A1) into (12) and totally differentiating it with respect to L_0 and V^* in the light of $C_t = W_t L_t/P_t$ gives us

$$\left\{-\sum_{t=0}^{t=T}\left[\rho^t\cdot V'(C_t)G'(L_t)D_t\frac{dL_t}{dL_0}\right] + \sum_{t=0}^{t=T}\left[\rho^t\cdot H'(L_t)\frac{dL_t}{dL_0}\right]\right\} dL_0 = dV^*. \tag{A5}$$

Since $V' > 0$, $G' < 0$, $D_t < 0$ from (A4), and $dL_t/dL_0 > 0$ from (A3) ($t = 0,\ldots,T$) and $H' < 0$, it is seen from (A5) that dL_0/dV^* is negative.

It is also immediate from (A3) and the sign of dL_0/dV^* that dL_t/dV^* ($1 \leqq t \leqq T$) are negative. (Q.E.D.)

Appendix B

(1) R_{t+1}: Series (i) Yields of Telephone and Telegram Bonds between t and t+1 taken from the *Monthly Statistics Report*. Series (ii) Yields of *Gensaki* between t and t+1 taken from the *Monthly Statistics Report*.

(2) P_t: General consumer price index taken from the *Monthly Report of Retail Prices*.

(3) K_t: Real capital stock per worker = $K_t^N/(N_t P_t^I)$.

N_t: Number of workers employed in all manufacturing industries taken from the *Quarterly Reports of Incorporated Enterprises Statistics*.

K_t^N: Depreciable asset in all manufacturing industries taken from the *Quarterly Reports of Incorporated Enterprises Statistics*. K_t is calculated in a book value.

P_t^I: Wholesale price index for investment goods taken from the *Price Indexes Monthly*.

(4) W_t: Cash earnings of regular workers in all manufacturing industries taken from the *Monthly Labor Survey*. Bonus payments are excluded from W_t.

(5) L_t: Series (i) Total working hours of regular workers in all manufacturing industries taken from the *Monthly Labor Survey*. Series (ii) Overtime working hours of regular workers in all manufacturing industries taken from the *Monthly Labor Survey*.

(6) C_t: Real Consumption per worker = C_t^N/P_t.

C_t^N: Living expenditures of worker's households taken from the *Monthly Report on the Family Income and Expenditure Survey*. Transfers are excluded from C_t.

All data are seasonally adjusted and available from the authors upon request.

Notes

1/ A large number of studies attempt to test the intertemporal substitution theory using data in the United States or the United Kingdom. See, for example, Hall (1980), Heckman and MaCurdy (1980), MaCurdy (1981)(1983), Altonji (1982), Clark and Summers (1982), Mankiw, Rotemberg and Summers (1985), Browning, Deaton and Irish (1985), Ham(1986), and Blundell and Walker (1986), Alogoskoufis (1987). For the empirical research on the Japanese economy, see Hanai (1985).

2/ See Ashenfelter and Card (1982) and Montgomery and Shaw (1985).

3/ The recent literature on unionized markets distinguishes between two models of wage and employment determination: the monopoly union and the static efficient contracting model. Under the monopoly union model, the union maximizes some objectives by unilateral wage setting; and the firm responds by choosing the level of employment on the firm's labor demand function in accordance with the wage rate. On the other hand, under the static efficient contracting model, wage and employment are determined by bilateral bargaining between the firm and the workers. Wage and employment outcomes are then fully Pareto efficient, so that these arrangements are on the parties' contract curve. Brown and Ashenfelter (1986), Eberts and Stone (1986), MaCurdy and Pencavel (1986), Svejnar (1986) and Abowd (1987) test these two models using panel data in the US unionized market. Their results provide strong evidence against the monopoly union model but not against the static efficient contracting model. Card (1986) extends the static efficient contracting model into the dynamic efficient contracting model with costly employment adjustment. Using panel data in the US unionized market, he confirms the tendencies similar to those found in the static efficient contracting model.

4/ The recent interesting paper of Abowd and Card (1987) has compared the implications of the intertemporal contracting and the intertemporal labor supply model. Abowd and Card prove that earning changes are less variable than hours changes in the intertemporal contracting model, but more variable in the intertemporal labor supply model. Their empirical evidence casts doubt on the usefulness of either the intertemporal contracting model or the intertemporal labor supply model. However, their analysis differs with ours in the following points: (1) Their Euler equation system is approximated by the linearized reduced form, so that nonlinear estimation is avoided; (2) Their attention is focused on the movements of working hours and wage earnings, and not on the movements of working hours and consumption; (3) Longitudinal data of households are used instead of aggregate data; (4) The productivity of worker is regarded as exogenous because their production function is linear in labor input.

5/ The expression 'long-term contract' used in this analysis implies an explicit or implicit intertemporal contract which stipulates the agreements negotiated between the firm and the workers. This intertemporal contract need not necessarily be identified with the lifetime employment contract even though the Japanese labor market is strongly characterized by the lifetime employment contract system.

6/ The bilateral bargaining model does not necessarily exclude the great extent of wage flexibility although the wage fluctuations are inconsistent with the marginal productivity condition. We may interprete within the bilateral bargaining model the movements in employment and real wages in the Japanese economy because wage fluctuations are relatively great in Japan.

7/ In the next sections, our equation systems are estimated using the nonlinear instrumental variables (NLIV) method. The NLIV estimatior to be asymptotically justifiable requires the variables to be transformed in order to become stationary. Transforming (4) into (5) satisfies this requirement.

8/ The optimum path is assumed to be attained at an interior solution.

9/ See note 7/.

10/ $\prod_{i=0}^{i=t} \frac{1}{1+R_i} = \left(\frac{1}{1+R_0}\right)\cdots\left(\frac{1}{1+R_t}\right)$. The optimum path is assumed to be attained at an interior solution.

11/ See note 7/.

12/ The ITS and the ELC model share the same reduced form; in other words, these two models are observationally equivalent.

13/ The estimated equations possibly include only a limited subset of information, so that there may be some predicted lagged variables which are not incorporated in the regression, but observed by the individual. The effects of these predicted lagged variables are reflected in the error terms. By definition, the factors of the error terms are uncorrelated with the included instrumental variables.

14/ To obtain a consistent estimate $\hat{\Sigma}_1$ of the contemporaneous variance-covariance matrix, we estimate the two equations ((20) and (22)) separately by the nonlinear two-stage least squares technique. A consistent estimator $\hat{\Sigma}_1$ is derived from the sample variance-covariance matrix of the residuals.

15/ Hansen (1982) proves this result using the more comprehensive assumption on the error term.

16/ In the subsequent estimation, K_t is measured in a book value . However, the measurement of K_t in a current value does not make substantial differences in the estimated results.

17/ The estimated results are available from the authors upon request.

18/ Horie (1985) constructs the *yearly* consumption data series of *worker's* *households* consisting of consumption expenditures on services and nondurables plus the value of service flows from consumer durables. Ogawa, Takenaka and Kuwata (1986) also makes the same kind of *quarterly* consumption data series of *all households*. These two data series, however, are inadequate for our purpose because we must use *quarterly* consumption data series of *worker's households*.

19/ The negative trend in the series of total working hours originates from a change in individual preferences to leisure or of employment practice. Since this negative trend is included in the constant term of (20), the parameter value estimated from the constant term is imprecise.

20/ In Japan, bonus payments are almost always made twice a year, once in the summer (in June or July) and once at the end of year (in December). Seasonal extra expenditures— *Ochugen* in July and *Oseibo* in December— are also made in a similar way. Since the Japanese fiscal half year is from April 1 to March 31 in the next year, the use of fiscal half year data eliminates some of the main causes of seasonally adjustment. The estimated results are available from the authors upon request.

Table 1

NL2SLS Estimates of the Parameters the Euler Equation in Labor Supply, (20)

	Total Working Hours and TTB Rate	Total Working Hours and Gensaki Rate	Overtime Working Hours and TTB Rate
$-\delta + \ln \rho$	0.0037	0.0052	-0.0017
	(0.0066)	(0.0064)	(0.0131)
β a/	5.2535	5.1617	2.5247
	(0.6820)	(0.6488)	(0.5700)
σ	0.5153	0.5246	0.5751
	(0.1778)	(0.1723)	(0.3575)
J(4) b/	2.287	1.563	7.346
	[J(4, 50) = 3.357]	[J(4, 75) = 1.923]	[J(4, 10) = 7.779]

Notes: Standard errors of the parameter estimates are given in parentheses. The well-behavedness of the utility function implies $0 < \rho < 1$ ($\ln \rho < 0$) and $1 < \beta$. The well-behavedness of the production function requires $0 < \delta$ and $0 < \sigma < 1$.

a/ The elasticity of intertemporal labor supply is calculated from the value of $(\beta - 1)^{-1}$.

b/ J(4) is a test of the overidentifying restrictions embodied in the model, asymptotically distributed as $\chi^2(4)$ under the null hypothesis. J(4, x) shows that J(4) is critical at the x% level; in other words, if J(4) is smaller than J(4, x), overidentifying restrictions cannot be rejected at the x% level.

Table 2

(a) NL2SLS Estimates of the Parameters of the Dynamic Marginal Productivity Equation, (22)

	Total Working Hours	Overtime Working Hours
δ	0.0123 (0.0032)	0.0109 (0.0031)
σ	1.2338 (0.0812)	1.0966 (0.0561)
J(5) a/	1.336 [J(5, 90) = 1.610]	1.517 [J(5, 90) = 1.610]

(b) NL3SLS Estimates of the Parameters of the ITS Model Represented by the Subsystem of (20) and (22)

	Total Working Hours and TTB Rate	Total Working Hours and Gensaki Rate	Overtime Working Hours and TTB Rate
$\ln \rho$	0.0100 (0.0692)	0.0115 (0.0684)	0.0049 (0.1172)
β	5.5843 (5.6516)	5.4263 (5.3031)	2.9538 (5.6003)
δ	0.0107 (0.0281)	0.0106 (0.0283)	0.0108 (0.0276)
σ	1.0607 (0.5972)	1.0543 (0.5906)	1.0797 (0.4889)
J(10) a/	61.48 [J(10, 0.5) = 25.19]	57.08 [J(10, 0.5) = 25.19]	67.43 [J(10, 0.5) = 25.19]

Notes: See the footnote in Table 1.
a/ J(n) is a test of the overidentifying restrictions embodied in the model, asymptotically distributed as $\chi^2(n)$ under the null hypothesis. J(n, x) shows that J(n) is critical at the x% level; in other words, if J(n) is smaller than J(n, x), overidentifying restrictions cannot be rejected at the x% level.

Table 3

NL3SLS Estimates of the Parameters of the ELC or ITS Model
(Based upon the System Exclusive of (19))

	ELC Model	ITS Model
$\ln \rho$	-0.0005 (0.0985)	0.0073 (0.0462)
α	0.9731 (0.1612)	0.8913 (0.1440)
β	18.7028 (27.9943)	9.9457 (6.4343)
δ	-0.0215 (0.2840)	0.0097 (0.0271)
σ	0.1277 (5.2227)	1.0055 (0.4737)
J(n) [a]	17.23 [J(9, 2.5) = 19.02]	114.0 [J(16, 0.5) = 34.27]

Notes: See the footnote in Table 1. Total working hours are used as labor hours and TTB rate as the interest rate.

a/ J(n) is a test of the overidentifying restrictions embodied in the model, asymptotically distributed as $\chi^2(9)$ under the ELC model and $\chi^2(16)$ under the ITS model. J(n, x) shows that J(n) is critical at the x% level; in other words, if J(n) is smaller than J(n, x), overidentifying restrictions cannot be rejected at the x% level.

Table 4

NL3SLS Estimates of the Parameters of the ELC or ITS Model
(Based upon the System Inclusive of (19))

	ELC Model	ITS Model
$\ln \rho$	0.0103	0.0087
	(0.0742)	(0.0453)
α	0.8364	0.8444
	(0.0590)	(0.0527)
β	10.0683	8.4619
	(9.4334)	(4.5133)
δ	0.0005	0.0098
	(0.1561)	(0.0269)
σ	0.3827	0.9873
	(2.7471)	(0.4229)
J(n) [a/]	27.71	127.38
	[J(16, 2.5) = 28.85]	[J(23, 0.5) = 44.18]

Notes: See the footnote in Table 3.
a/ J(n) is a test of the overidentifying restrictions embodied in the model, asymptotically distributed as $\chi^2(16)$ under the ELC model and $\chi^2(23)$ under the ITS model. J(n, x) shows that J(n) is critical at the x% level; in other words, if J(n) is smaller than J(n, x), overidentifying restrictions cannot be rejected at the x% level.

Table 5

NL3SLS Estimates of the Parameters of the ITS Model
(Based upon the System of Equations (5) and (8)-(10))

	(10)	(5) and (9)	(8) and (9)	(8)-(10)
ln ρ	0.01229 (0.01026)	0.009620 (0.05766)	0.01979 (0.1436)	0.01569 (0.07353)
α	-------	--------	1.426 (9.702)	-2.0542 (4.392)
β	8.292 (1.187)	5.737 (3.311)	32.77 (59.85)	27.49 (41.87)
δ	-------	0.01019 (0.02873)	--------	--------
σ	-------	1.008 (0.5714)	--------	--------
J(n) a/	1.983 [J(5, 75) = 2.675]	81.35 [J(10, 0.5) = 25.19]	66.18 [J(11, 0.5) = 26.76]	102.88 [J(18, 0.5) = 37.16]

Notes: See the footnote in Table 3.
a/ J(n) is a test of the overidentifying restrictions embodied in the model, asymptotically distributed as $\chi^2(n)$ under the null hypothesis. J(n, x) shows that J(n) is critical at the x% level; in other words, if J(n) is smaller than J(n, x), overidentifying restrictions cannot be rejected at the x% level.

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