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OPTIMAL NEGOTIATION PATTERN UNDER A REVENUE-INDEXING CONTRACT

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This paper studies a model of long-term contracts in which the choice of the negotiation pattern is endogenized and the nominal wage rate is tied to a share of the contracting sector's total revenue. It is shown that a revenue-indexing contract under certain circumstances may favor a pattern of short-term and synchronized negotiations to enhance macroeconomic performance in the sense of lowering output and employment fluctuations. Therefore, this finding suggests that Japan and Korea using a form of revenue-indexing contracts might go through annual and synchronized wage settlements in the spring time, so called Shunto.

I. INTRODUCTION

Typical models of long-term wage contracts impose a negotiation pattern (i. e., synchronizing or staggering) and then develop the implications of this particular structure for the aggregate economy; see, for example, Fischer (1977), Gray (1976, 1978), and Taylor (1979). Those models fail to explain how contracting sectors choose the timing of wage negotiations. Recent works, however, develop extended models in which the choice of the negotiation pattern is endogenized; see, for example, Matsukaw (1986), Ball (1987), and Fethke and Policano (1984, 1986).

Fethke and Policano (1984, 1986) examine the optimality of the negotiation pattern in an economy where each sector is subject to both aggregate and relative (sector-specific) shocks. They show under a fixed-wage contract that synchronized negotiation shortens the contract length and thereby reduces both the degree of wage inertia and the variability of aggregate output. This indicates that short-term and synchronized negotiation pattern is optimal in the criterion of aggregate output variability.

However, they argue that synchronizing might eliminate a cost-reducing exter-

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nality associated with staggering when contracting sectors use the resource cost of contracting (i. e., a degree of labor market disequilibrium for the contracting sector plus the negotiation cost) to judge the optimality of the negotiation pattern.[1] Specifically, in the presence of relative shocks, staggering reduces the resource cost of contracting because adjustments made by negotiating sectors transmit beneficial employment effects into other sectors that are locked into previously negotiated contracts. Furthermore, staggering reduces the resource costs of contracting by increasing the contract length. These results imply that long-term and staggered negotiation patterns seem desirable in a decentralized economy subject to relatively important sector-specific shocks. It helps to explain the persistence of three-year (i.e., relatively long-term) and staggered contracts in American and Canadian labor markets where fixed-wage contracts are prevalent and sector-specific shocks are relatively important.

The purpose of this paper is to determine whether the results of Fethke and Policano's model hold even under a revenue-indexing contract in which the nominal wage rate is directly tied to a share of the contracting sector's total revenue. This wage contract entails that the nominal wage rate reflects the price movement as well as the sector-specific output movement on economic shocks. This analysis may help to explain labor market distinctions in economies using a type of revenue-indexing contracts.

When the revenue-indexing contract is built into the Fethke and Policano (1984)'s model, the main results of optimal negotiation pattern are as follows.

(1) As in the Fethke and Policano's model, synchronized negotiation reduces the degree of wage inertia by decreasing the contract length and thereby lowers the variation in aggregate output.

(2) In the criterion of the resource cost of contracting, the optimality of the negotiation pattern depends on the relative importance of aggregate versus relative shocks that affect the economy. Specifically, synchronizing is optimal in the presence of aggregate shocks while staggering is optimal in the presence of relative shocks. In addition, the optimal negotiation pattern in case of full indexation to the contracting sector's total revenue is not relevant on the type of economic shocks.

The result of (1) implies that, even under the revenue-indexing contract, short-term and synchronized negotiation is optimal for the variability in aggregate output. The result of (2) suggests that a revenue-indexing type of an economy

[1] Here the objective function of minimizing the contracting costs is used as the distortions in the contracting sector's labor market. By using the concept of general equilibrium, Aizenman and Frenkel (1985) show that the minimization of the contracting costs of distortions in the labor market is equivalent to maximizing the utility function of the contracting sectors given the technology constraint. This indicates that it is rational for the contracting sectors to use their contracting costs associated with the distortions in their labor markets when they determine optimal negotiation patterns.

subject to relatively important aggregate shocks might choose short-term and synchronized negotiation to reduce the resource cost of contracting. These findings may be able to give annual (i. e., relatively short-term) and synchronized wage settlements in Japanese and Korean labor markets where the bonus system, a form of revenue-indexing contracts, is prevalent and aggregate shocks rather than relative shocks are dominate.[2)]

This paper proceeds as follows. The second section introduces the basic long-term contract model used. In the third sections, we examine the optimal choice of the negotiation pattern under the two criteria; the resource cost of contracting and the variability of aggregate output. A summary of conclusions is contained in the final section.

II. THE BASIC MODEL

We adopt Fethke and Policano (1984)'s two sector model in which each sector is subject to sector-specific shocks and aggregate shocks. Each sector produces one identical commodity and outputs are sold in a single market. Assume that capital is fixed and all firms in the ith sector are identical. All variables are expressed in logarithms.

Output in each sector is represented by

$$y_{it}^{S} = \alpha_0 l_{it} + z_{it} + u_t, \quad 0 < \alpha_0 < 1 \tag{1}$$

where y_{it}^{s}, l_{it}, z_{it}, and u_t denote, respectively, output for sector i, employment for sector i, and a relative productivity shock, and an aggregate productivity (supply) shock. The relative productivity shock, z_{it}, is assumed to sum to zero across the sectors each period ($z_{1t} + z_{2t} = 0$). The relative and aggregate productivity shocks, z_{it} and u_t, follow independently distributed random walk processes with zero mean and forecast variance $\sigma_z^2 t$, and $\sigma_u^2 t$, respectively.

Labor demand and labor supply in each sector are given by

$$l_{it}^{D} = -\alpha_1(w_{it} - p_t - u_t - z_{it}), \ \alpha_1 = \frac{1}{1-\alpha_0} \tag{2}$$

and

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[2] Some economists argue that synchronized negotiation in Japan originates in labor market institutions and industrial relations. Gordon (1982, p37) points out that the simultaneity of contract negotiations may be partially explained as an attempt by the Japanese trade union movement to compensate for its basic weakness and fragmentation. And Freeman (1984, p127) states that in Japan the spring wage offensive occurs because Japanese industrial relations are more centralized at least on the wage side.

$$l_{it}^{S} = \delta(w_{it} - p_t), \quad \delta > 0 \tag{3}$$

where w_{it} is the nominal wage in the ith sector and p_t is the price level. Labor demand is derived from the profit-maximization problem of firms in the ith sector. Labor supply is a positive function of the real wage in the ith sector. For simplicity, the intercept of the labor demand and supply schedules is set to zero.

The market-clearing value of the nominal wage of sector i is obtained by equating the demand and supply of labor,

$$\hat{w}_{it} = p_t + (1-\beta)(z_{it} + u_t), \quad 0 < \beta = \frac{\delta}{\alpha_1 + \delta} < 1. \tag{4}$$

Substituting eq.(4) into eq.(2) yields the equilibrium level of employment in each sector,

$$\hat{l}_{it} = \alpha_1 \beta (z_{it} + u_t). \tag{5}$$

Each sector is assumed to have a pool of immobile workers. These workers sign nominal wage contracts that are indexed to unexpected total revenue movements in contracting sectors. Once wage contracts are signed, employment becomes the labor demand schedule determined. Consequently, workers may be off their labor supply schedule after contracts are negotiated. Given these assumptions, the wage-setting rule of each sector is given by

$$w_{it} = {}_h\hat{w}_{it} + bR_{it}, \qquad R_{it} = (p_t - {}_hp_t) + (y_{it} - {}_hy_{it}) \tag{6}$$

where ${}_h\hat{w}_{it}$ is $E(\hat{w}_{it} \mid I_h)$, the mathematical expectation of the equilibrium wage rate conditional on information available at the time of negotiation, $t=h$, b is an indexing parameter($0 \leq b \leq 1$), and R_{it} is the contracting sector's total revenue. For $b=0$, no indexation occurs, for $b=1$ nominal wages are fully indexed, and for $0 < b < 1$ nominal wages are partially indexed. The information set, I_h, includes knowledge of the parameters and structure of the economy. Firms and workers know the structure of the economy and the distributions of all disturbance terms when wage contracts are signed.

Substitution of eq. (6) into eq. (2) yields the actual employment at time t under the revenue-indexing contract,

$$l_{it} = \frac{\alpha_1(1-b)}{1+b\phi}(p_t - {}_hp_t) + \frac{\alpha_1(1-b)}{1+b\phi}(u_t - {}_hu_t) + \frac{\alpha_1(1-b)}{1+b\phi}(z_{it} - {}_hz_{it})$$
$$+ \alpha_1\beta({}_hu_t + {}_hz_{it}). \tag{7}$$

Substitution of eq. (7) into eq. (1) provides output for sector i, contingent on contract negotiation at time $t = h$,

$$y_{it} = \frac{\phi(1-b)}{1+b\phi}(p_t - {}_hp_t) + \frac{\phi(1-b)}{1+b\phi}(u_t - {}_hu_t) + \frac{\phi(1-b)}{1+b\phi}(z_{it} - {}_hz_{it})$$

$$+ \phi\beta({}_hu_t + {}_hz_{it}) + (u_t + z_{it}), \quad \phi = \alpha_0\alpha_1. \tag{8}$$

Aggregate demand for the product is given by the simple quantity equation with constant velocity,

$$y_t^D = m_t - p_t \tag{9}$$

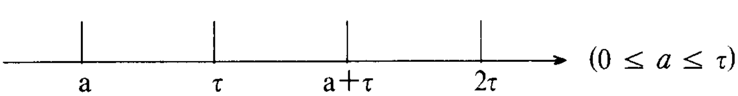
where an aggregate demand shock, m_t, follows an independently distributed random walk with forecast variance $\sigma_m^2 t$. Treatment of m_t as an exogenous stochastic process implies that nominal income is exogenous.

III. THE PATTERN OF CONTRACT NEGOTIATION

We now turn to examine how each contracting sector under a revenue-indexing contract selects its negotiation pattern. Suppose that the choice of the negotiation pattern is endogenized. The optimality of negotiation pattern is respectively analyzed through the two criteria: the resource cost of contracting and the variability of aggregate output.

3.1 The Criterion of the Resource Cost of Contracting

Each sector negotiates a contract of length τ. The nominal wage for each sector is set at the beginning of the contract period to equate the expected demand and supply of labor over the contract interval. The figure below describes the identification of the information sets on which each contracting sector acts. Arbitrarily, let sector 1 negotiate at t=τ and next at t=2τ, while sector 2 negotiates at t=a and next at t=a+τ. If a=0 or τ, then sector 2 negotiates a contract at the same time as sector 1 and thus negotiation is synchronized.



If $0 < a < \tau$, sectors negotiate contracts at different times and the contract intervals overlap. In this case, negotiation is staggered. When staggered negotiation occurs, the sector negotiating in the current period acts on information that was not available to the other sector previously negotiated.

The optimal choice of the negotiation pattern is determined in the sense of a symmetric noncooperative Nash solution. Given the negotiation date of the other sector, each contracting sector chooses the contract length (τ) and the timing of its negotiation date (a) so as to minimize the expected resource cost of contracting. This cost consists of the negotiation cost plus the expected cost of inefficiency that occurs whenever employment departs from the equilibrium level. Then, given the negotiation date of sector 1, the average of these costs for a contract of length τ for sector 2 is given by

$$\Psi_2 = \frac{1}{\tau}\{k[\int_{\tau}^{a+\tau} {}_aE(l_{2t}-\hat{l}_{2t})^2\,dt + \int_{a+\tau}^{2\tau} {}_{a+\tau}E(l_{2t}-\hat{l}_{2t})^2\,dt]+c\} \tag{10}$$

where $k=(1/\alpha_1)^2$. l_{2t} and $\hat{l}_{2t}$ are the actual level of employment given by eq. (7) and the equilibrium level of employment given by eq. (5), respectively. c is the fixed cost per negotiation. The expression ${}_aE(l_{2t}-\hat{l}_{2t})^2$ represents the mean-square discrepancy in employment that depends on the wage rate negotiated at $t=a$. Similarly, ${}_{a+\tau}E(l_{2t}-\hat{l}_{2t})^2$ is the mean-square discrepancy in employment that depends on the wage rate negotiated at $t=a+\tau$.

Aggregate supply depends on the timing of contract negotiation dates. It is assumed to be a geometrically weighted average of individual sector outputs. Based on the timing of contract negotiation, we derive aggregate supply from eq. (8). For the interval $\tau \leq t < a+\tau$, the expression is given by

$$\begin{aligned} y_t^S = {} & \frac{\phi(1-b)}{1+b\phi}p_t + \frac{1+\phi}{1+b\phi}u_t - \frac{\phi(1-b)}{2(1+b\phi)}({}_ap_t + {}_\tau p_t) \\ & + \frac{\phi}{2}[\frac{(1-b)}{1+b\phi} - \beta]({}_au_t + {}_\tau u_t) + \frac{\phi}{2}[\frac{(1-b)}{1+b\phi} - \beta]({}_az_{2t} + {}_\tau z_{2t}). \end{aligned} \tag{11}$$

A similar expression for aggregate supply can be obtained over the interval $a+\tau \leq t < 2\tau$:

$$\begin{aligned} y_t^S = {} & \frac{\phi(1-b)}{1+b\phi}p_t + \frac{1+\phi}{1+b\phi}u_t - \frac{\phi(1-b)}{2(1+b\phi)}({}_{a+\tau}p_t + {}_\tau p_t) \\ & + \frac{\phi}{2}[\frac{(1-b)}{1+b\phi} - \beta]({}_{a+\tau}u_t + {}_\tau u_t) + \frac{\phi}{2}[\frac{(1-b)}{1+b\phi} - \beta]({}_{a+\tau}z_{2t} + {}_\tau z_{2t}). \end{aligned} \tag{12}$$

The derivation of eqs. (11) and (12) is provided in the appendix. Equating aggregate demand, eq. (9), with aggregate supply, eq. (11), we have the price level for the interval $\tau \leq t < a+\tau$:

$$p_t = \frac{1+b\phi}{1+\phi} m_t - u_t + \frac{\phi(1-b)}{2(1+\phi)} ({}_a p_t + {}_\tau p_t)$$
$$+ \frac{\phi}{2(1+\phi)} [(1-b) - \beta(1+b\phi)]({}_a u_t + {}_\tau u_t) \tag{13}$$
$$- \frac{\phi}{2(1+\phi)} [(1-b) - \beta(1+b\phi)]({}_\tau z_{2t} - {}_a z_{2t}).$$

The price level is a function of ${}_a p_t$, ${}_\tau p_t$, and the realizations and expectations of all disturbances. Using the rational expectation's assumption, the expectation of price formed at $t=a$ is given by

$${}_a p_t = {}_a m_t - (1+\phi\beta){}_a u_t. \tag{14}$$

Substituting eq. (14) into eq. (13) and forming the conditional expectation on information available at $t=\tau$, we have

$${}_\tau p_t = \frac{2(1+b\phi)}{2+\phi(1+b)} {}_\tau m_t + \frac{\phi(1-b)}{2+\phi(1+b)} {}_a m_t - {}_\tau u_t - \frac{\phi\beta(1+\phi)}{2+\phi(1+b)} ({}_a u_t + {}_\tau u_t)$$
$$- \frac{\phi}{2+\phi(1+b)} [(1-b) - \beta(1+b\phi)]({}_\tau z_{2t} - {}_a z_{2t}). \tag{15}$$

Finally, substituting eqs. (14) and (15) into (13), we have the reduced form of the price level for any period $\tau \leq t < a+\tau$,

$$p_t = \frac{1+b\phi}{1+\phi} (m_t - {}_\tau m_t) + \frac{2(1+b\phi)}{2+\phi(1+b)} ({}_\tau m_t - {}_a m_t) - (u_t - {}_\tau u_t)$$
$$- \frac{(1+\phi)+(1+\phi\beta)(1+b\phi)}{2+\phi(1+b)} ({}_\tau u_t - {}_a u_t)$$
$$- \frac{\phi(1-b)-\phi\beta(1+b\phi)}{2+\phi(1+b)} ({}_\tau z_{2t} - {}_a z_{2t}) + {}_a m_t - (1+\phi\beta){}_a u_t. \tag{16}$$

An important implication of eq. (16) is that the price level over the interval $\tau \leq t < a+\tau$ is affected by $({}_\tau z_{2t} - {}_a z_{2t})$. If contracts are staggered, sector 1 observes the current relative shock at time $t=\tau$ and optimally adjusts its employment and output. This adjustment affects the price level, p_t.

Similarly, we can obtain the reduced-form for the price level for any period in the interval $a+\tau \leq t < 2\tau$,

$$
\begin{aligned}
p_t = {} & \frac{1+b\phi}{1+\phi}(m_t - {}_{a+\tau}m_t) + \frac{2(1+b\phi)}{2+\phi(1+b)}({}_{a+\tau}m_t - {}_{\tau}m_t) - (u_t - {}_{a+\tau}u_t) \\
& - \frac{(1+\phi)+(1+\phi\beta)(1+b\phi)}{2+\phi(1+b)}({}_{a+\tau}u_t - {}_{\tau}u_t) \\
& - \frac{\phi(1-b)-\phi\beta(1+b\phi)}{2+\phi(1+b)}({}_{a+\tau}z_{2t} - {}_{\tau}z_{2t}) + {}_{\tau}m_t - (1+\phi\beta)\,{}_{\tau}u_t.
\end{aligned} \tag{17}
$$

For sector 2, the discrepancy between equilibrium employment and actual employment over the interval $\tau \leq t < a+\tau$ is determined from eqs. (7) and (5) and is given by

$$
\begin{aligned}
l_{2t} - \hat{l}_{2t} = {} & \frac{\alpha_1(1-b)}{1+b\phi}[(p_t - {}_a p_t) + (u_t - {}_a u_t) + (z_{2t} - {}_a z_{2t})] \\
& - \alpha_1\beta[(u_t - {}_a u_t) + (z_{2t} - {}_a z_{2t})].
\end{aligned} \tag{18}
$$

Using eqs. (16) and (14) to form $p_t - {}_a p_t$ and also the properties of the exogenous stochastic processes, we have[3]

$$
\begin{aligned}
{}_aE(l_{2t} - \hat{l}_{2t})^2 = {} & (\alpha_1)^2\left[\left(\frac{(1-b)}{1+\phi}\right)^2\sigma_m^2 + \beta^2\sigma_u^2 + \left(\frac{(1-b)-\beta(1+b\phi)}{1+b\phi}\right)^2\sigma_z^2\right](t-\tau) \\
& + (\alpha_1)^2\left[\left(\frac{2(1-b)}{2+\phi+b\phi}\right)^2\sigma_m^2 + \left(\beta + \frac{(1-b)(\phi\beta)}{(1+b\phi)(2+\phi+b\phi)}\right)^2\sigma_u^2\right. \\
& \left. + \left(\frac{(1-b)-\beta(1+b\phi)}{1+b\phi}\right)^2\left(\frac{2+2b\phi}{2+\phi+b\phi}\right)^2\sigma_z^2\right](\tau-a).
\end{aligned} \tag{19}
$$

Similarly, we obtain the corresponding expression for the period $a+\tau \leq t < 2\tau$:

$$
\begin{aligned}
{}_{a+\tau}E(l_{2t} - \hat{l}_{2t})^2 = {} & (\alpha_1)^2\left[\left(\frac{1-b}{1+\phi}\right)^2\sigma_m^2 + \beta^2\sigma_u^2 + \left(\frac{(1-b)-\beta(1+b\phi)}{1+b\phi}\right)^2\sigma_z^2\right] \\
& \times (t-(a+\tau)).
\end{aligned} \tag{20}
$$

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[3] Suppose that a stochastic process, X(t), $0 \leq t < \infty$ satisfies the following properties:

(a) X(0) = 0.

(b) An increment, X(t)-X(s), has a normal distribution with mean 0 and variance σ^2(t-s) for s $\leq$ t.

(c) $X(t_2)-X(t_1)$, $X(t_3)-X(t_2)$, $\cdots$, $X(t_n)-X(t_{n-1})$ are independent for $t_1 \leq t_2 \leq \cdots t_n$.

This process is Brownian motion with parameter σ^2. Part (c) means that we assume that X(t+s)-X(s) is independent of the past; if we know X(s)=x_0, then no further knowledge of the values of X(d) for d<s has any effect on our knowledge of the probability law governing X(t+s)-X(s).

Substituting eqs. (19) and (20) into eq. (10) and integrating the resulting expression, the average resource cost for a contract of sector 2 is given by

$$\Psi_2 = \frac{V_1\tau}{2} + \frac{(V_1 - V_2)(a^2 - \tau a)}{\tau} + \frac{c}{\tau} \tag{21}$$

where

$$V_1 = \left(\frac{1-b}{1+\phi}\right)\sigma_m^2 + \beta^2\sigma_u^2 + \left[\frac{(1-b)-\beta(1+b\phi)}{1+b\phi}\right]^2\sigma_z^2$$

$$V_2 = \left[\frac{2(1-b)}{2+\phi+b\phi}\right]^2\sigma_m^2 + \beta^2\left[\frac{2(1+\phi)}{2+\phi+b\phi}\right]^2\sigma_u^2$$

$$+\left[\frac{(1-b)-\beta(1+b\phi)}{1+b\phi}\right]^2\left(\frac{2+2b\phi}{2+\phi+b\phi}\right)^2\sigma_z^2.$$

The derivation of eq. (21) is provided in the appendix.

3.1.1 Synchronized Negotiation (a=0 or a=τ)

In this case, sector 2 and sector 1 negotiate at the same point in time. First, differentiating eq. (21) with a=τ, we have the optimal contract length

$$\tau^* = \left(\frac{2c}{V_1}\right)^{\frac{1}{2}}. \tag{22}$$

This reveals that the optimal contract length decreases if there are increases in the variances, σ_u^2, σ_m^2, and σ_z^2 or the contracting cost decreases. That is, contract length shortens as the amount of uncertainty impinging on the economy increases. These results are similar to those obtained by Gray (1978), Fethke and Policano (1984), and Gray and Kandil (1991).

Under synchronized negotiation, the minimum resource cost of contracting is given by

$$\min \Psi_2^{syn} = (2cV_1)^{\frac{1}{2}}. \tag{23}$$

3.1.2 Staggered Negotiation (0<a<τ)

In this case, given the negotiation date of sector 1, the timing of contract negotiation dates, a, for sector 2 is endogenous. Differentiating eq. (21) with respect to a and setting the resulting expression equal to zero, we have $a^*=\tau/2$. This implies that the optimal strategy for sector 2 is to negotiate its wage contract at the midpoint of sector 1's contract. Substitution of a^* into eq. (21) and differentiation of the resulting expression yields

$$\tau^{**} = \left(\frac{4c}{V_1+V_2}\right)^{\frac{1}{2}}. \tag{24}$$

where τ^{**} is the optimal contract length under staggered negotiation and it is satisfied with the condition $V_1 - V_2 > 0$.[4]

Substituting a^* and eq. (25) into eq. (21), we have the minimum resource cost of contracting under staggered negotiation:

$$\min \Psi_2^{stag} = [4c/(V_1+V_2)]^{\frac{1}{2}}. \tag{25}$$

Not surprisingly, a comparison of eq. (22) and eq. (24) shows that $\tau^* < \tau^{**}$. If staggered negotiation is optimal, i. e., $V_1 - V_2 > 0$(relative shocks are dominant), it indicates that staggering can decrease the average resource cost by increasing the contract length. Intuitively, under staggering, contracting sectors gain by increasing the contract length in order that they obtain complete information of current (relative) shocks, because adjustments of negotiating sectors cause beneficial employment effects to other sectors previously negotiated. Therefore, the contract length under staggered negotiation becomes longer than that under synchronized negotiation.

3.1.3 The optimality of negotiation pattern

Consider a comparison of eq. (25) with eq. (23). Staggered negotiation will reduce the resource cost of contracting whenever $V_1 - V_2 > 0$, that is, when

$$\begin{aligned}
&\left(\frac{1-b}{1+\phi}\right)^2 \sigma_m^2 + \beta^2\sigma_u^2 + \left[\frac{(1-b)-\beta(1+b\phi)}{(1+b\phi)}\right]^2 \sigma_z^2 > \\
&\left[\frac{2(1-b)}{2+\phi+b\phi}\right]^2 \sigma_m^2 + \beta^2\left[\frac{2(1+\phi)}{2+\phi+b\phi}\right]^2 \sigma_u^2 \\
&+\left[\frac{(1-b)-\beta(1+b\phi)}{1+b\phi}\right]^2 \left[\frac{2+2b\phi}{2+\phi+b\phi}\right]^2 \sigma_z^2 .
\end{aligned} \tag{26}$$

[4] Second-order conditions for the minimization problem are $\frac{\partial^2\Psi_2^{stag}}{\partial a^2} = \frac{2(V_1-V_2)}{\tau} > 0$, $\frac{\partial^2\Psi_2^{stag}}{\partial\tau^2} = \frac{c}{\tau^3} + \frac{(V_1-V_2)a^2}{\tau^3} > 0$, $\frac{\partial\Psi_2^{stag}}{\partial a}\frac{\partial\Psi_2^{stag}}{\partial\tau} - \left(\frac{\partial\Psi_2^{stag}}{\partial a\partial\tau}\right)^2 = \frac{4c(V_1-V_2)}{\tau^2} > 0$.
These conditions are satisfied if $V_1 - V_2 > 0$.

However, if $V_1 - V_2 < 0$, d^* becomes zero (or τ) to produce the minimum resource cost of contracting. Therefore, synchronized negotiation is optimal whenever $V_1 - V_2 < 0$.

Consider the inequality (26). Since $\phi > 0$, in the presence of aggregate demand and/or supply shocks, $\sigma_m^2 > 0$ and/or $\sigma_u^2 > 0$, inequality (26) can not hold. This implies that synchronized negotiation is optimal to reduce the resource cost of contracting for each sector. However, in the presence of relative productivity shocks, $\sigma_z^2 > 0$, inequality (26) is true. In this case, staggering is optimal to reduce the resource cost of contracting for each sector. In other words, relative shocks create an incentive to stagger because negotiation by one sector transmits desirable employment effects into the other sector previously negotiated.[5]

When an economy faces both types of shocks at the same time, the optimality of the negotiation pattern depends on the relative importance of aggregate versus relative shocks that affect the economy.[6] As relative shocks weaken, the desirable employment effects become smaller. Thus, if disturbances to the economy derive primarily from aggregate shocks, the pattern of negotiation should be synchronized. Notice that, in a case of full indexation to the contracting sector's total revenue, i. e., b=1, the pattern of negotiation is not relevant on the type of economic shocks.

These results suggest that the revenue-indexing type of an economy subject to relatively important aggregate shocks choose short-term and synchronized negotiation to reduce the resource cost of contracting. These findings may be able to give economy-wide annual wage settlements in Japanese and Korean labor markets where the bonus system, a type of revenue-indexing contracts, is prevalent and aggregate shocks rather than relative shocks are dominate in the economy.[7] [8]

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5 Fethke and Policano (1986) show under a fixed wage contract that the role of sector-specific shocks depends on the number of contracting sectors. If there are a few large sectors and firms within a sector receive the same shocks, then sector-specific shocks create staggered negotiation. That is, by staggering, adjustment made by the contracting sector has beneficial effects to other sectors that currently locked into previously negotiated contracts. But, as the number of contracting sectors increases, the correlation between sector-specific shocks weakens and it becomes less likely that staggered negotiation will be optimal. This argument can be applied to our model.

6 Actually aggregate shocks consist of aggregate demand and productivity shocks. As shown in the results, both shocks have the same effects on determining the optimality of the negotiation pattern.

7 In Japan and Korea, bonuses are paid several times a year. The bonus is usually related to a firm or industry's performance, i. e., its profits or revenues. Freeman and Weitzman (1987) and Kim (1988) argue that bonuses in these countries operate a form of profit or revenue-indexing. The reason for using a revenue-indexing contract instead of a profit-sharing contract is to avoid our model's complexity. The results on both cases are consistent.

8 In fact, it is not easy to obtain the quantitative estimation of each type of economic shocks for a source of macroeconomic variability. Therefore, our conclusion is based on the fact that Japanese and Korean economies are prone to accommodate relatively aggregate shocks than sector-specific shocks. Actually, the changes of real activity in these economies have been considerably affected by common domestic and external shocks, e. g., fiscal and monetary shocks, and import price shocks.

3.2 The Criterion of the Variability of Aggregate Output

Negotiation patterns can affect the aggregate variability of output. Here, it is shown under a revenue-indexing contract that short-term and synchronized negotiation patterns enhance aggregate stability.

Using eqs. (11), (14), (15), and (16), aggregate output for the interval $\tau \leq t < a + \tau$ is given by

$$y_t^S = (m_t - {}_a m_t) + \frac{1+b\phi}{1+\phi}(m_t - {}_\tau m_t) + \frac{2(1+b\phi)}{2+\phi(1+b)}({}_\tau m_t - {}_a m_t)$$

$$-(u_t - {}_\tau u_t) - \frac{(1+\phi)+(1+\phi\beta)(1+b\phi)}{2+\phi(1+b)}({}_\tau u_t - {}_a u_t)$$

$$- \frac{\phi(1-b)-\phi\beta(1+b\phi)}{2+\phi(1+b)}({}_\tau z_{2t} - {}_a z_{2t}) - (1+\phi\beta){}_a u_t . \tag{27}$$

A similar expression can be developed for the interval $a+\tau \leq t < 2\tau$:

$$y_t^S = (m_t - {}_\tau m_t) + \frac{1+b\phi}{1+\phi}(m_t - {}_{a+\tau} m_t) + \frac{2(1+b\phi)}{2+\phi(1+b)}({}_{a+\tau} m_t - {}_\tau m_t)$$

$$-(u_t - {}_{a+\tau} u_t) - \frac{(1+\phi)+(1+\phi\beta)(1+b\phi)}{2+\phi(1+b)}({}_{a+\tau} u_t - {}_\tau u_t)$$

$$- \frac{\phi(1-b)-\phi\beta(1+b\phi)}{2+\phi(1+b)}({}_{a+\tau} z_{2t} - {}_\tau z_{2t}) - (1+\phi\beta){}_\tau u_t . \tag{28}$$

The variation in aggregate output is measured by the mean-square discrepancy between actual aggregate output and the equilibrium level of output, $y_t - \hat{y}_t$. In the case of staggered negotiation, the average of contracting costs in the criterion of aggregate output variability is given by

$$\Phi = \frac{1}{\tau}\{\int_\tau^{a+\tau} E_1(y_t - \hat{y}_t)^2\, dt + \int_{a+\tau}^{2\tau} E_2(y_t - \hat{y}_t)^2\, dt + c\}$$

$$= \frac{B_1\tau}{2} + \frac{(B_1 - 2B_2)(a^2 - a\tau)}{\tau} + \frac{c}{\tau} \tag{29}$$

where

$$B_1 = \left[\frac{\phi(1-b)}{1+\phi}\right]^2 \sigma_m^2 + (\phi\beta)^2 \sigma_u^2 > 0 \text{ and}$$

$$B_2 = \left[\frac{\phi(1-b)}{2+\phi+b\phi} \right]^2 \sigma_m^2 + \left[\frac{\phi\beta(1+\phi)}{2+\phi+b\phi} \right]^2 \sigma_u^2 + \left[\frac{(1+\phi)-\phi\beta(1+\phi)}{2+\phi+b\phi} \right]^2 \sigma_z^2 > 0.$$

The derivation of eq. (29) is provided in appendix. The expectation operator E_1 indicates, for the interval $\tau \leq t < a+\tau$, that sector 2's wage is based on information available at $t=a$, while sector 1's wage is based on information available at $t=\tau$. Similarly, for the interval $a+\tau \leq t < 2\tau$, E_2 indicates that sector 2's wage is based on information available $t=a+\tau$.

3.2.1 The optimality of the negotiation pattern

From eq. (29), if the contract length is optimally determined, the minimum costs of contracting under each negotiation are given by

$$\min \Phi^{syn} = (2\, B_1 c)^{\frac{1}{2}} \text{ and}$$

$$\min \Phi^{stag} = [4c/(B_1+2\, B_2)]^{\frac{1}{2}} \text{ if } \quad B_1-2\, B_2 > 0.$$

Notice that the optimal contract length under each negotiation pattern can be obtained as in the derivation of the previous section, and the optimal contract length under synchronized negotiation is shorter than that under staggered negotiation; $\tau^* < \tau^{**}$. By comparing the minimum costs of contracting under each negotiation, we know that the variation of aggregate output under synchronized negotiation is less than that under staggered negotiation. It indicates that short-term and synchronized negotiation under revenue-indexing contracts enhances aggregate stability from both aggregate and relative shocks because synchronizing reduces the contract length and, thus, the inertia of the wage rate. This result helps to explain that the labor market of countries such as Japan and Korea, where bonus payments, a revenue-indexing type of contracts, are prevalent, may flavor annual (i. e., relatively short-term) and synchronized wage settlements in the spring time to foster macroeconomic efficiency.

Ⅳ. SUMMARY AND CONCLUSIONS

This paper introduced a model of long-term contracts in which the choice of the negotiation pattern is endogenized and wage contracts follow revenue-indexing payments, and then examined the optimal pattern of contract negotiation.

Main results are as follows. First, synchronized negotiation under the revenue-indexing contract reduces the degree of wage inertia by decreasing the contract length and thus lowers the variation in aggregate output. Second, in the criterion of the resource cost of contracting, the decision of contracting sectors depends on the relative importance of aggregate versus relative shocks that affect the economy. Specifically, synchronized negotiation is optimal in the presence of aggregate shocks while staggered negotiation pattern is optimal in the presence of relative shocks. And in a case of full indexation to the contracting sector's total revenue, the optimality of the negotiation pattern does not depend on the type of economic shocks.

These results suggest that revenue-indexing contracts under certain conditions may favor a pattern of short-term and synchronized negotiations, and that they may enhance macroeconomic performance in the sense of lowering output and employment fluctuations. As shown in the Fethke and Policano model, a fixed-wage type of decentralized economies like the United State and Canada may be characterized by long-term and staggered contracts. However, a revenue-indexing type of centralized economies like Japan and Korea may choose short-term and synchronized negotiation patterns. These phenomena show in actual labor markets on these countries; the United States and Canada follow a type of staggered pattern with a three year periodicity, and Japan and Korea use annually economy-wide wage contracts in the spring time. Therefore, we conclude that the wage negotiation pattern of these countries is indeed efficiently determined by economic reasons.

APPENDIX

A. Derivation of (11) and (12)

Based on the timing of negotiation dates, we derive aggregate supply for the interval $\tau \leq t < a+\tau$. Using the assumption that $z_{1t} + z_{2t} = 0$, aggregate supply is given by

$$
\begin{aligned}
y_t^S &= \frac{1}{2} y_{1t}^S + \frac{1}{2} y_{2t}^S \\
&= u_t + \left(\frac{\phi}{2}\right)[(p_t - {}_\tau p_t) + (u_t - {}_\tau u_t) + (z_{1t} - {}_\tau z_{1t})] \\
&+ \left(\frac{\phi}{2}\right)[(p_t - {}_a p_t) + (u_t - {}_a u_t) + (z_{2t} - {}_a z_{2t})] \\
&= \phi[p_t + u_t - \frac{1}{2}({}_\tau p_t + {}_a p_t) - \frac{1}{2}({}_\tau u_t + {}_a u_t) + \frac{1}{2}({}_\tau z_{2t} + {}_a z_{2t})] + u_t .
\end{aligned}
$$

Similarly, aggregate supply for the interval $a+\tau \leq t < 2\tau$ can be obtained by

$$
y_t^S = u_t + \left(\frac{\phi}{2}\right)[(p_t - {}_\tau p_t) + (u_t - {}_\tau u_t) + (z_{1t} - {}_\tau z_{1t})]
$$

$$+\left(\frac{\phi}{2}\right)[(p_t - {}_{a+\tau}p_t) + (u_t - {}_{a+\tau}u_t) + (z_{2t} - {}_{a+\tau}z_{2t})].$$
$$= \phi[p_t + u_t - \frac{1}{2}({}_{a+\tau}p_t + {}_{\tau}p_t) - \frac{1}{2}({}_{a+\tau}u_t + {}_{\tau}u_t) + \frac{1}{2}({}_{\tau}z_{2t} - {}_{a+\tau}z_{2t})] + u_t.$$

B. Derivation of (21)

Substituting eqs. (19) and (20) into eq. (10) and integrating the resulting expression, the average resource cost for a contract of sector 2 is given by

$$\Psi_2 = \frac{1}{\tau}\{k[\int_{\tau}^{a+\tau}(V_1(t-\tau) + V_2(\tau-a))dt + \int_{a+\tau}^{2\tau} V_1(t-(a+\tau))dt] + c\}.$$

Calculating this, we have eq. (21):

$$\Psi_2 = \frac{1}{\tau}\Big[\frac{V_1(a+\tau)^2}{2} - V_1\tau(a+\tau) + V_2(\tau-a)(a+\tau) - \frac{V_1\tau^2}{2}$$
$$+ V_1\tau^2 - V_2(\tau-a)\tau + \frac{V_1(2\tau)^2}{2} - \frac{V_1(a+\tau)^2}{2} - V_1(a+\tau)2\tau + V_1(a+\tau)^2\Big] + \frac{c}{\tau}$$
$$= \left(\frac{V_1}{2}\right)\tau + \frac{(V_1 - V_2)(a^2 - \tau a)}{\tau} + \frac{c}{\tau}.$$

C. Derivation of eq. (29)

From eqs. (1) and (5), we have the equilibrium level of output :

$$\hat{y}_t^S = (1 + \phi\beta)\, u_t. \tag{C.1}$$

Using eqs. (27), (28), and (C. 1), we can obtain Φ:

$$\Phi = \frac{1}{\tau}\{\int_{\tau}^{a+\tau}(B_1(t-\tau) + B_2(\tau-a))dt$$
$$+ \int_{a+\tau}^{2\tau}(B_1(t-(a+\tau)) + B_2((a+\tau)-\tau)dt\} + \frac{c}{\tau}.$$

Calculating this, we have eq. (29):

$$\Phi = \Big[\frac{B_1(a+\tau)^2}{2} - B_1\tau(a+\tau) + B_2(\tau-a)(a+\tau) - \frac{B_1\tau^2}{2}$$
$$+ B_1\tau^2 - B_2(\tau-a)\tau + \frac{B_1(2\tau)^2}{2} - B_1(a+\tau)2\tau + B_2a(2\tau)$$
$$- \frac{B_1(a+\tau)^2}{2} - B_1(a+\tau)^2 - B_2a(a+\tau)\Big] + \frac{c}{\tau}$$
$$= \frac{B_1\tau}{2} + \frac{(B_1 - 2B_2)(a^2 - a\tau)}{\tau} + \frac{c}{\tau}.$$

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