AGGREGATE PATTERN OF TIME-DEPENDENT ADJUSTMENT RULES, I: A GAME-THEORETIC ANALYSIS OF STAGGERED VERSUS SYNCHRONISED WAGE SETTING*

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This paper studies the benefits of staggered wage setting in reducing strategic conflicts. It is shown that when wage setters interact strategically and dynamically, they prefer moving alternatingly, because by doing so, they are able to commit temporarily not to offset the effects of each other’s action. It is also shown that synchronisation represents a better arrangement when agents are able to coordinate. These results are consistent with the presence of non-synchronous and decentralised wage decisions in the United States and the United Kingdom and the presence of synchronous bargaining (in Shunto) and coordination in wage determination in Japan.

This paper examines two aspects of the labour market institutions – staggered versus synchronised wage setting, and coordinated/centralised versus non-cooperative decentralised wage adjustment – by relating them to the ability to ‘overcome the externalities involved in decentralised wage-setting’ (Layard et al. 1991, p. 483). While in general there may be different forms of externalities related to wage setting behaviour, this paper focuses on the macroeconomic aspect. A vivid description of this macroeconomic externality, as suggested by former UK Prime Minister Harold Wilson, is that under decentralised bargaining, ‘one man’s wage increase is another man’s price increase’ (cited in Layard et al., 1991, p. 483).

In the presence of externalities in the wage determination process, it is natural to go further by investigating what will result when wage setters take this factor into account and interact accordingly. This paper pursues this idea and provides a game-theoretic analysis of the two previously-mentioned labour market institutional features. While the relationship of macroeconomic externalities and these labour market institutions has been mentioned, implicitly or explicitly, in previous work such as Gordon (1982), Koshiro (1983), Jackman (1985) and Layard et al. (1991), this paper conducts a formal analysis of these issues.

In order to model these dynamic issues in a manageable way, certain stylised facts about the macroeconomic aspects of a wage setting process are relied on. The wage setting game considered in this paper captures that (a) the wage setters care about, among other things, their real wages, but they can only control directly nominal wages; (b) nominal wage is renewed at a fairly regular interval, i.e. the assumption of time-dependent wage adjustment rules is

* I am grateful to Andrew Caplin, Paul Chen, Steven Durlauf, Robert Hall, Denise Hare, Kenneth Judd, Lawrence Lau, Albert Ma, John Pencavel, anonymous referees and especially John Taylor for comments, suggestions and encouragement. Earlier versions of this paper have been presented at various places, and thanks are expressed to the helpful criticisms of the seminar participants.
reasonable; (c) an increase in the nominal wage of one sector will, other things being equal, cause negative externalities on the welfare of other agents; (d) the optimal reaction to an increase in nominal wages elsewhere in the economy is to have one's own nominal wage increased, i.e. strategic complementarity (instead of strategic substitutability) is present; and (e) the nominal wages are chosen in response to random shocks as well. Given the diverse and complicated labour market phenomena in different economies and the lack of consensus on what is the best theoretical framework, the validity of these stylised facts is surely not unlimited. Nevertheless, it is always helpful to make clear what the analysis is based on before it is conducted; moreover, the above stylised facts are reasonably consistent with a lot of economists' perception of the labour market at the macroeconomic level.

The main result of this paper is that there are benefits associated with staggered wage setting in a decentralised economy. As suggested in Maskin and Tirole (1987, 1988a, b), the nature of a game may differ with respect to the timing pattern; see also the discussion in Blanchard and Fischer (1989, p. 401). The intuition in the present context is that if the wage setters choose wages at the same time, then nominal wages increase (say, in response to an adverse price shock) by ‘too much’ for the usual strategic reason, yet the effect of utility maximising wage setting behaviour in any sector is offset by similar behaviour in other sectors. There is a better outcome with lower nominal wages in all sectors because the resulting aggregate demand is higher; however, this is not an equilibrium under synchronised wage adjustment since the individual wage setter would have an incentive to deviate given the behaviour in other sectors. On the other hand, if the timing pattern is non-synchronous, a wage setter choosing his current nominal wage does not have the above worry. Therefore, the increase in nominal wage does not have to be exceedingly high. Furthermore, such action, which lasts for some duration, will induce other agents to follow in the future since strategic complementarity exists. A staggered timing pattern, therefore, provides a mechanism for wage setters to obtain higher welfare when compared with a synchronous timing pattern.

This paper also shows that when coordination in wage determination is present, synchronisation represents a better arrangement. Since the potential problem of strategic conflicts is solved by cooperation, wage setters will not prefer the inefficient wage persistence associated with non-synchronisation. The results of this paper are consistent with the stylised observations that a non-synchronous timing pattern tends to appear in countries with decentralisation in the wage determination process (such as the United States and the United Kingdom) but synchronisation tends to appear in those with coordination in wage setting (such as Japan and some European countries). By relating to

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1 De Fraja (1993) considers a microeconomic/industry wage setting game, with real wage setting, positive externality effect, strategic complementarity and no random element. As mentioned in footnote 3 of that paper, the different mechanisms emphasised in a microeconomic wage setting model versus a macroeconomic one such as Jackman (1985) and this paper, which is developed independently of De Fraja (1993), are not necessarily in conflict. A discussion of a microeconomic versus macroeconomic wage setting game is given in Section II.D.

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strategic interaction and the possibility of coordination, a simple game-theoretic interpretation of the observed timing pattern of wage contracts in an economy is given – *synchronised wage setting is observed in countries with more centralised and coordinated bargaining, whereas staggered wage adjustment is present in countries with a more decentralised wage determination process* because cooperation is less likely to happen and thus wage setters interacting non-cooperatively will prefer non-synchronisation.

This paper is organised as follows. Section I describes the wage setting model. The timing pattern issues in the absence and presence of coordination are considered in Sections II and III respectively. The last section provides conclusions.

I. THE WAGE SETTING GAME: NEGATIVE EXTERNALITY AND STRATEGIC COMPLEMENTARITY

The infinite-horizon stationary economy consists of two identical sectors, A and B. While a model with many sectors may be more general, the assumption that there are just two players simplifies the exposition but still preserves the strategic aspect. The two wage setters are, therefore, not allowed to coordinate their actions, except in section III where the consequence of cooperation is considered. As mentioned above, the model used in this paper is specified to capture various stylised facts. First, time-dependent wage adjustment rules are assumed – contract length is exogenously fixed to be two periods, which is meant to capture the idea that wage is adjusted quite frequently, yet the frequency is still lower than that of the arrival of random shocks. In order to endogenise the timing pattern of wage contract renewal, wage setters are allowed to choose whether to have their contracts started at even-numbered or odd-numbered periods. The assumptions that the choice variables last for two periods and an agent’s only timing decision is to change the strategic variable in every odd or every even period represent the simplest way to endogenise the timing pattern. Ball and Cecchetti (1988) and Ball and Romer (1989) also adopt this approach.

The wage determination process is modelled as follows. Wage setters in a particular sector care about their real wages, but they can only control directly their nominal wages since the general price level is affected by the decisions

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2 The term ‘wage setter’ in this paper may be interpreted as a labour union if the union monopoly model is used (as in De Fraja, 1993), or a coalition of the employers and the employees of a sector such that their individual payoffs are determined by a bargaining process (as in Layard *et al.*, 1991, chapter 2) at a later stage.

3 Casual observation suggests that the assumption of time-dependent (instead of state-dependent) adjustment rules for wage contracts is justified. Blanchard and Fischer (1989, p. 413) discuss these two types of rules and explain why wage contracts are more likely to be time-dependent. Moreover, because of tractability, contract length is assumed in this paper to be fixed and independent of other structural parameters. Ideally, the choices of wage levels, contract length and contract renewal dates should be considered jointly in a single model which also incorporates, for example, the cost associated with contract renegotiation.

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elsewhere in the economy. At the time of choosing the nominal wage level, say at period $s$, wage setter $i (i = A, B)$ will maximise his intertemporal objective:

$$E_s \left[ \sum_{t=s}^{\infty} \beta^{t-s} U^i_t \right],$$

where

$$U^i_t = (x^i_t - p_t) [h - (x^i_t - p_t)] - g(m_t - p_t)^2,$$

and

$$p_t = \frac{x^A_t + x^B_t}{2} + e_t,$$

and $x^i_t =$ nominal wage (in log) of sector $i$ at $t$, $p_t =$ general price level (in log) at $t$, $m_t$ and $e_t$ are money and price (i.e. demand and supply) shocks at $t$, $\beta \in (0, 1)$ is the discount factor, and $g (0 < g < 1)$ and $h (h > 0)$ are constants. The operator $E_s$ represents the mathematical expectation of a variable, conditioned on the information set at time $s$. In this paper, all random shocks are assumed to be aggregate. The money and price shocks are assumed to be uncorrelated zero-mean random processes with variance $\sigma^2_m$ and $\sigma^2_e$ respectively. Substituting (3) into (2), it can be observed that the objective function depends on the nominal wages in both sectors and the two random shocks, i.e. $U^i_t = U^i(x^A_t, x^B_t, m_t, e_t)$ $i, j = A, B$ and $i \neq j$. The utility function is chosen to be quadratic for tractability.

The objective function (2) is similar, but not identical, to those used by Jackman (1985), Ball and Cecchetti (1988) and Ball and Romer (1989). One way to interpret the objective function (2) is that the utility of a wage setter is a function of real wage and employment (or equivalently relative price and product demand in the model of producer-consumers). Moreover, the specification of the second term on the right hand side of (2) is to capture the presence of interdependence, such as the aggregate demand externality when the underlying industrial structure is monopolistic competition (Rotemberg, 1982).

The following function:

$$U^i_t = h(x^i_t - p_t) - f(x^i_t - p_t)^2 + d(x^i_t - p_t)(m_t - p_t) - g(m_t - p_t)^2,$$

where parameters $d, f, g$ and $h$ are non-negative, nests the various objective functions used by Jackman (1985), Ball and Cecchetti (1988), Ball and Romer (1989) and this paper. According to footnote 12, parameter $g$ has to be non-zero for the problem in Section III to be well-defined. On the other hand, footnote 7 makes clear that parameter $h$ has to be non-zero in order to have the presence of externality effect in the relevant region; when $h > 0$, there is a negative externality around the Nash equilibrium, which is consistent with observed wage setting phenomenon at the macro level. The objective function (2) can be regarded as the simplest specification of (2') satisfying the above restrictions, with $d = 0$ and $f$ normalised to be 1. Moreover, the restriction $g < 1$ is used to ensure the presence of strategic complementarity.

In Jackman (1985), the union's objective is specified to be a Stone–Geary function of real wage and employment, with the labour demand modelled, after Rotemberg (1982), as a function of its own real wage and real money balances. When there is equal preference for wage stability and employment stability, and when the 'fallback' levels of real wage and employment are normalised to be zero, then the objective function is equivalent to (2') in footnote 4 with $g = 0$ and $d$ normalised to be 1. Moreover, the money supply process is specified to be deterministic and there is no price shock. In the model of producer-consumers used in Ball and Cecchetti (1988) and Ball and Romer (1989), both aggregate and sector-specific shocks are present. If sector-specific shock is absent, the objective functions in both papers will be identical, and equivalent to (2') with $h = 0, d^2 = 4g$ and $f$ normalised to be 1. In these two papers, the objective function is interpreted as a quadratic approximation around the utility maximising level, and the aggregate shock is a monetary shock.
I996] STAGGERED VERSUS SYNCHRONISED WAGE SETTING 1649

1982; Blanchard, 1986; Blanchard and Kiyotaki, 1987). In a sense, equation (2) is only a 'reduced form' specification, intended to capture some stylised facts without a more detailed modelling of the objective functions of individual employers and employees, and their interaction. This simplification makes the model more tractable and is consistent with the focus of this paper. The present paper emphasises the interaction across sectors (i.e. wage-wage spiral and its prevention) instead of within a sector (i.e. between the employers and the employees of a particular firm or industry), and therefore adopts a model focusing on the strategic interaction between two identical wage setters, rather than among four heterogenous players.

In this economic environment, the choice of nominal wage in one sector is linked to the welfare in another sector through the price level, as observed in (3). Specifically, a higher nominal wage level in one sector will lead to a higher general price level and, and therefore, other things being equal, a lower real wage (and therefore a higher labour demand) in the other sector and a decrease in real money balances (and lower aggregate demand). In principle, the overall externality effect may be positive or negative. Regarding the macroeconomic externalities emphasised in this paper, it seems to be more plausible for an increase in nominal wage in one sector to have an adverse effect on others through the general price level (see Jackman (1985) for example). As a result, the objective function in this paper is chosen such that the externality effect (around the equilibrium) is negative.

Finally, the sequence of events in a period is assumed to happen in the following manner. The random shocks are realised at the very beginning of a period. If the wage contract of a sector just expires, a new nominal wage is set for the next two periods. All information is perfect and the only uncertainty is represented by the random shocks. The information set at (the beginning of) a period $t$ is defined such that it consists of the sequence of all choice variables up to the previous period and the sequence of the realised shocks up to the current period.

II. THE ECONOMY WITH STRATEGIC AND DYNAMIC INTERACTION

When the wage setters interact noncooperatively, the outcome of the economy is first derived under each of the two possible arrangements respectively: non-synchronisation is considered in Section II.A and synchronisation in Section II.B. In light of these results, Section II.C compares these two outcomes and Section II.D discusses the intuition and implications by relating to existing literature.

II.A. Behaviour under Staggered Wage Setting

With non-synchronisation, it is assumed that wage setter $A$ ($B$) chooses the wage at every even (odd) period, which lasts for two periods. Therefore, $x^A_{2k+1} = x^A_{2k}$ and $x^B_{2k} = x^B_{2k-1}$. To simplify notation, the superscript referring to the wage setting group is introduced explicitly only when it is necessary, and

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$x^A_{2k} (x^B_{2k+1})$ is simply represented by $x_{2k} (x_{2k+1})$. Each wage setter is assumed to choose a Markov strategy, i.e. an action dependent on the state variables only. In the present model, each player's strategy is a function of his opponent's most recent wage and the realisation of the two random shocks, which are the only variables in the current information set affecting the player's objective function. Under the restriction of Markov strategy, the reaction functions are of the following form: $x_{2k} = R_A(x_{2k-1}; m_{2k}, e_{2k})$ and $x_{2k+1} = R_B(x_{2k}; m_{2k+1}, e_{2k+1})$ where $R_A(\cdot, \cdot, \cdot)$ and $R_B(\cdot, \cdot, \cdot)$ are time-invariant functions. A more detailed discussion of alternating-move dynamic games and related issues such as the Markov strategy is found in Maskin and Tirole (1987, 1988a, b).

The equilibrium in this economy shall include, for each player, a reaction function specifying his action as a function of the state variables, and an expectations formation mechanism concerning future random variables. The equilibrium concept adopted here is a Markov perfect equilibrium (MPE). In the present context, a MPE is defined as: a Markov reaction function pair \{$R_A(x^A_{-1}; m, e)$, $R_B(x^B_1; m, e)$\} constitutes a MPE if the reaction function of player $i$ ($i = A, B$) maximises the expected value of his intertemporal utility given his opponent's reaction function and given that expectations of future random variables are formed according to mathematical expectations conditioned on the current information set. It can be seen that the equilibrium is time consistent.

For this alternating-move dynamic game with random shocks, it can be shown that the equilibrium reaction function is given by:

$$x_t = R_i(x_{t-1}; m_t, e_t) = \frac{(1 + \beta) bh}{(1 - g)(1 + \beta b)} + bx_{t-1} + \frac{2gb}{1 - g} m_t + 2be_t,$$

where $i = A$ (if $t = 2k$) or $B$ (if $t = 2k+1$), and $b \in (0, 1)$ is given by:

$$b = \frac{(1 + \beta)(1 + g) - \sqrt{[(1 - \beta)^2 (1 + g)^2 + 16\beta g]}}{2\beta(1 - g)}.$$

(All detailed derivations are contained in an Appendix available from the author upon request.)

II.B. Behaviour under Synchronous Wage Setting

The outcome of the economy with synchronous wage contracts is now derived. All structure is the same as in Section II.A except that both wage setters choose their wages at the same time. This arrangement, together with the fact that there is no state variable in the model, implies that the problem can be broken down into a series of disjoint two-period problems. Without loss of generality,

$^6$ Since this paper intends to highlight the role of staggered timing pattern to solve the strategic conflicts of wage adjustment, the comparison is with a synchronous timing pattern. To concentrate on the roles of different timing patterns, other possible mechanisms such as those discussed in the supergame literature are not examined. Therefore, the possibility of having actions contingent on payoff-irrelevant history is not considered.

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it is assumed that they set wages at even periods. At time $2k$, after observing the realisation of the random shocks and taking the opponent's decision as given, player $i$ ($i = A, B$) chooses $x_{2k}^i$ to maximise the expected value of $(U_k^i + \beta U_{2k+1}^i)$. It is straightforward to show that the (symmetric) Nash equilibrium is given by:

$$x_{2k}^A = x_{2k}^B = \frac{(1 + \beta)h + 2gm_{2k} + 2(1 - g)e_{2k}}{2(1 + \beta)g}.$$  \hspace{1cm} (6)

II.C. Pareto Optimal Pattern of Wage Adjustment

This section examines the conditions under which a non-synchronous timing pattern provides an overall benefit to the wage setters. The analysis of Pareto optimal timing pattern is closely related to that of equilibrium timing pattern. In the simplest interpretation (Ball and Romer, 1989, p. 186), one may think of an extended game in which the players choose irreversibly whether to move at even or odd periods, before the wage setting stage-game begins; moreover, it is assumed that a coin is tossed to decide who makes the timing decision first. In this case, it is not difficult to see the connection between Pareto optimal timing pattern of the wage setting game and the equilibrium pattern of the extended game. Suppose the players are better off under non-synchronisation in the wage setting game, then it will not be an equilibrium for both players to move at even (odd) periods since that if the first player moves at even (odd) periods, the other would optimally choose to move at odd (even) periods. On the other hand, in discussing endogenous timing issues in their various papers, Maskin and Tirole consider more realistic but also more complicated alternatives such as allowing the players the choice in moving from one cohort to another by waiting an extra period. While in general, the conclusions regarding the equilibrium timing pattern may depend on auxiliary assumptions of the dynamic model (such as whether the players are allowed to change the duration of a wage contract and how the initial timing pattern is assigned), it appears from Maskin and Tirole (1987, 1988a, b), De Fraja (1993) and Lau (1996) that in most cases, the Pareto optimal timing pattern is also the equilibrium outcome. Therefore, this paper simply conducts an analysis on the merits of different patterns of wage adjustment without considering the detailed and technical issues related to the modelling of equilibrium timing pattern.

For a deterministic dynamic game, the criterion of steady state payoff is usually used to compare the benefits of different timing patterns. Such a criterion can be extended to a dynamic game with stochastic shocks. With the presence of random elements, the payoffs in the first and second halves of a contract may

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7 If the more general objective function ($g'$) in footnote 4 is used, the first order condition for each player in this game is given by: $x_{2k}^i = [(1 + \beta)(f-g)x_{2k}^i + (1 + \beta)h + (d+2g)m_{2k} + 2(f-g)e_{2k}]/[(1 + \beta)(d+f+g)]$. In order for the problem to be well-defined, either a non-zero $d$ or a non-zero $g$ is required. Moreover, the externality effect ($U_j^i$) at the Nash equilibrium for the deterministic version (in which the random shocks are absent) is given by $-2gh/(d+2g)$. Therefore, if $d = 0$, the externality effect is negative when $h \neq 0$; if $d \neq 0$, the externality effect is negative when $h + g \neq 0$.

8 Further discussion regarding why the Pareto superior timing pattern is likely to be the equilibrium outcome can be found in Maskin and Tirole (1987, p. 963).
differ even in the stochastic steady state. For the wage setting game of this paper, the unconditional expected utility of a wage setter over a contract (i.e. the expectation is taken with respect to all possible initial states) is used to compare the benefits of synchronisation versus nonsynchronisation. Equal weight is given to the utility level in the first and second periods of the contract.\footnote{The reason for using the undiscounted sum of payoff over a contract at the steady state as the criterion is to prevent the arbitrariness of assigning a higher weight on either the first or second half of a contract. (This is consistent with, say, the interpretation that a wage setter is not certain whether he or his rival makes the timing decision first, before the tossing of a coin.) By interpreting this payoff to be the average over the two possibilities of beginning with either the first or second half of a contract, the apparent inconsistency between the objective functions used in Sections II.A and II.B (with discounting) and the criterion used here (without discounting) is reconciled. When there is no stochastic shock, this criterion becomes the steady state payoff used in Maskin and Tirole (1987).}

Define $U_{STAG}$ and $U_{SYNC}$ as the expected utility level of a player over a contract under staggered and synchronous timing patterns respectively. Under a staggered timing pattern, define $U_{STAG,1}$ and $U_{STAG,2}$ as the unconditional expectation of the utility level of a (representative) player in the first and second periods of a contract respectively; the sum of these two terms is $U_{STAG}$. Direct substitution yields either $U_{STAG,1}$ or $U_{STAG,2}$ as a linear function of $\sigma_m^2$ and $\sigma_e^2$ with a negative intercept. Moreover, $U_{STAG,1} > U_{STAG,2}$ since in the second period of a contract, the player’s wage has already been chosen and cannot respond to the current random shocks. Similarly, define $U_{SYNC,1}$ and $U_{SYNC,2}$ as the unconditional expectation of a player’s utility in the first and second periods of a contract respectively, under synchronisation. The sum of these two terms is $U_{SYNC}$. Substitution also yields either $U_{SYNC,1}$ or $U_{SYNC,2}$ as a function of $\sigma_m^2$ and $\sigma_e^2$ with a negative intercept, and a player’s steady state payoff under synchronisation is higher in the first than the second period.

The difference of $U_{STAG}$ and $U_{SYNC}$ indicates the relative merits of the two arrangements, and yields:

$$U_{STAG} - U_{SYNC} = \frac{2\beta b}{1 + \beta b} \left[ \frac{1}{2g} + \frac{(1 + \beta) b}{(1 - g)(1 + \beta b)(1 - b)} \right] h^2 + \left[ \frac{-2\beta g(1 + \beta - \beta b)}{(1 + \beta)^2} \right] \sigma_m^2 + \left[ \frac{2(1 - g)(1 + \beta g)(1 + \beta - \beta b)}{(1 + \beta)^2 g} \right] \sigma_e^2. \tag{7}$$

The coefficients of $h^2$ and $\sigma_m^2$ in (7) are positive and that of $\sigma_e^2$ is negative. When there is no random shock in the model (i.e. $\sigma_m^2 = \sigma_e^2 = 0$), $U_{STAG}$ is always higher than $U_{SYNC}$ for all $0 < \beta < 1$ and $0 < g < 1$. On the other hand, the difference of $U_{STAG}$ and $U_{SYNC}$ is increasing in the variance of the price shock but is decreasing in the variance of the money shock.

II.D. Intuition and Implications

Equation (7) suggests that there are two factors influencing the merits of staggered wage setting as compared to synchronisation: the importance of strategic dependence and that of the random shocks. Regarding the first factor,
staggered wage setting provides a mechanism for the players to obtain higher payoffs. The intuition behind this result lies in the interdependence between the wage setters. When they set wages at the same time, the equilibrium outcome is given by equation (6). In response to a positive money or price shock, each wage setter has an incentive to set a higher nominal wage to compensate for the loss. With synchronisation, each wage setter’s action is offset by his opponent. However, wage increases in all sectors will lead to a higher price level, and therefore both wage setters suffer due to lower real money balances.

Under staggered wage adjustment, when a wage setter chooses the nominal wage, he need not worry about his action being nullified by his opponent, at least temporarily. Therefore, the increase in nominal wage will be less than that under synchronisation. As a result, such an action has both beneficial and adverse effects on his opponents which is locked into previously negotiated contracts. The adverse effect operates through the decrease in his opponent’s real wage, while the beneficial effect works through the not-so-high price level which both wage setters prefer. Although the overall externality effect is still negative, as assumed, the beneficial effect associated with this timing pattern allows the agents to sustain a better outcome in a non-cooperative setting when compared to synchronisation.

To study the determinants of the aggregate patterns of time-dependent adjustment rules when agents interact strategically, Lau (1996) pursues the interpretation (as suggested in Tirole, 1988, p. 343) of an alternating-move dynamic game as a series of Stackelberg games in which each player alternatingly and symmetrically assumes the roles of Stackelberg ‘leader’ and ‘follower’. Since the leader of a Stackelberg game always has a higher (or at least identical) payoff when compared with his payoff in a simultaneous-move game, the effect of the leader’s action on the follower is crucial in determining the better timing pattern. Applying the above idea to the present macroeconomic wage setting game with negative externality and strategic complementarity, player i knows that his payoff will be increased if his rival’s nominal wage is reduced (because of negative externality); to induce his opponent to do that, player i decreases his nominal wage since strategic complementarity is present, i.e. a decrease in nominal wage of sector i will decrease the marginal payoff of player j ($U_j' = (1 - g)/2 > 0$ for the game in this paper). This explains why a wage setter would like to reduce his nominal wage from the Nash equilibrium level. On the other hand, because of negative externality, a decrease in the nominal wage of a player (with the intention of raising his own payoff) will have the effect of benefiting his rival as well. Therefore, by moving alternatingly, each wage setter has a higher payoff than its Nash equilibrium counterpart, both in the first and second halves of a contract when he is a ‘follower’ and ‘leader’ respectively.

On the other hand, in the microeconomic wage setting game of De Fraja (1993) which exhibits positive externality and strategic complementarity, a player knows that his payoff will be increased if his rival’s strategic variable, real wage, is increased (because of positive externality); to induce his opponent...
to do that, the player increases his real wage since strategic complementarity is present. This explains why a player would like to increase his real wage from the Nash equilibrium level. A consequence of such an increase in real wage is the higher payoff of his rival as well because of positive externality. Therefore, the similarity of the wage setting games in De Fraja (1993) and this paper, of which non-synchronisation is the better outcome, is traced to the presence of strategic complementarity. On the other hand, the difference of these two games is traced to positive versus negative externalities: the higher steady state real wage under nonsynchronisation than that under synchronisation for the microeconomic wage setting game in De Fraja (1993) is due to positive externality, but the lower steady state nominal wage under non-synchronisation than that under synchronisation for the macroeconomic wage setting game in this paper is due to negative externality.

Regarding the effects associated with the response to the random shocks in a decentralised economy, the above results show that while there are persistent effects of the shocks under nonsynchronisation, such phenomena may be relatively efficient or inefficient when compared to synchronised wage setting, depending on the major source of shocks. Combining both the strategic benefits (i.e. the first term on the right hand side of (7)) and the effects of the two shocks, it can be concluded that nonsynchronisation will provide an overall benefit when the money shock is not exceedingly important. In particular, when there are only aggregate price shocks in the above model, staggered wage setting is unambiguously the better outcome even in the absence of sector-specific shock.

The above results also contribute to the microfoundation literature on staggered decisions in a decentralised economy. This institutional feature is assumed in a number of 'new Keynesian' macroeconomic models (Fischer, 1977; Taylor, 1979, 1980; Blanchard, 1986). In earlier work on endogenising this timing pattern, a necessary condition for non-synchronisation to become an equilibrium is the presence of sector specific shocks. In Fethke and Policano (1984, 1986), staggered contracts allow the transmission of an employment effect, through the aggregate price level, from the sector signing a new contract into the 'lock-in' sector. The externality is beneficial with relative productivity shocks (which net out across different sectors), but adverse with aggregate shocks affecting all sectors uniformly. Therefore, nonsynchronisation will be the equilibrium outcome only when sector-specific shock is more significant. In Ball and Romer (1989), it is assumed that half of the firms receive idiosyncratic shocks every even period and half every odd period. Therefore, staggered price setting has a natural advantage in permitting rapid adjustment to firm-specific shocks. However, there is a disadvantage of price shocks. The analysis in Section III suggests that when the problem of strategic conflicts is solved by coordination (and, as a result, nominal wages react positively to money shocks but negatively to price shocks), the presence of stochastic shocks causes inefficiency in non-synchronisation. Together with the results in this section that wages react positively to both shocks when cooperation is absent, it may be concluded that price shocks pose a bigger problem of strategic conflicts than money shocks. As a consequence, the benefits provided by staggered wage adjustment over synchronisation in a decentralised economy is higher for price shocks.

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inertia associated with it. Non-synchronisation will not be an equilibrium when there is no idiosyncratic shock. In Ball and Cecchetti (1988), there is imperfect information – each firm’s desired price depends on a firm-specific and an aggregate demand shock, but it only observes their sum. With a staggered timing pattern, firms gain information by observing prices set by other firms. When there is only aggregate shock, information is perfect and the signal extraction problem disappears. Thus, synchronisation will be the equilibrium. Ball and Cecchetti (1988) and Ball and Romer (1989) conjecture that in models where agents are identical and all shocks are aggregate, if the timing decision is endogenous, then synchronisation will be the equilibrium outcome. They also demonstrate it formally for the Blanchard–Kiyotaki model (Blanchard, 1986; Blanchard and Kiyotaki, 1987).

A common feature of these microfoundation papers is that the choices of individual agents, in terms of the contract renewal dates and the price or wage levels, will affect the welfare of other agents in the economy. The presence of externality is a necessary condition for the pattern of wage or price changes to be a relevant issue. However, in these papers, even though an agent’s welfare depends on the level of these variables set by other agents, strategic interaction among the agents only appears in the choice of contract renewal dates but not in the choice of the price or wage level, presumably because of the assumption of sufficiently many price or wage setters in a particular sector.

A distinguishing feature of this paper is that the wage setters take their interdependence into account and interact strategically. By incorporating strategic interaction in the choice of nominal wages, this paper is able to show that in a model with identical agents and aggregate random shocks, synchronisation can be dominated. Although staggered wage setting leads to persistent effects of the aggregate shocks which may be inefficient (as demonstrated in this paper and others), this timing pattern can still provide an overall advantage in the presence of strategic conflicts. The presence of idiosyncratic disturbances is not necessary for non-synchronisation to be the preferred outcome.

III. THE ECONOMY WITH COORDINATION

Section II assumes a non-cooperative environment to capture wage setting behaviour in a decentralised economy. To account for the possibility of coordination, this section derives the timing pattern when the two wage setters jointly maximise their payoffs. The expected payoff of a player under synchronisation and non-synchronisation is calculated, and then compared to determine which regime will offer a higher benefit.

As before, it suffices to consider a series of two-period problems under synchronisation. After the random shocks are observed at the beginning of period $2k$, the wages $x^A_{2k}$ and $x^B_{2k}$ are jointly chosen to maximise the expected

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1 This section concentrates on the implications of coordination among the wage setters and simply assumes, without further examination, the presence of mechanisms that make cooperation possible.

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value of \( U^A_{2k} + U^B_{2k} + \beta(U^A_{2k+1} + U^B_{2k+1}) \). It is straightforward to show that the optimal choices are given by:\(^{12}\)

\[
x^A_{2k} = x^B_{2k} = \frac{m_{2k} - \epsilon_{2k}}{1 + \beta}.
\]

Substitution yields \( U^{(C)}_{SYNC} \), the expected utility of a player over a contract under cooperation and synchronous contracts, as a function of \( \sigma^2_m \) and \( \sigma^2_\epsilon \) with no intercept. Comparing (8) with (6), one can discover that the non-stochastic part of each player's wage under cooperation is lower than that when they do not cooperate;\(^{13}\) moreover, the wage setters respond negatively to the price shock under cooperation, but positively when they interact non-cooperatively.

Next, the cooperative outcome under non-synchronisation is considered. In this case, the problem is equivalent to selecting a sequence of contingent plans \( \{x_t(x_{t-1}; m_t, \epsilon_t), t = 0, 1, \ldots, \infty\} \) to maximise

\[
\sum_{t=0}^{\infty} \beta^t E_0(U_t^A + U_t^B).
\]

The solution is given by:

\[
x_t = bx_{t-1} + \frac{2gb}{1-g}(m_t - \epsilon_t),
\]

where the coefficient \( b \) is the same as that in equation (5). Note that the nominal wage reacts negatively to price shocks under staggered and coordinated wage setting. This is similar to synchronisation with cooperation, but different from non-synchronisation with no coordination. Substitution also yields \( U^{(C)}_{STAG} \), the expected utility of a player over a contract under cooperation and non-synchronisation, as a function of \( \sigma^2_m \) and \( \sigma^2_\epsilon \) with no intercept.

The algebra for the comparison of the two timing patterns under cooperation turns out to be similar as above and

\[
U^{(C)}_{SYNC} - U^{(C)}_{STAG} = \frac{2\beta g(1 + \beta - \beta b) b}{(1 + \beta)^2} (\sigma^2_m + \sigma^2_\epsilon).
\]

The coefficients of \( (\sigma^2_m + \sigma^2_\epsilon) \) in equation (11) are positive for all \( 0 < \beta < 1 \) and \( 0 < g < 1 \). Therefore, \( U^{(C)}_{SYNC} \) is equal to \( U^{(C)}_{STAG} \) in the absence of random shocks but is strictly higher than \( U^{(C)}_{STAG} \) in its presence.\(^{14}\) When there is no random shock, which timing pattern is better depends on its contribution to solve the strategic conflicts between the players. Since this potential problem

\[^{12}\] If the more general objective function (2') in footnote \(^4\) is used, the two first order conditions are given by \( x^4_{2k} = [(1 + \beta)(f-g)x^4_{2k} + 2gm_{2k} + (d-2g)\epsilon_{2k})]/[(1 + \beta)(f+g)]. \) The coefficient \( g \) has to be non-zero for this problem to be well-defined.

\[^{13}\] This is also seen from the fact that there is no intercept in \( U^{(C)}_{SYNC} \) but a negative intercept in \( U^{(C)}_{SYNC} \).

\[^{14}\] A corollary of this result is that \( U^{(C)}_{SYNC} > U^{(C)}_{STAG} \) implying synchronisation under cooperation represents a better pattern than non-synchronisation without cooperation. The reason is that \( U^{(C)}_{STAG} > U^{(C)}_{STAG} \), which holds because equation (4) is feasible, but not optimal, in maximising (9). This result could be regarded as an answer to Fender's (1985, p. 381) comment that 'a compelling case has not been made for more coordination of wage changes.'
associated with strategic interaction has already been solved by cooperation between the players, they are indifferent between the two timing patterns (as demonstrated by the absence of a constant term in both equations (8) and (10)). On the other hand, there is an inefficiency associated with the wage inertia caused by non-synchronisation in the present model, which is consistent with the results in the previously-mentioned microfoundation papers. Therefore, with the presence of either money or price shock, synchronisation will be preferred when the wage setters are able to cooperate.\textsuperscript{15}

This result is consistent with the stylised facts in Japan. The wage negotiation pattern in Japan is highly synchronous since many labour contracts are negotiated in the Shunto (Spring Offensive); moreover, there is evidence that different sectors coordinate in setting wages. As an example, the unions in the four metal industries coordinated to hold down wage increases in the mid-seventies, after realising the significance of the oil crisis to the economy (Koshiro, 1983, pp. 215, 219).

\textbf{IV. CONCLUSION}

The paper studies two aspects of the labour market institutions – staggered versus synchronised wage setting, and coordinated/centralised versus non-cooperative decentralised wage adjustment. The fundamental element in the analysis is the presence of strategic conflicts among the wage setters. Specifically, the model exhibits negative externality, strategic complementarity and the presence of stochastic shocks to capture various relevant aspects of a wage setting mechanism. To solve the strategic conflicts in this economy, this paper analyses two possible mechanisms – timing pattern of wage changes and cooperation. The main result of this paper is that staggered wage setting is preferred when the agents interact strategically and dynamically. By choosing wages at different times, the action of each wage setter will not be offset by that of his opponent. Therefore, a player does not need to set a very high nominal wage and this action further induces his opponent to follow in the future.\textsuperscript{16} As a result, both players obtain higher payoffs.

This paper also examines the optimal timing pattern when coordination is possible. Since the strategic conflicts can be solved by cooperation, whether a staggered or synchronous timing pattern is preferred depends on the behaviour

\textsuperscript{15} Sheshinski and Weiss (1992) show that in the presence of strategic complementarity, non-synchronised decision is unlikely to be optimal in a model of multiproduct monopoly, which may be interpreted as the cooperative outcome of a duopoly game. Although consistent with their results, the reason for non-synchronisation to be inferior in the present context is the inefficiency associated with the persistent effects of the random shocks.

\textsuperscript{16} As explained in Section II.D, the lower (steady state) nominal wage under non-synchronisation is due to the assumption of negative (instead of positive) externalities in the wage setting process. Note that while decentralised and staggered bargaining leads to lower wage settlements than decentralised and synchronised bargaining (compare equations (4) and (6)), decentralised and staggered bargaining leads to higher wage settlements than coordinated and synchronised bargaining (compare equations (4) and (8)). Since it is optimal to have nonsynchronisation under decentralised wage adjustment but synchronisation under coordinated wage setting, the results of this paper could be regarded as providing an alternative explanation to the phenomenon mentioned in De Fraja (1993, p. 1521) that 'staggered bargaining leads to higher wage settlements than simultaneous bargaining.'

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of the random shocks in each regime. Synchronisation is preferred because the persistent effect of the random shocks under nonsynchronisation is inefficient. The results of this paper are consistent with the stylised facts of staggered and non-cooperative wage setting in the United States and United Kingdom on one hand, and the synchronised and coordinated wage negotiation in Japan on the other.

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Date of receipt of final typescript: March 1996

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