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THE SENSITIVITY OF QUARTERLY MODELS OF WAGE DETERMINATION TO AGGREGATION ASSUMPTIONS

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In the continuing controversy over the concept of a stable Phillips curve, the institutional features of the labour market have been largely ignored. As Tobin points out in his A.E.A. presidential address,

> "Keynes emphasized the institutional fact that wages are bargained and set in the monetary unit of account. Money wage rates are, to use an unKeynesian term, "administered prices". That is, they are not set and reset in daily auctions but posted and fixed for finite periods of time" [27, p. 3].

While Tobin goes on to discuss the theoretical implications of such institutional arrangements, the implications for aggregation and estimation may be of equal importance. The proliferation of collective bargaining and the development of longer-term contractual agreements have presumably increased the incidence of such discontinuities in wage adjustments (i.e., the phenomenon that wage-rate changes typically occur at discrete points in time and are "locked-in" place until a subsequent date). Consequently, the specification of such discontinuities is crucial for the correct temporal specification of the explanatory variables and for the implementation of an efficient estimation technique. Failure to analyze such discontinuities is particularly acute in quarterly time series research where highly restrictive (and unrealistic) assumptions are imposed in the aggregation process and severe estimation problems are ignored.

The purposes of this paper are essentially twofold: (1) to present an analytical framework for the empirical investigation of these institutional labour market features and (2) to present some empirical results demonstrating the gravity of the problem. We begin with a brief review of the aggregation assumptions imposed in the conventional overlapping annual wage-change (OAWC) model employed in quarterly wage research.[1] Such assumptions entail moving-average transformations for all explanatory variables as well as for the error term. Given this moving average property of the error term, the familiar conditions for the classical linear model are not fulfilled, and the "usual" least squares estimators are inefficient relative to Aitken's estimation procedure of generalized least squares.

In Section II the critical aggregation assumptions in the specification of the OAWC model are shown to be empirically "dubious". Such findings may seriously jeopardize the interpretation of conventional quarterly estimates. To assess this potential problem, the model is generalized to present a more accurate description of the institutional features of the labour market. In particular, different seasonal bargaining patterns, multi-year contracts, and front-end loading features are incorporated into the model. Utilizing this expanded analytical format, empirical results are presented for a number of alternative institutional assumptions. Employing efficient estimation techniques, the model is found to be highly sensitive to the set of institutional (aggregation) assumptions imposed.

I

The almost universal adoption of the OAWC model can be traced back to the early work of Dicks-Mireaux and Dow [5], and Perry [14]. In these early studies, the institutional characteristics of the labour market, particularly the discontinuous nature of wage changes, are clearly recognized. The OAWC model, with its fundamental distinction between discontinuous, unobservable, micro-wage relations for particular groups in the labour force and an aggregate relation formed from them, was advanced as a statistical device to capture the institutional flavour of the labour market. Since we have presented a complete analysis of the general model elsewhere [20], only a brief statement of the aggregation - institutional assumptions and a set of sufficient conditions for the OAWC model are given. Most of these assumptions are either implicitly or explicitly stated in Dicks-Mireaux and Dow [5] and Perry [14, pages 30-31].

Aggregation Assumptions for the Conventional Quarterly Wage Change Model

(A1) Wages are set annually for all workers, and, once established, remain fixed until the next annual negotiation and settlement.

(A2) The labour force is divided into four distinct groups on the basis of the quarter in which their annual wage negotiations and/or reviews take place.

(A3) The ratios of all seasonal groups in the labour force to the total labour force are constant. In other words, the percentage of workers who bargain in the j-th quarter of the year is constant over the entire sample period.

(A4) The percentage change in wages for each of the four seasonal groups is a function of the same set of explanatory variables with the same parameter values for each group. Explanatory variables (X) and error term (u) are dated in the quarter in which the wage negotiation, settlement, and/or review took place (j). That is,

$$\frac{w_j^h - w_{j-4}^h}{w_{j-4}^h} = aX_j + u_j$$

for $h = 1, \ldots, 4$ and where w_j^h is the wage-rate for the h-th group in the j-th quarter.

(A5) The relative change in the aggregate wage-rate is approximated by a moving average for the relative changes in the wage-rates of the four groups. The weights of this moving average are assumed to be equal (.25). In essence this latter assumption equalizes the four seasonal bargaining groups.[2]

$$\frac{w_t - w_{t-4}}{w_{t-4}} = \sum_{h=1}^{4} .25 \left(\frac{w_t^h - w_{t-4}^h}{w_{t-4}^h} \right)$$

$$\frac{w_t - w_{t-4}}{w_{t-4}} = a \sum_{i=0}^{3} .25\, X_{t-i} + \sum_{i=0}^{3} .25\, u_{t-i} \quad ,$$

where w_t is the aggregate wage-rate.

For estimation purposes, the model is completed by the specification of the distribution for the error term $\{u_t\}$ in the micro equations. We adopt the conventional assumption that $\{u_t\}$ be a sequence of normally distributed errors which are mutually independent and have constant, equal variances. With this additional assumption we return to a discussion of the above equation. The Yule-Slutsky effect of prior aggregation is clearly indicated. Errors for the aggregative specification are generated by a moving average of the micro errors. Furthermore, the weights for this m.a. of errors are identical with those of the m.a.'s of the explanatory variables. In the absence of other complications, the above equation would provide an ideal basis for the rare application of the Aitken technique of generalized least squares (GLS).

While complete details of the application of GLS to wage models are provided elsewhere [20], two aspects of the estimation problem are reviewed here. First, the properties of the dispersion matrix for the error term are straightforward. The assumption of four equal groups results in the following Laurent matrix, apart from a scalar factor. Increasing the number of bargaining groups and permitting unequal weighting of such groups (as we shall do below) simply lengthens the positive band and gives rise to recurring cyclical patterns in the elements.

$$\begin{bmatrix} 4 & 3 & 2 & 1 & \ddots & & & & \\ 3 & 4 & 3 & 2 & 1 & \ddots & & & 0 \\ 2 & 3 & 4 & 3 & 2 & 1 & \ddots & & \\ 1 & 2 & 3 & 4 & 3 & 2 & 1 & \ddots & \\ \ddots & 1 & 2 & 3 & 4 & 3 & 2 & 1 & \ddots \\ & \ddots & & & & & & & \\ & 0 & \ddots & & & & & & \end{bmatrix}$$

In terms of alternative estimation procedures, we would make the following points. First, potential numerical difficulties associated with the inversion of a large matrix in GLS can be overcome by applying the Cholesky technique (which utilizes the symmetry and "bandedness" properties of the matrix for efficient calculation). Thus, the GLS technique presents no computational problems. Second, the simple application of least squares (OLS) to the OAWC model yields biased estimates of standard errors and invalid student t-statistics. As shown elsewhere [21], t-statistics are highly inflated with many of the usual variables (e.g., unemployment and prices) insignificant when efficient and appropriate estimation techniques are employed. Thirdly, this autocorrelation cannot be eliminated by autoregressive transformations of the type introduced by Cochrane and Orcutt [3] or similar approaches such as the Hildreth-Lu [9] scan procedure (see [22] for further details). Finally, OLS estimation of quarterly changes (as opposed to OAWC's) is only acceptable under the strict set of assumptions given above. If the group weights are unequal and/or there are multiple increments contained in one contract, then problems of heteroscedasticity and/or moving-average autocorrelation will again arise, requiring the adoption of an estimation technique like GLS.

II

Having outlined the aggregation model and an appropriate estimation technique, we now return to the empirical validity of the aggregation assumptions. Without venturing into a methodological debate about realism of assumptions, we would point out two conclusions if such aggregation assumptions are invalid:

(1) Given the mis-specification of the moving-averages for the

explanatory variables, the parametric estimates will be biased.

(2) Since such mis-specifcation also affects the properties of the error term, classical statistical inferences will not be appropriate.

While bias in parametric estimates is a serious consequence of a mis-specification of the institutional-aggregation assumptions, the latter conclusion is perhaps more important. Explanatory variables may appear to be "significant" (and conversely variables may be incorrectly diagnosed as "insignificant") simply because the estimates of the variances are based on incorrect formulae. Furthermore, the aggregation-institutional assumptions cannot be verified through the successively passing of conventional statistical tests since only the "correct" aggregation assumptions (an unknown in the model) will have unbiased estimates of variances. In short, one must assert that the aggregation assumptions are empirically valid and proceed with statistical inference to verify the theoretical relations postulated at the micro level. Consequently, the empirical validity of the aggregation assumptions in the model is not a trivial matter.

Unfortunately data to examine these assumptions are primarily of a fragmentary nature. As Dicks-Mireaux and Dow point out in their seminal article on quarterly wage determination in Britain, such assumptions are "only roughly realistic". The following table reproduced from their work clearly indicates a non-uniform seasonal distribution of wage settlements. They further report that the hypothesis of an even distribution throughout the year is unsupported by the χ^2 test.

TABLE 1

The Distribution of Wage Settlements, 1946-56*
(Great Britain)

Year	Workers Affected by Settlements (millions)	Distribution Through Year (Percentage)			
		First Quarter	Second Quarter	Third Quarter	Fourth Quarter
1946	8.3	24	41	24	11
1947	5.5	14	14	29	43
1948	7.8	25	18	23	34
1949	5.9	49	16	15	20
1950	6.4	30	7	19	44
1951	19.1	31	16	21	32
1952	13.7	29	15	28	28
1953	10.6	28	15	33	24
1954	13.6	26	39	14	21
1955	15.7	50	28	10	12
1956	16.8	53	28	11	8

*Taken from [5 , page 150].

Even less information is available on seasonal patterns in U.S. wage settlements. Expiration dates of contracts involving 1,000 or more workers are available for only a few selected years (see Table 2 for 1956 data). Assuming that settlement data are related to expiration data, the assumption of equal weights appears totally unrealistic, particularly as one disaggregates.

More recently, the U.S. Department of Labour has been collecting data on the number of workers covered by wage decisions reached in major collective bargaining sessions (1,000 workers or more) on a regular basis. As

TABLE 2

Distribution of Expiration Dates for 1956
(United States)

	Distribution through year in %				Employees Covered (thousands)	
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Expiration Date in 1956	Expiration Date Not in 1956
Manufacturing	19.2%	49.3%	20.3%	11.2%	2047.3	2476.3
Railroads	0	0	0	0	0.0	1161.0
Transportation	8.2	21.9	48.6	21.3	135.7	369.6
Communications	11.9	24.5	19.5	44.1	514.6	9.8
Construction	14.6	61.0	12.3	12.17	169.3	344.1
Other	17.7	28.1	38.9	15.3	612.6	387.8
All industries	17.2	41.4	24.2	17.2	3480.0	7224.9

Source: U.S. Department of Labour, BLS Report No. 102, (Collective Bargaining Activity in 1956), pages 5-6.

shown in Table 3, the seasonal pattern for manufacturing workers is erratic. In only one year, 1971, does the assumption of equal weights bear any resemblance to reality. In terms of employee coverage, about one third of manufacturing production workers are covered in this survey with many workers not bargaining in a particular year.

As suggested above, the multi-year contract in collective bargaining is a fact of life. While there are no continuous time series on contract length, data for selected years reveal a high incidence of long-term contracts

TABLE 3

Distribution of Wage Settlements In
U.S. Manufacturing Industries

Year	Workers Affected By Settlements (millions)	Distribution Through Year (Percentage)			
		First Quarter	Second Quarter	Third Quarter	Fourth Quarter
1968	2.29	19.9	23.0	41.1	16.0
1969	1.46	33.7	28.1	26.7	11.5
1970	2.18	20.7	27.1	14.0	38.2
1971*	1.39	24.7	25.5	29.7	20.1

*Preliminary

Source: U.S. Department of Labour, unpublished.

(see Table 4). Canadian data on bargaining units of 500 workers or more reveal that over 80% of all employees were on multi-year contracts with the average contract length exceeding two years [23, pages 11-13].

TABLE 4

Distribution of U.S. Employees by Contract Length
For Agreement of 1,000 Workers or More

	1956	1961
0 - 12 months	16%	3%
13 - 24 months	32%	27%
25 - 36 months	25%	49%
37 - months or indefinite	28%	21%

Source: U.S. Department of Labour, Bulletin No. 1353, pp. 8-9.

Given the prevalence of longer term contracts, the pattern of internal increments during the life of the contract becomes important. If, for example, an industry is characterized by three-year contracts, knowledge of the timing of the "locked-in" increments is critical both for a correct specification of the lags in the explanatory variables and for an analysis of the properties of the error term. Unfortunately, virtually no summary evidence exists on the temporal pattern of such internal increments. However, a high degree of "front-end" loading (i.e. the apportionment of a relatively large portion of the total increment to the first year of the contract) is known to be present (see Table 5).

TABLE 5

Average Wage Changes in U.S. Collective Bargaining Agreements Covering 1,000 or More Workers Negotiated in a Given Year

Year	All Industries		Manufacturing	
	First Year % Increment	Annual % Increment Over Entire Contract	First Year % Increment	Annual % Increment Over Entire Contract
1963	3.4%	2.5%	3.0%	n.a.
1964	3.2	3.0	2.2	n.a.
1965	3.9	3.3	4.1	n.a.
1966	4.8	3.9	4.2	3.8
1967	5.7	5.0	6.4	5.1
1968	7.2	5.2	6.9	4.9
1969	8.0	6.8	7.0	5.8
1970	10.0	8.1	7.5	5.8

Source: U.S. Department of Labour, No. 282, July 1971, page 53.

In summary, the unionized portion of the labour force bears no relationship to the standard aggregation assumptions imposed. Such workers typically sign multi-year contracts which are seasonally "bunched" and call for future increments of smaller size. Settlement patterns for the non-unionized sector are conjectural, although one assumes some "imitation" of union settlements as well as institutional discontinuities of other varieties (e.g. annual wage reviews). In short, the standard assumptions, while plausible as first guesses, are of dubious empirical validity. One's suspicions increase as data are disaggregated, particularly when disaggregated units involve increasing proportions of unionized labour.

III

As stated above, the empirical validity of the aggregation assumptions cannot be verified by employing the usual statistical tests. Even worse, inappropriate aggregation assumptions produce biased parametric estimates and inappropriate statistical inferences for the underlying theoretical relationships. Available fragmentary evidence presented in Section II does not substantiate the standard aggregation assumptions imposed. Therefore, it is of crucial importance that the sensitivity of the model to alternative aggregation assumptions be determined.

Before proceeding to the model sensitivity experiments, the aggregation model presented in Section I must be generalized to permit a "richer" set of aggregation assumptions. The intent of this elaboration is to capture as much of the institutional flavour of the labour market as possible in the context of an integrated model. First, assumption (A1) is replaced by two new assumptions which permit multi-year wage contracts (A1'a) and which specify the temporal pattern of the increments during the contract period (A1'b). Such modified assumptions require a restatement of (A2).

(A1'a) Workers can be grouped on the basis of whether they sign one-year, two-year, or three-year contracts over the sample period.

(A1'b) Wage increments take place when the contract is negotiated and on succeeding anniversaries for multi-year contracts (i.e., a two-year contract has two increments and a three year contract three increments). The subsequent "locked-in" increments in multi-year contracts are determined at the time of the contract signing.

(A2'a) The labour force is divided into twenty-four distinct groups on the basis of the quarter in which the wage negotiations take place and the length of the contracts signed.

(A2'b) Let these twenty-four groups be represented by the following notation:
(i) One year contracts: C1, C2, C3, C4
(ii) Two year contracts: D1, D2, ..., D8
(iii) Three year contracts: E1, E2, ..., E12.

Assumption (A3) is retained, but (A4) must be modified to incorporate future "locked-in" increments.

(A4'a) The average annual percentage change in wages over the life of the contract is invariant with respect to the length of the contract.

(A4'b) The annual percentage change in wages over the entire length of the contract is a function of the same set of explanatory variables with the same parameter values for all groups.[3] Explanatory variables (X) and error term are dated in the quarter in which the wage settlement is negotiated (j)

$$\frac{w_i^h - w_{i-4}^h}{w_{i-4}^h} = aX_j + u_j$$

where $h = 1, \ldots, 24$ and w_i^h is the wage rate for the h-th group in the i-th quarter.

(A4'c) The distribution of this average annual percentage change in wages over the entire contract is given by the following "loading" factors: $\lambda^C, \lambda_1^D, \lambda_2^D, \lambda_1^E, \lambda_2^E, \lambda_3^E$.

These three assumptions simply postulate that the average annual percentage-change in wages for any group over any contract length is a function of the same set of economic factors at the time of negotiations. However, to the extent that $\lambda_1^D > \lambda_2^D$ and $\lambda_1^E > \lambda_2^E > \lambda_3^E$, front end loading is permitted. For example, in a three year contract, the pattern of increments is the following:

$$\text{Increment \#1} \quad \frac{w_j^h - w_{j-4}^h}{w_{j-4}^h} = \lambda_1^E \left(\frac{w_i^h - w_{i-4}^h}{w_{i-4}^h} \right)$$

$$\text{Increment \#2} \quad \frac{w_{j+4}^h - w_j^h}{w_j^h} = \lambda_2^E \left(\frac{w_i^h - w_{i-4}^h}{w_{i-4}^h} \right)$$

$$\text{Increment \#3} \quad \frac{w_{j+8}^h - w_{j+4}^h}{w_{j+4}^h} = \lambda_3^E \left(\frac{w_i^h - w_{i-4}^h}{w_{i-4}^h} \right)$$

To accommodate the twenty-four labour groups and "front-end" loading, we generalize (A5).

(A5'a) The relative change in the aggregate (observable) wage-rate (W) is approximated by a moving-average of the relative changes in the wage rates for all groups, producing the following estimable equation

$$\frac{W_t - W_{t-4}}{W_{t-4}} = \sum_{i=0}^{11} \eta_{i,t} \, (aX_{t-i} + u_{t-i})$$

where $\{\eta_{i,t}\}$ are a set of known weights.

To describe the particular pattern of weights $\{\eta_{i,t}\}$ for the moving-averages, we begin with the sequence of groups which receive increments in a given time period (see Table 6). This pattern repeats every twenty-four time periods. Given the annual step-functions for all individual bargaining group wage-rate series, the overlapping annual wage-change will include a positive entry for each group in the aggregation summation. However, these increments will be arranged (negotiated) at some point during the last twelve quarters (since the maximum contract length is three years). In terms

TABLE 6

Groups Receiving Increments

Time Period (t)	Bargained for in t	Bargained for in t-4	Bargained for in t-8
1	C1 + D1 + E1	D5 + E9	E5
2	C2 + D2 + E2	D6 + E10	E6
3	C3 + D3 + E3	D7 + E11	E7
4	C4 + D4 + E4	D8 + E12	E8
5	C1 + D5 + E5	D1 + E1	E9
9	C1 + D1 + E9	D5 + E5	E1
13	C1 + D5 + E1	D1 + E9	E5
17	C1 + D1 + E5	D5 + E1	E9
21	C1 + D5 + E9	D1 + E5	E1
25	C1 + D1 + E1	D5 + E9	E5

of the "dating" of the individual group increments in the aggregate summation, the following configuration of weights is obtained (Table 7).

If all increments within a contract were of equal size (i.e. all λ's = 1), then this matrix of 24 x 12 weights would be employed to construct the moving averages for the explanatory variables, as well as in the calculation of the dispersion matrix for GLS. To incorporate "front-end" loading features, each component of each weight in the moving-average is scaled by the appropriate λ factor (see Table 7). For example, E1 to E12 is scaled by λ_1^E if this element is dated in t to t-3, by λ_2^E if dated in t-4 to t-7 and by λ_3^E if dated in t-8 to t-11. Thus the final composite set of weights consists of 24 x 12 different elements repeating every 24 quarters and containing three internal cycling processes (t to t-3; t-4 to t-7; and t-8 to t-11). To specify these 288 elements, thirty different time-invariant

TABLE 7

Pattern of Moving Averages in Terms of Labour Groups

Increments Dated in the Following Quarters

t	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11
1	C1 + D1 + E1	C4 + D8 + E12	C3 + D7 + E11	C2 + D6 + E10	D5 + E9	D4 + E8	D3 + E7	D2 + E6	E5	E4	E3	E2
2	C2 + D2 + E2	C1 + D1 + E1	C4 + D8 + E12	C3 + D7 + E11	D6 + E10	D5 + E9	D4 + E8	D3 + E7	E6	E5	E4	E3
3	C3 + D3 + E3	C2 + D2 + E2	C1 + D1 + E1	C4 + D8 + E12	D7 + E11	D6 + E10	D5 + E9	D4 + E8	E7	E6	E5	E4
4	C4 + D4 + E4	C3 + D3 + E3	C2 + D2 + E2	C1 + D1 + E1	D8 + E12	D7 + E11	D6 + E10	D5 + E9	E8	E7	E6	E5
5	C1 + D5 + E5	C4 + D4 + E4	C3 + D3 + E3	C2 + D2 + E2	D1 + E1	D8 + E12	D7 + E11	D6 + E10	E9	E8	E7	E6
9	C1 + D1 + E9	C4 + D8 + E8	C3 + D7 + E7	C2 + D6 + E6	D5 + E5	D4 + E4	D3 + E3	D2 + E2	E1	E12	E11	E10
13	C1 + D5 + E1	C4 + D4 + E12	C3 + D3 + E11	C2 + D2 + E10	D1 + E9	D8 + E8	D7 + E7	D6 + E6	E5	E4	E3	E2
17	C1 + D1 + E5	C4 + D8 + E4	C3 + D7 + E3	C2 + D6 + E2	D5 + E1	D4 + E12	D3 + E11	D2 + E10	E9	E8	E7	E6
21	C1 + D5 + E9	C4 + D4 + E8	C3 + D3 + E7	C2 + D2 + E6	D1 + E5	D8 + E4	D7 + E3	D6 + E2	E1	E12	E11	E10
25	C1 + D1 + E1	C4 + D8 + E12	C3 + D7 + E11	C2 + D6 + E10	D5 + E9	D4 + E8	D3 + E7	D2 + E6	E5	E4	E3	E2
SCALING FACTORS	$\lambda^C ; \lambda_1^D ; \lambda_1^E$	$\lambda^C ; \lambda_1^D ; \lambda_1^E$	$\lambda^C ; \lambda_1^D ; \lambda_1^E$	$\lambda^C ; \lambda_1^D ; \lambda_1^E$	$\lambda_2^D ; \lambda_2^E$	$\lambda_2^D ; \lambda_2^E$	$\lambda_2^D ; \lambda_2^E$	$\lambda_2^D ; \lambda_2^E$	λ_3^E	λ_3^E	λ_3^E	λ_3^E

parameters are required (C1, C2, ... , C4; D1, D2, ... , D8; E1, E2, ... , E12; λ_1^C, λ_1^D, λ_2^D, λ_1^E, λ_2^E, λ_3^E).

IV

Ideally one would like to have institutional data to specify these thirty different parameters in the model. As stated above, such information is fragmentary at best, and thus we have to resort to repeated experiments employing various different (random) sets of institutional parameters. To the extent that inferences and parametric estimates vary over this set of experiments, then we would conclude that the model is sensitive to the specification of such parameters.

The Perry model has been selected for the theoretical underpinning of our experiments, primarily on the basis of its widespread popularity in the empirical literature. The dependent variable is the OAWC in straight-time average hourly earnings of production workers, with the following explanatory variables defined as weighted moving averages of quarterly raw data: a specially constructed unemployment rate (U),[4] the quarterly change in the consumer price index (C.P.I.);[5] net profits as a percentage of stockholders equity (π);[6] and a guidepost dummy (G). All of our experiments are based on 1952-1968 quarterly data for the U.S. manufacturing sector.

Our preliminary analysis focuses on the conventional aggregation model. Assumptions (A1) to (A5) are retained with only one exception: the four micro labour groups are not constrained to be equal. Thus, "seasonal bunching" is permitted in the context of the usual OAWC model with 4th order m.a.'s for all explanatory variables. Since there is no reason to believe that any one particular seasonal distribution of workers dominates another, we have simply drawn eight sets of random numbers for these distributions. In addition, four different permutations of each set are employed by varying the initial element in the sequence. An "equal" weights regression is calculated for comparative purposes.

GLS results for these thirty-three seasonal distributions are presented in Table 8. As pointed out above, one cannot test the "significance" of the aggregation assumptions (in this case different seasonal bunching patterns). One must simply postulate an empirical set of aggregation assumptions as the basis for testing one's wage theory. Table 8 therefore provides 32 additional sets of estimates to compare with any one equation selected (by the reader?) to represent the closest approximation to the institutional features of the labour market. In other words, if one had stipulated a different seasonal pattern, would one have drawn different inferences concerning the significance and magnitude of various theoretical variables.

Clearly Table 8 reveals a high degree of sensitivity concerning parametric estimates for different seasonal bargaining patterns. In terms of significance levels, there is a dramatic difference between seasonal patterns 2 and 6 (four of five variables apparently significant at the .05 level) and patterns 8, 16, 21, 25, 26, 27 and 32 (none apparently significant even at the .10 level). In contrast to the usual equal-weight assumption, the postulation of almost any other seasonal bargaining assumption improves one's chances of detecting a significant coefficient for the major explanatory variables ($\dot{CPI}$, π, and U). In short, the specification of the particular seasonal pattern has a pronounced effect on the statistical inferences drawn with respect to each of the explanatory variables. It would have been much more re-assuring if variables were either consistently significant or insig-

TABLE 8

Sensitivity of Conventional OAWC Model to Specification of Seasonal Bargaining Distribution in U.S. Manufacturing Sector, 1953-68

	Seasonal Weight Set				Constant	Ċ.P.I.	π	U^{-1}	G	F-test
(1)	.250	.250	.250	.250	-.0248	.2960	.4538	.0593	-.0172*	40.32
(2)	.106	.226	.243	.425	-.0592*	.6256	.6024*	.1184*	-.0218*	25.04
(3)	.425	.106	.226	.243	-.0379	-.1782	.6426*	.0444	-.0190*	20.75
(4)	.243	.425	.106	.226	-.0482	.1058	.6473	.0698	-.0227†	12.34
(5)	.226	.243	.425	.106	-.0216	.9552	.4902	.0300	-.0231*	15.41
(6)	.074	.229	.238	.459	-.0842*	.6582	.7428*	.1544*	-.0271*	16.36
(7)	.459	.974	.229	.238	-.0530	-.2117	.8204*	.0337	-.0217†	13.53
(8)	.238	.459	.074	.229	-.0693	.1163	.8235	.0769	-.0268	6.76
(9)	.229	.238	.459	.074	-.0204	1.0356†	.5293	.0143	-.0278†	8.68
(10)	.028	.458	.403	.111	-.2096	1.2088	1.5383	.3041*	-.0652*	5.32
(11)	.111	.028	.458	.403	-.1719*	-.4119	1.8310*	.0831	-.0408	4.06
(12)	.403	.111	.028	.458	-.1687	.0732	.6766	.4977†	-.0311	2.24
(13)	.458	.403	.111	.028	-.0521	2.8987†	1.3029	-.1657	-.0640	2.00
(14)	.008	.347	.395	.250	-.7347*	1.4985†	4.5834	1.0505*	-.1769†	4.28
(15)	.250	.008	.347	.395	-.4782*	-.5225	5.1204†	-.0497	-.0897	1.40
(16)	.395	.250	.008	.347	-.5619	.2200	3.1724	.9734	-.1044	.94
(17)	.347	.395	.250	.008	-.0155	2.4634*	2.0636	-.5040	-.1550	1.87
(18)	.415	.157	.388	.040	-.0219	1.2795*	.7838	-.0613	-.0431	3.53
(19)	.040	.415	.157	.388	-.1562*	.7488	1.0821	.2810*	-.0445	8.25
(20)	.388	.040	.415	.157	-.0940†	-.2558	1.3115	.0073	-.0319†	5.58
(21)	.157	.388	.040	.415	-.1327	.1097	1.0074	.2299	-.0332	3.09
(22)	.350	.340	.247	.063	-.0193	1.7857†	.6046	-.0269	-.0310†	6.72
(23)	.063	.350	.340	.247	-.0890*	.9761	.7890†	.1514*	-.0316*	13.25
(24)	.247	.063	.350	.340	-.0650†	-.3019	.8842*	.0513	.0222†	13.76
(25)	.340	.247	.063	.350	-.0719	.1142	.6462	.1569	.0227	5.80

TABLE 8 (Continued)

	Seasonal Weight Set				Constant	$\dot{C}$.P.I.	π	U^{-1}	G	F-test
(26)	.456	.184	.100	.260	-.0466	-.0740	.5994	.0894	-.0202	10.66
(27)	.260	.456	.184	.100	-.0307	.7989	.5936	.0236	-.0264	11.00
(28)	.100	.260	.456	.184	-.0531†	.7349	.6393*	.0863†	-.0252	19.02
(29)	.184	.100	.260	.456	-.0541*	.1211	.6568*	.0877†	-.0192*	23.37
(30)	.097	.366	.170	.367	-.0660*	.4866	.6279†	.1339*	-.0243*	18.88
(31)	.367	.097	.366	.170	-.0373	-.0382	.6765*	.0321	-.0216	17.79
(32)	.170	.367	.097	.366	-.0607	.1264	.6197	.1223	-.0221	12.09
(33)	.366	.170	.367	.097	-.0217	.7850	.5482	.0158	-.0246*	12.32

* significant at .05 level

† significant at .10 level

nificant across all seasonal patterns.

As pointed out above, variation in the estimated parametric values is expected since an inappropriate "seasonal bunching" assumption will introduce specification error and bias into the estimates. Estimated coefficients for the consumer price variable range from -.52 to +2.46[7] while estimated coefficients for the profit rate variable range from .45 to 5.12. Given the widespread interest in the position and shape of the Phillips curve, we have presented the thirty-three estimated Phillips curves in Sections A to H of Chart I. (All other variables are specified in terms of their 1968 levels.) Each Section of the Chart depicts the four permutations of a particular weight set together with the "equal weight" Phillips curves (the conventional estimates). A solid line, as opposed to a broken line, signifies (apparent) significance at the .10 level. Again, there is considerable variation depending upon which weight set one selects to represent the seasonal pattern of wage bargains and/or reviews. In particular, one notes the dramatic differences in the Phillips curves presented in Charts 1C, 1D and 1E. Even if one restricts oneself to apparently significant estimates, the Phillips curves generated with weight sets (10), (12), (14) and (19) are substantially more inelastic than those generated with weight sets (2), (6), (23), (28), (29) and (30).

Having demonstrated the sensitivity of the conventional model to the relaxation of one assumption, we now return to our more general model. Again we specify our micro labour-market groups by drawing eight sets of <u>twenty-four</u> random numbers in addition to a ninth set of "equal" groups. The importance given to each of the three different lengths of contracts (i.e. groups

CHART 1A

Phillips Curves for Different Seasonal Bargaining Patterns

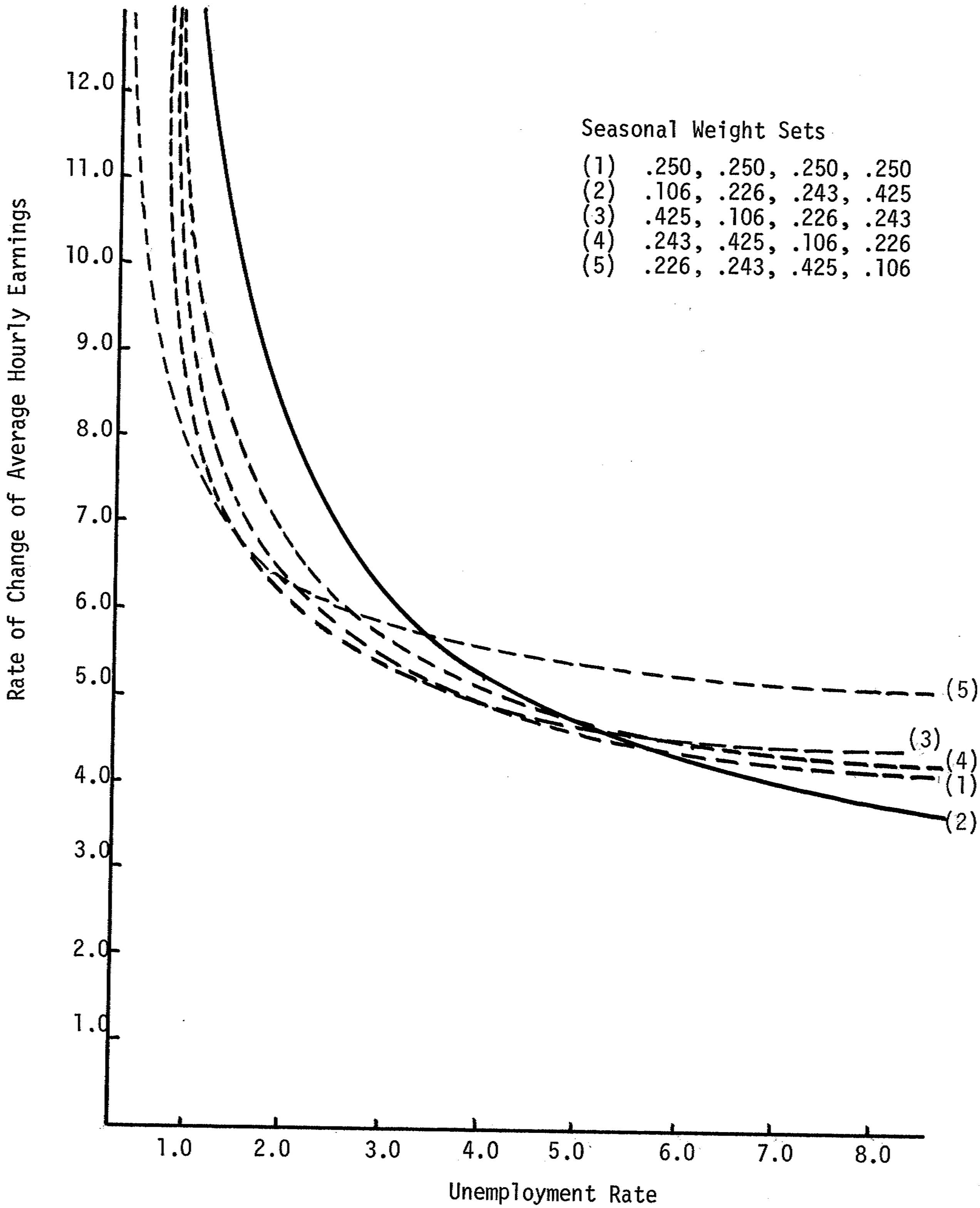


CHART 1B

Phillips Curves for Different Seasonal

Bargaining Patterns

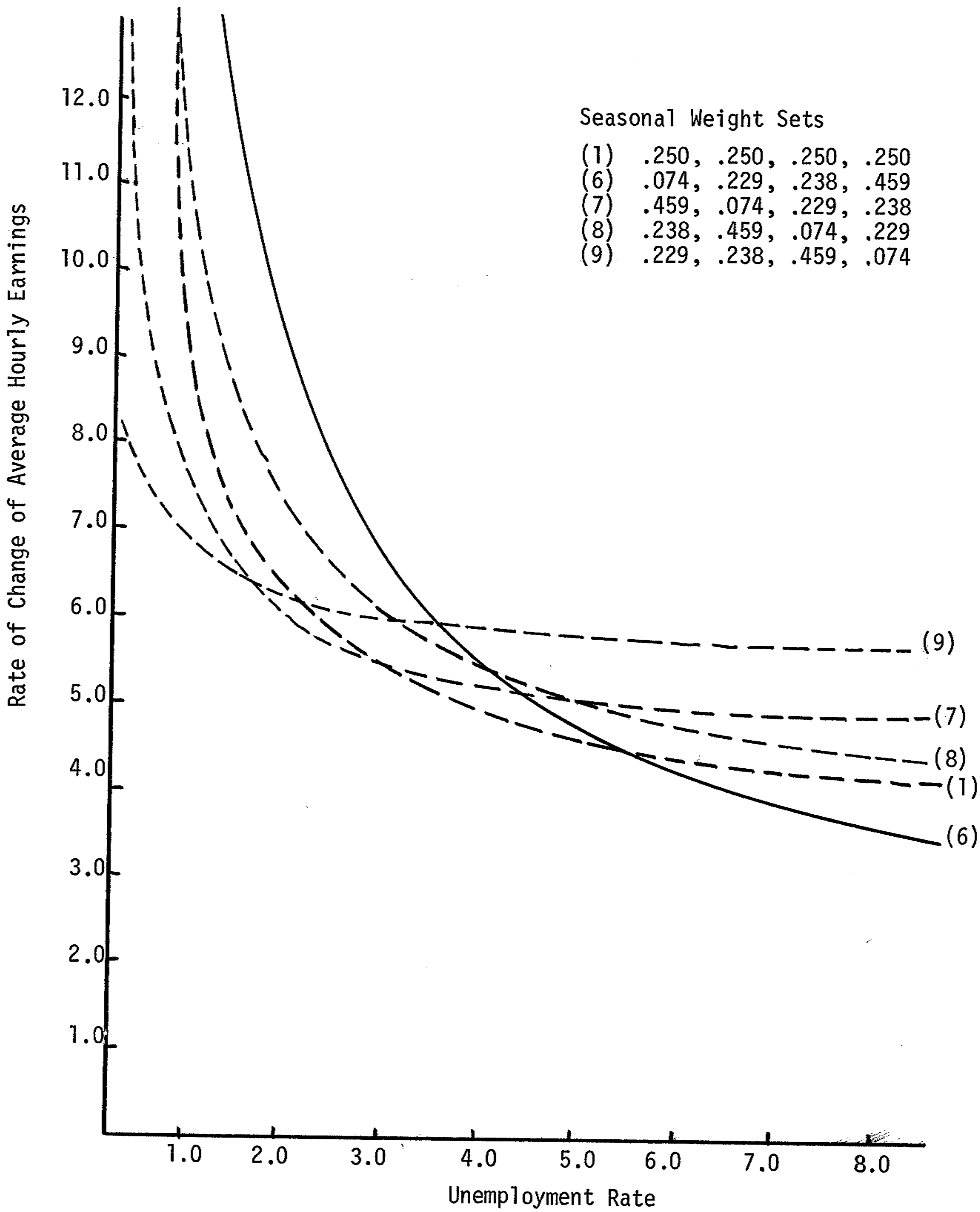


CHART 1C

Phillips Curves for Different Seasonal

Bargaining Patterns

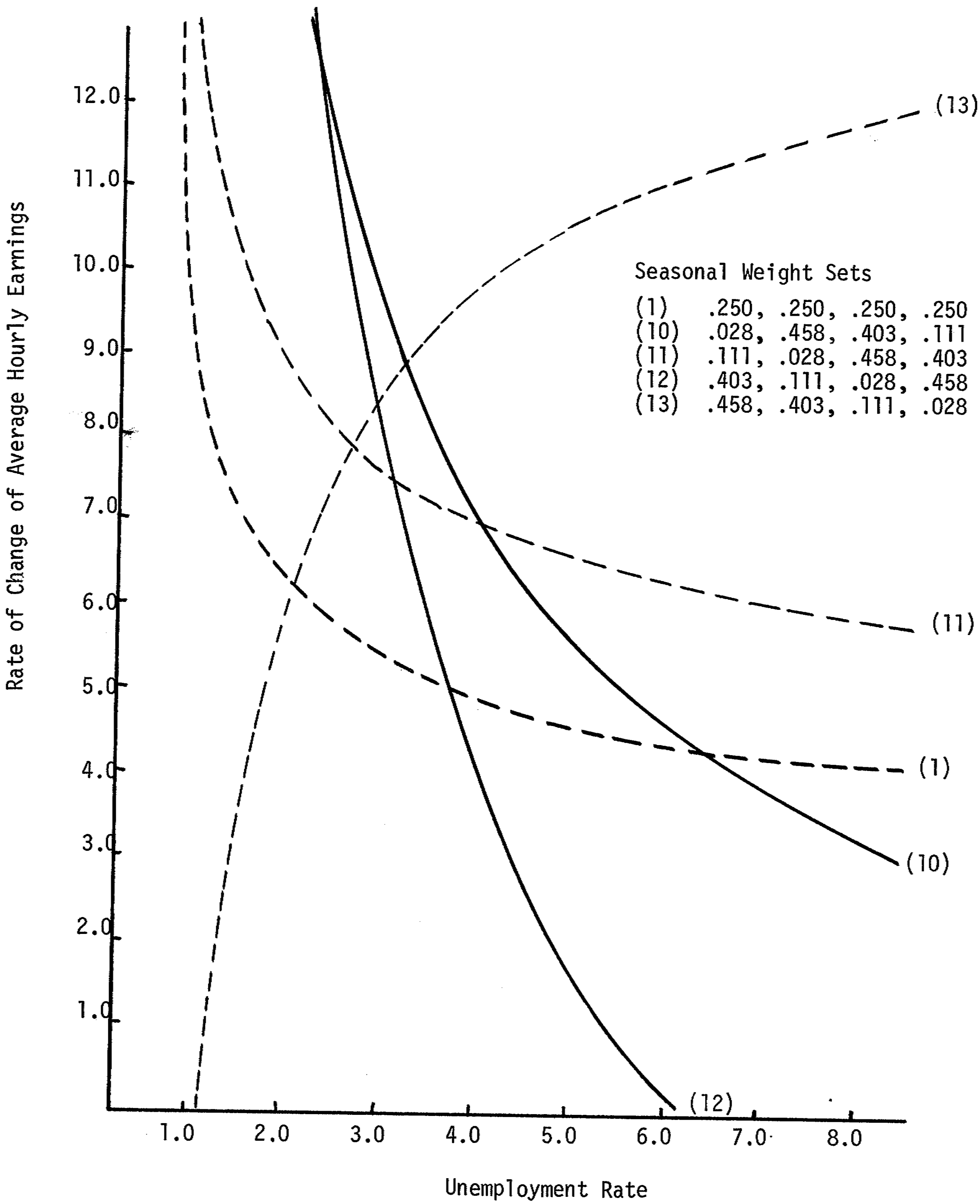


CHART 1D

Phillips Curves for Different Seasonal

Bargaining Patterns

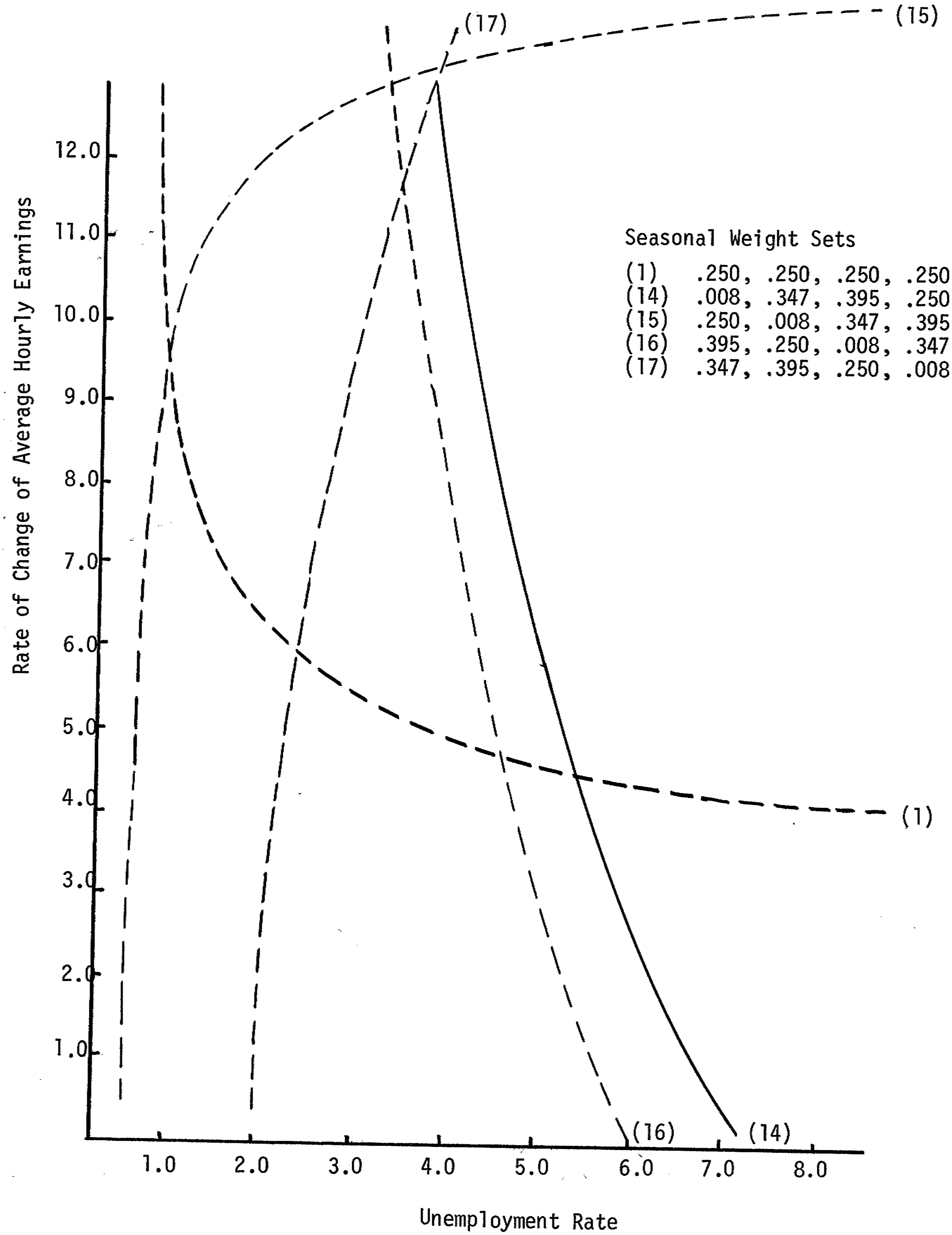


CHART 1E

Phillips Curves for Different Seasonal Bargaining Patterns

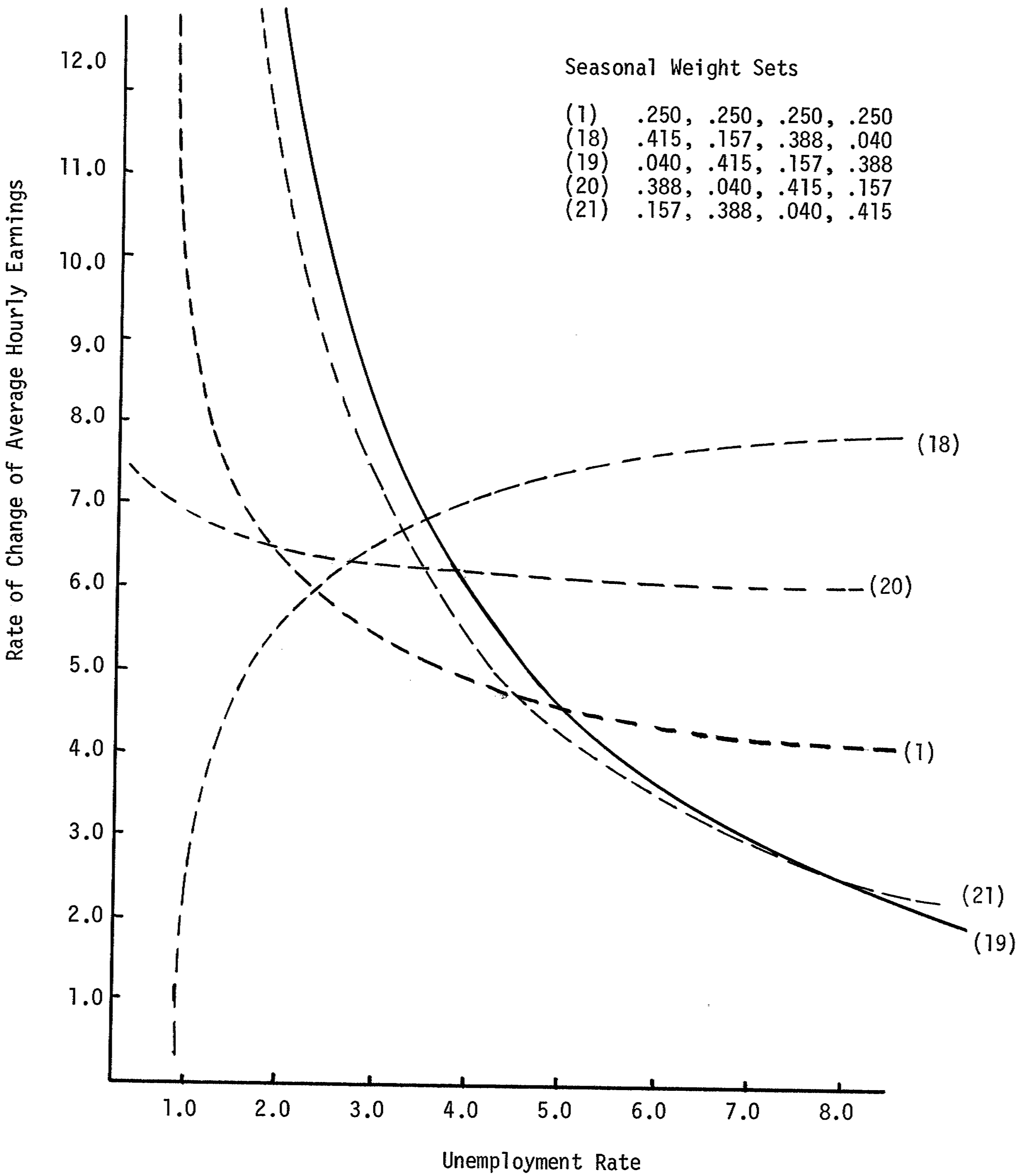


CHART 1F

Phillips Curves for Different Seasonal

Bargaining Patterns

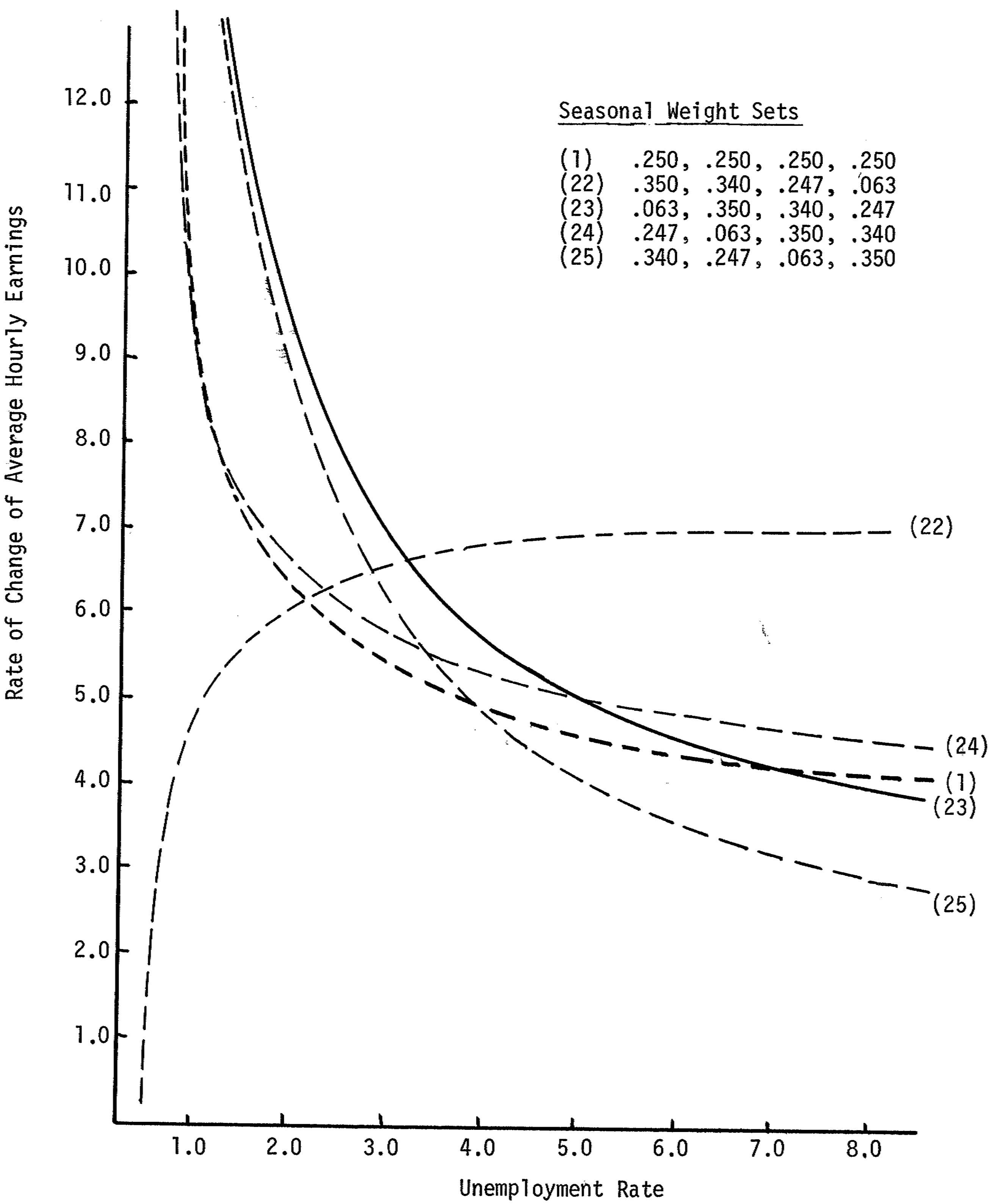


CHART 1G

Phillips Curves for Different Seasonal Bargaining Patterns

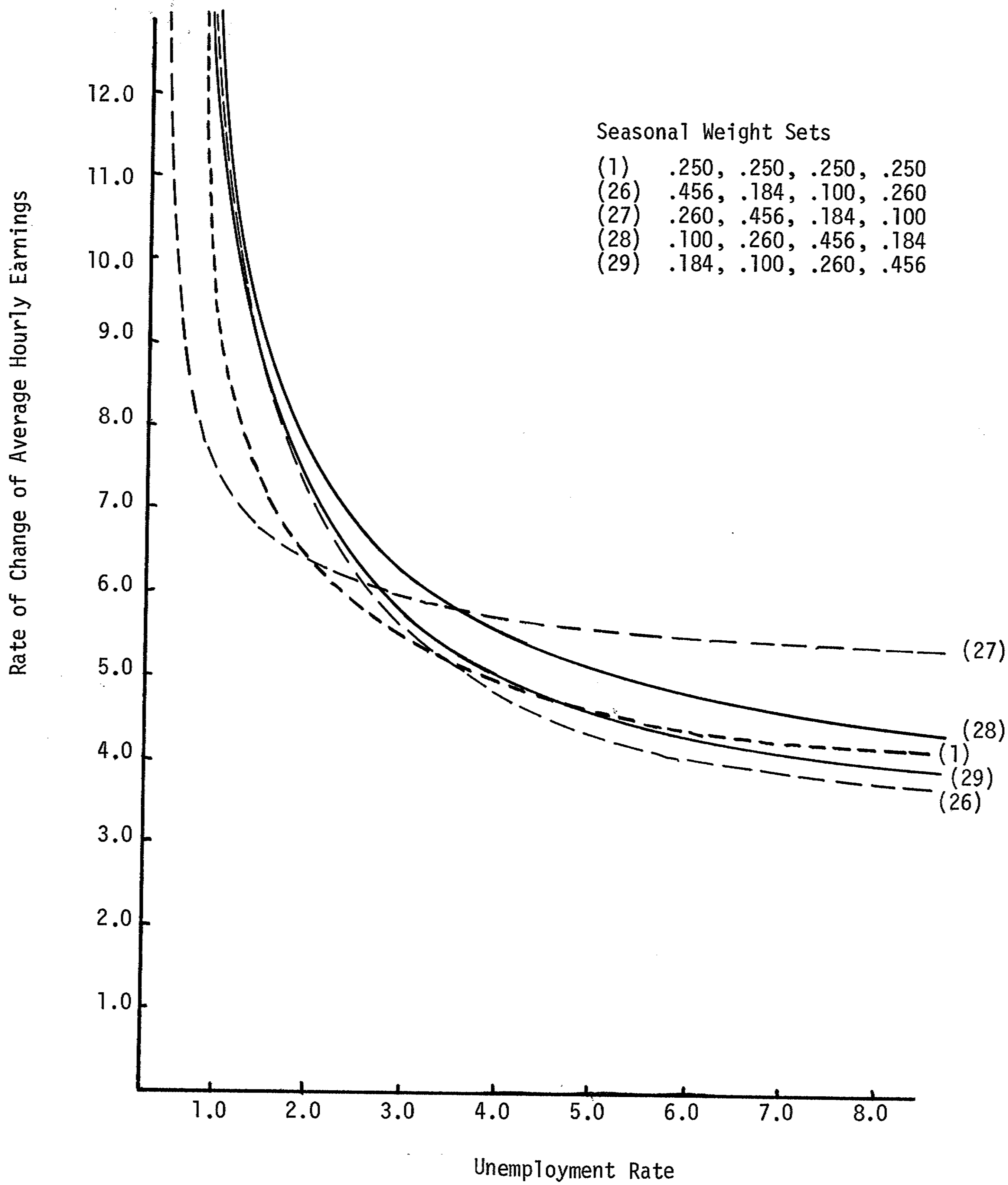
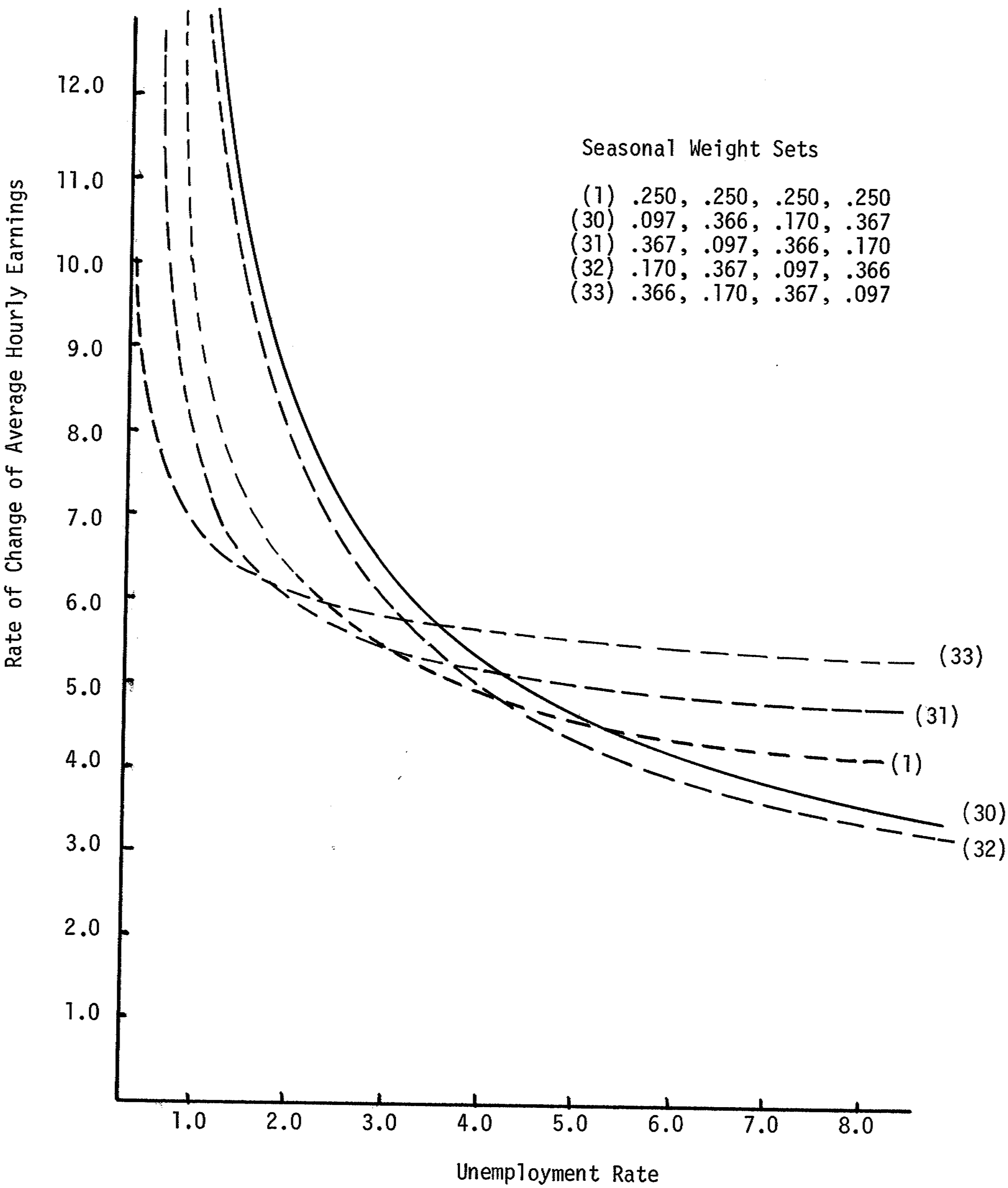


CHART 1H

Phillips Curves for Different Seasonal

Bargaining Patterns



C, D and E) must also be established. Of our five different weighting schemes two are completely arbitrary: (1) no constraints on weighting (therefore the E group has an expected weight of 12/24 or ½) and (2) equal weights for each of the three groups (therefore the E group has an expected weight of 1/3). Our third weighting scheme simply utilizes 1961 U.S. data for 3,152,000 manufacturing workers to establish the weights for the three groups (5.1% for C, 40.2% for D and 54.8% for E). Since this data only includes part of the labour force we generate two more sets of group weights by assuming (4) that there is an equal number of "uncovered" workers in the C group as in the total "covered" data set and (5) there are twice as many "uncovered" workers in the C group. Table 9 summarizes the five different group weights for our experiments.

Our assumptions concerning front-end loading are also arbitrary in nature. We simply employ three different sets of loading factors to create no, moderate, and heavy front-end loading (see Table 10). Thus, we have 9 x 5 x 3 different experiments performed on our basic set of data.

GLS results for these 135 experiments are presented in Tables 11A - 11D with each table presenting the estimated coefficient for one of the explanatory variables. In addition to the 135 experimental regressions, 18 regressions were also computed under the assumption that all labour groups sign one-year contracts. Again the eight sets of random numbers were employed to create different seasonal patterns, along with the ninth set of equal weights. Two different time periods were utilized for these one year contract regressions, 1953-68 and 1955-68. The latter corresponds to the number of observations in the 135 experimental regressions whereas

TABLE 9

Group Weights by Contract Length

	Expected Values for the Following Groups		
	One Year (C)	Two Year (D)	Three Year (E)
(1) Unconstrained	16.7%	33.3%	50.0%
(2) Equally weighted	33.3	33.3	33.3
(3) Historical data	5.1	40.2	54.8
(4) ½ Historical data ½ one year contracts	52.5	20.1	27.4
(5) 1/3 Historical data 2/3 one year contracts	68.3	13.4	18.3

TABLE 10

Front-End Loading Assumptions

	λ^C	λ_1^D	λ_2^D	λ_1^E	λ_2^E	λ_3^E
(1) No F.E.L.	1.00	1.00	1.00	1.00	1.00	1.00
(2) Moderate F.E.L.	1.00	1.12	.88	1.25	1.00	.75
(3) Heavy F.E.L.	1.00	1.34	.66	1.67	1.00	.33

TABLE 11A

Estimated Coefficients for the Change in Consumer Prices

	Percentage of Total Accounted for by Each Major Group			Weight Sets								
				Randomly Drawn for 24 Groups								Equal
	C	D	E	1	2	3	4	5	6	7	8	9
1953-68	100.0	0	0	.6256	.6582	1.2088	1.4985+	1.2795*	1.7857+	-.0740	.4866	.2960
1955-68	100.0	0	0	.9228	.9816+	2.2113	2.1093*	1.6419*	2.3875*	-.3092	.7966	.2986
No Front End Loading												
	5.1	40.2	54.8	3.2533*	-.1266	-1.9136	.3663	3.4686*	-.3100	1.0756	2.1753	1.7559
	16.7	33.3	50.0	2.7603+	.6773	-2.0906	5.1973*	1.5292	.7910	.9937	1.3846	1.1138
	33.3	33.3	33.3	2.1128*	2.3268*	.5260	5.8059*	.7573	-.0392	.6368	.9342	.8179
	52.5	20.1	27.4	1.6950*	1.9080*	1.3260	6.7382*	.1397	-.4862	.5379	1.2616	.5274
	68.3	13.4	18.3	1.5489*	1.6434*	1.8320	5.6545*	.0351	-.3804	.2327	1.2828+	.4203
Moderate Front End Loading												
	5.1	40.2	54.8	1.4624	-.3347	-1.9944	-.0565	2.0654	.6361	.2605	1.4754	1.3347
	16.7	33.3	50.0	1.5209	.3930	-1.9606	2.0436	.6257	.4204	.2057	1.1324	.9727
	33.3	33.3	33.3	1.2425	1.6165	.1283	2.6815+	.6758	.5039	.0077	.9368	.7715
	52.5	20.1	27.4	1.2492	1.5549+	1.0809	4.9571*	.7328	.3998	-.0477	1.2710	.5264
	68.3	13.4	18.3	1.3527+	1.4874*	1.5780	4.8592*	.5898	.2529	-.0804	1.2909+	.4082
Heavy Front End Loading												
	5.1	40.2	54.8	.4122	.4491	-1.3525	-.1291	1.1001	1.0128	.8221	.5237	.9482
	16.7	33.3	50.0	.8064	.7140	-1.2617	1.3244	.3343	.1328	.6476	.5767	.8097
	33.3	33.3	33.3	.9976	1.5247	-.3236	1.7021	.2671	.5245	.1141	.7463	.6208
	52.5	20.1	27.4	1.1762	1.4330+	.6093	3.6476*	.7371	.5965	-.1757	1.1545	.4631
	68.3	13.4	18.3	1.2580+	1.3966*	1.1009	4.0668*	.8636	.5845	-.3033	1.2127*	.3805

TABLE 11B

Estimated Coefficients for the Profit Rate

	Percentage of Total Accounted for by Each Major Group			Weight Sets								
				Randomly Drawn for 24 Groups								Equal
	C	D	E	1	2	3	4	5	6	7	8	9
1953-68	100.0	0	0	.6024*	.7428+	1.5383	4.5830	.7838	.6046	.5994	.6279+	.4538
1955-68	100.0	0	0	.6272	.8323	1.7347	6.1417	.3610	.3465	.2954	.6385	.2859
No Front End Loading												
	5.1	40.2	54.8	2.0097*	1.5981+	1.3740	2.0911+	1.8720*	1.7726	1.4077	2.0632*	1.7366*
	16.7	33.3	50.0	1.7864*	1.6662*	1.3721	2.9674*	1.3444	1.4175	1.5346*	1.8363*	1.5282*
	33.3	33.3	33.3	1.5434*	1.3122*	1.6400*	2.7983*	1.1505	1.1373	.9907+	1.3557*	1.0640*
	52.5	20.1	27.4	1.1953*	1.0100+	1.5814*	2.7833*	.8925	.6274	.9565+	1.0796*	.7022
	68.3	13.4	18.3	.9162+	.7468	1.5523*	2.6017*	.7655	.4337	.7968	.8606+	.4936
Moderate Front End Loading												
	5.1	40.2	54.8	.4199	-.0531	1.2926*	.3778	.4635	.6875+	-.4994	.6501*	1.4366*
	16.7	33.3	50.0	.6613*	.1046	1.2413*	.0386	.7765*	1.4189*	-.4700	.7047*	1.2401*
	33.3	33.3	33.3	.6369*	.1388	1.6429*	-.1397	1.4822*	1.4811*	-.1378	.7618*	.8944+
	52.5	20.1	27.4	.6440+	.3050	1.5255*	-.2137	1.6322*	1.4199+	.0867	.6974*	.6227
	68.3	13.4	18.3	.7140+	.4198	1.4814*	-.2618	1.6452*	1.1321	.2963	.6646+	.4581
Heavy Front End Loading												
	5.1	40.2	54.8	.3067+	.1437	.7141*	.2321	.4052*	.2661	-.0057	.3726*	.9710+
	16.7	33.3	50.0	.3458*	.1610	.6912*	.1329	.4981*	.5574*	-.0354	.3826*	.8485+
	33.3	33.3	33.3	.3254+	.1310	.9973*	-.0243	.8939*	.5972*	-.0876	.4197*	.6510
	52.5	20.1	27.4	.3164	.1451	1.0037*	-.2252	1.2087*	.8040*	-.1766	.4000+	.5039
	68.3	13.4	18.3	.3853	.1562	1.0532*	-.3961	1.6004*	1.0376*	-.1170	.4350+	.4041

TABLE 11C

Estimated Coefficients for the Unemployment Rate (Reciprocal)

	Percentage of Total Accounted for by Each Major Group			Weight Sets								
				Randomly Drawn for 24 Groups								Equal
	C	D	E	1	2	3	4	5	6	7	8	9
1953-68	100.0	0	0	.1184*	.1544*	.3041*	1.0505*	-.0613	-.0269	.0894	.1339*	.0593
1955-68	100.0	0	0	.0756	.0872	.1167	.3792	-.1051	-.0647	.1462	.0925	.0748
No Front End Loading												
	5.1	40.2	54.8	-.3076	-.1408	-.1273	-.2788	-.3335	-.2423	-.1478	-.3517+	-.2502
	16.7	33.3	50.0	-.2594	-.1618	-.1210	-.5610*	-.1595	-.1486	-.1644	-.2599+	-.1745
	33.3	33.3	33.3	-.1784	-.1410	-.1779	-.5331*	-.0911	-.0507	-.0449	-.1305	-.0640
	52.5	20.1	27.4	-.1094	-.0849	-.1717	-.6159*	.0144	.1090	-.0313	-.0919	.0170
	68.3	13.4	18.3	-.0714	-.0448	-.1749	-.5884*	.0852	.1694	.0142	-.0645	.0529
Moderate Front End Loading												
	5.1	40.2	54.8	.0465	.1948*	-.0667	.1180	.0444	.0136	.2937*	.0033	-.1674
	16.7	33.3	50.0	-.0150	.1551+	-.0578	.0864	.0336	-.1213	.2910*	-.0013	-.1084
	33.3	33.3	33.3	.0180	.1126	-.1642	.1315	-.1154	-.1182	.2197*	-.0146	-.0304
	52.5	20.1	27.4	.0075	.0640	-.1634	.0329	-.1410	-.0848	.1714	-.0236	.0284
	68.3	13.4	18.3	-.0312	.0208	-.1659	-.0139	-.1192	-.0079	.1284	-.0325	.0568
Heavy Front End Loading												
	5.1	40.2	54.8	.0958	.1124*	.0382	.1162	.0683	.0831	.1847*	.0608	-.0581
	16.7	33.3	50.0	.0674	.0969+	.0390	.0520	.0814	.0480	.1962*	.0531	-.0274
	33.3	33.3	33.3	.0700	.0833	-.0219	.0811	.0197	.0465	.2105*	.0356	.0155
	52.5	20.1	27.4	.0591	.0714	-.0514	.0179	-.0441	.0272	.2312*	.0190	.0456
	68.3	13.4	18.3	.0290	.0595	-.0768	-.0226	-.1170	-.0078	.2203*	.0025	.0622

TABLE 11D

Estimated Coefficients for the Guidepost Dummy

Percentage of Total Accounted for by Each Major Group				Weight Sets								
				Randomly Drawn for 24 Groups								Equal
	C	D	E	1	2	3	4	5	6	7	8	9
1953-68	100.0	0	0	-.0218*	-.0271*	-.0652*	-.1769+	-.0431	-.0310+	-.0202	-.0243*	-.0172*
1955-68	100.0	0	0	-.0211*	-.0272*	-.0691*	-.1968+	-.0429+	-.0291*	-.0138	-.0225*	-.0149*
No Front End Loading												
	5.1	40.2	54.8	-.0417+	-.0255	-.0102	-.0415	-.0289	-.0246	-.0186	-.0276	-.0227
	16.7	33.3	50.0	-.0380+	-.0305+	-.0105	-.0547*	-.0185	-.0186	-.0213	-.0262	-.0224
	33.3	33.3	33.3	-.0325*	-.0276+	-.0279	-.0556*	-.0154	-.0144	-.0170	-.0245+	-.0194+
	52.5	20.1	27.4	-.0285*	-.0265*	-.0302+	-.0536*	-.0133	-.0104	-.0183	-.0239*	-.0172+
	68.3	13.4	18.3	-.0258*	-.0258*	-.0324+	-.0564*	-.0133	-.0106	-.0176+	-.0234*	-.0160+
Moderate Front End Loading												
	5.1	40.2	54.8	-.0232	-.0069	-.0094	-.0174	-.0163	-.0120	-.0015	-.0025	-.0211
	16.7	33.3	50.0	-.0212	-.0125	-.0086	-.0244	-.0148	-.0213	-.0019	-.0077	-.0204
	33.3	33.3	33.3	-.0230+	-.0154	-.0262+	-.0251	-.0206	-.0198	-.0065	-.0154	-.0183+
	52.5	20.1	27.4	-.0236*	-.0200	-.0282+	-.0267	-.0213	-.0188	-.0101	-.0184+	-.0167+
	68.3	13.4	18.3	-.0246*	-.0231+	-.0311+	-.0319	-.0221	-.0173	-.0130	-.0206*	-.0157+
Heavy Front End Loading												
	5.1	40.2	54.8	-.0238	-.0119	-.0095	-.0166	-.0205	-.0113	-.0108	-.0072	-.0183
	16.7	33.3	50.0	-.0192	-.0145	-.0089	-.0252	-.0163	-.0152	-.0103	-.0090	-.0177+
	33.3	33.3	33.3	-.0207+	-.0155	-.0197	-.0253	-.0177	-.0145	-.0091	-.0129	-.0166+
	52.5	20.1	27.4	-.0207*	-.0180+	-.0227+	-.0279	-.0184	-.0154	-.0083	-.0156+	-.0159+
	68.3	13.4	18.3	-.0216*	-.0200+	-.0269+	-.0319	-.0212	-.0174	-.0093	-.0182*	-.0154*

the former spans the wage-bargains or reviews (some dating back to 1953 and 1954) which are explained in the experimental regressions.

While it is somewhat difficult to present an overview of these 612 estimated coefficients, a cursory examination of Tables 11A-11D reveals substantial differences in these coefficients. With few exceptions, the specification of a particular set of aggregation-institutional assumptions has a dramatic effect on inferences drawn with respect to significance levels and parameter values. As a possible benchmark for a review of these sensitivity experiments, one might employ the assumption of a one year contract with equal weights (column 9, rows 1 and 2) since these are the results always presented in the empirical literature. However, this assumption is arbitrary in the same sense as any other choice with respect to seasonal bargaining patterns, lengths of contracts and the degree of front-end loading in the absence of prior knowledge.

Conclusion

The results for two experiments are reported above. In the first experiment, the problem of equal weights for proportions of the labour force is considered within the context of a one-year contract model whereas, in the second experiment, several other well-known features of the labour market are incorporated into the model. The graphical displays for the first experiment and the tabular displays for the second one strongly indicate that the institutional details of the labour market must be given far more attention than they have received in recent research concerned with the determinants of wage-changes as revealed in quarterly time series. Knowledge of these details is an essential preliminary for econometric analyses since the size of parametric estimates and their apparent statistical significances, according to conventional criteria, depend very critically on such knowledge. Further, the patterns suggested by invalid aggregation-institutional assumptions are sufficiently perverse for us to assert that no simple correctional modifications can necessarily reduce the effects of our ignorance. Statistical analyses of the OAWC model cannot reveal the nature of the wage-determination process without a substantial effort by both the users and collectors of economic data to clarify the structural form of the institutional background in the labour market.

FOOTNOTES

1. A partial list of studies which employ the OAWC model would include [1], [2], [4], [5], [6], [7], [8], [10], [11], [12], [13], [14], [15], [16], [17], [18], [24], [25], and [28].

2. As shown elsewhere [19], this assumption of equal weights is inconsistent with the previous aggregation assumptions. It also ignores the stochastic elements contained in the weights.

3. These latter two assumptions are not above criticism. For example, Sparks and Wilton [26] found that a trade-off existed for wage settlements and contract length (i.e., parameter estimates differed for short and long contracts) in the Canadian manufacturing sector.

4. For further details, see [15, pp. 36-38].

5. While this variable is often simply entered as an overlapping annual change (like the dependent variable), unequal group weighting necessitates its decomposition into a weighted average of quarterly changes.

6. The change in profit rate variable in the Perry model has been omitted given its insignificance throughout all of our experiments.

7. Given that the dependent variable represents the annual change in wages for each bargain group while the explanatory variable for consumer price changes is on a quarterly basis, all consumer price coefficients should be scaled by a factor of approximately one-quarter.

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