Union Wage Settlements During a Disinflation

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The three-year union labor contract has been singled out by many economists as a major factor underlying the persistence of wage inflation in the United States, and a reason for the resistance of inflation to aggregate demand policy. Set throughout a three-year cycle of decentralized collective bargaining settlements, these overlapping contracts have also been cited as the primary institutional difference between U.S. wage determination and that of other countries, such as Germany and Japan, where nominal wage inflation has appeared to be less persistent.[1] Such differences have even led to proposals for shortening the terms of U.S. labor union contracts and centralizing contract settlements in order to reduce the persistence of inflation.

The basic rationale for assigning a major role in the inflation process to the institution of three-year union contracts follows closely from arguments developed in the labor economics literature and, in particular, the early "pattern bargaining" literature of Arthur Ross (1948) and John Dunlop (1957). One union sets a pattern wage increase and other unions who follow in the bargaining cycle imitate with a similar wage increase. For example, in making a case for centralization reforms, Lester Thurow has recently argued:[2]

> American wages are now set in a context of overlapping three-year indexed contracts. In such a system it becomes very difficult to phase down wage gains unless an industry is on the brink of extinction. Suppose that this year the Machinists' union is negotiating a new three-year contract. Last year the Auto Workers negotiated a three-year contract for 10% rise per year. In many plants machinists work right next to auto workers. No leader of the machinists can settle for less than 10% per year and still remain in office. And in two years' time the auto leaders will be similarly imprisoned by what the machinists negotiate today...All contracts should run the same length of time, so that the country could negotiate in simultaneous national wage negotiations. [1982, p. 32]

Recently, formal, though highly aggregated, models of overlapping wage setting have appeared in the macroeconomic literature. These models are somewhat different from the earlier explanations of wage persistence in that explicit theories of endogenous inflationary expectations have been incorporated into the wage contracting process (see my 1980 article, for example). The results have indicated that the persistence of inflation generated by overlapping contracts is considerably different and potentially much less resistant to changes in macroeconomic policy than earlier studies have indicated.[3] To date, however, these aggregate models have not incorporated any *explicit* characteristics of long-term union contracts in the United States—the actual lengths of contracts, the number of workers negotiating at different dates throughout the year, the deferred wage increases, and the escalator clauses. Although the models have been formulated in enough detail for aggregate econometric work, institutional details (such as the distribution of workers by contract

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[1]Jeffrey Sachs (1979) has tabulated the different institutional arrangements for wage determination in the United States and several other countries. William Branson and Julio Rotemberg (1980), and Robert J. Gordon (1982) have presented econometric estimates which suggest that aggregate wage inflation has more inertia in the United States.

[2]Barry Bosworth (1981) has also recommended similar changes in U.S. collective bargaining.

[3]A recent critical analysis of the pattern bargaining hypothesis is reported in Daniel Mitchell (1980, pp. 163–207).

length) have been treated as parameters to be estimated. Hence, these models have not been able to address explicit issues involving wage settlements in the union sector.

The purpose of this paper is to examine some of these issues by developing and simulating a model of overlapping contracts explicitly oriented toward the major union sector in the United States, but which takes account of expectations as in the more aggregated models in the macro literature. Using data on union wage settlements, I calculate the distribution of workers by contract length and take account of the deferred wage increases and the escalator clauses which have come to be important features of many long-term contracts. The main aim in developing such a model is to determine the constraints which the long-term overlapping contracts put on attempts to reduce the rate of inflation, or to break the momentum of inflation. The most effective way to characterize these constraints is to calculate the maximum speed of disinflation which can occur without a rise in unemployment and without wage concessions in *existing* contracts. The model indicates that the maximum speed may be extremely slow in the early phases of disinflation—almost imperceptable in the first few quarters—followed by a period of greater deceleration of wages until the new lower rate of inflation is reached.[4] Such a disinflation path is considerably different than the instantaneous drop to low inflation rates observed by Thomas Sargent (1982) in his study of the end of the hyperinflations in the 1920's. However, the existence of a path of inflation reduction along which the increase in unemployment is minimal, despite the long-term contracts, raises questions about whether the institution of overlapping union wage setting is really the central difficulty in reducing inflation without real costs, and whether centralization reforms would be of much value.[5] The model indicates that a *gradual* reduction in the growth of aggregate demand is necessary to reduce inflation without great costs in an economy with long-term contracts. The difficulty with such a path is that it may raise doubts in the early stages about whether a lower inflation rate will ever be reached. Potentially, the information provided by the model may be of some value to policymakers in planning and communicating a monetary disinflation, as well as to individual wage negotiators deciding what to do during such a disinflation. It may even help in improving the accuracy of inflation forecasting.

The paper is organized as follows: Section I describes the central features of overlapping wage contracts in the major union sector of the United States. Section II examines the problem of determining an appropriate level of disaggregation for modeling purposes and introduces notation and assumptions used in the model. Section III describes the behavioral equations of the model, and Sections IV and V report the results of calculations and simulations of a disinflation from 10 to 3 percent wage inflation.

I. Characteristics of Long-Term Union Wage Contracting in the United States

In May 1981, the United Mine Workers signed a contract with the Bituminous Coal Operators which is typical of the kind of wage adjustment found in the major union sector in recent years of relatively high inflation. Affecting about 160,000 workers, the contract called for wage increases over a set period of 40 months through September 1984. The wage increases would average 11 percent per year, starting with an immediate adjustment of $1.20 and followed by deferred increases of $1.10 and $1.00 in the second and third years, and $.30 in the last quarter. Clearly these deferred increases reflect high expected inflation rates on the part of both the firms and workers, but the contract in-

[4]As is described in more detail below, the disinflation similations are made as if the major union sector constituted the entire U.S. labor force. Since long-term contracts are more prevalent in the major union sector, the results are likely to be biased toward slow adjustment, and a useful extension of the model would be to consider an adjustment for such bias.

[5]Such a path also exists for the more elementary models of wage contracts and has been explored by Edmund Phelps (1979).

volves no escalation clause. In this later respect, it is similar to about 45 percent of all major union contracts. The approximately 10 percent wage adjustments in the second and third year will occur according to schedule, unless the contract is reopened and concessions are made; an event which generally occurs only when the industry or certain firms reach distressed conditions.

The coal contract is one of the major union contracts (defined as affecting 1,000 or more workers) about which this type of detailed information on wage adjustment is available[6] in the United States. Approximately 10 million workers are involved in these major union contracts, or about one-half of all unionized workers who currently constitute about 20 percent of the labor force in the United States. The model developed below will focus on the workers in this major union sector for which such data are available. Although this sector accounts for only 10 percent of the U.S. labor force, there are good reasons to study this group of workers, even were it not for this data limitation.[7] The vast majority of three-year labor contracts are accounted for by this group of workers, and it is this group which has received most of the attention in current discussions about the international differences in wage-setting institutions. Although the evidence is mixed about whether these unions influence wage setting in the small union or the nonunion sector, or the reverse,[8] it is clear that close attention is paid to these contracts in policy discussions. Furthermore, once an adequate description of wage determination in these unions is developed, it would be possible to extend the framework to include the other wage-setting sectors, though we would have to rely on indirect estimation of the form of contracts in those sectors. In any case, in what follows, I will take the major union sector as the universe of workers in this analysis and base the calculations of aggregate wage change and inflation on this sector.

Table 1 summarizes the pattern of bargaining activity in this major union sector during the 1970's. Not all workers in this group are under three-year contracts, but a significant fraction are. The three-year cycle in the longer-term contracts is evident in Table 1, with 1979 and 1980 being heavy years in terms of collective bargaining, and 1981 being light, and with the three-year pattern continuing on a regular basis. Moreover, there is an obvious seasonal pattern with most bargaining activity taking place in the second and third quarters. There is some gradual shifting of these patterns caused either by delays in reaching a settlement or by early settlements. These shifts will move a group of workers out of its cycle, at least temporarily. Some of the shifting is also caused by deviations from the exact one-, two-, and three-year durations.

Table 2 summarizes the quarterly pattern of negotiated wage increases for the workers in the major union sector. Clearly a significant fraction of any wage adjustment occurs in the later years of long-term contracts, but there is some front-end loading with the current settlements a bit larger than the deferred increases. Moreover, any cyclical sensitivity of wage adjustment appears to occur mainly in the short-term contracts, or in the first year of the long-term contracts. The deferred wage increases show almost no cyclical sensitivity.

In interpreting these deferred wage increases, it is important to take account of the degree of escalation in these contracts. The data reported in Tables 1 and Tables 2 relate to both indexed and nonindexed contracts. About 55 percent of the workers in this major union sector have some type of escalation clause in their contracts, though it is usually less than full indexation to price changes. There is an obvious tradeoff between the size of the set deferred increase and the amount of indexing for any given expected rate of inflation. This is seen in Table 3 where a comparison of first-year and length-of-contract wage adjustments is given

[6]The data is kept on file at the U.S. Bureau of Labor Statistics. Summaries and cross tabulations are reported in various issues of *Current Wage Developments*.

[7]It should be emphasized, however, that this group may not be representative of workers in the United States where one-year implicit contracts seem to dominate most wage-setting situations.

[8]For a recent empirical investigation, see R. J. Flanagan (1976).

TABLE 1—NUMBER OF WORKERS IN MAJOR UNION SETTLEMENTS BY CONTRACT LENGTH, 1974:I–1980:IV
(Thousands of workers)

	Contract Length			
	One-Year	Two-Year	Three-Year	Total
1974: I	116	114	263	493
II	379	373	850	1602
III	233	269	1477	1979
IV	157	177	692	1026
1975: I	67	86	395	548
II	172	326	264	762
III	325	215	529	1069
IV	77	84	231	553
1976: I	29	67	158	254
II	109	259	1044	1412
III	163	159	673	995
IV	82	78	1104	1264
1977: I	43	98	226	367
II	215	138	950	1303
III	125	121	1325	1571
IV	52	60	400	512
1978: I	19	29	338	386
II	104	195	380	679
III	70	238	599	907
IV	58	97	378	533
1979: I	45	31	186	262
II	107	164	836	1107
III	39	49	1166	1254
IV	29	135	667	831
1980: I	10	60	299	369
II	80	167	693	940
III	99	203	1325	1627
IV	25	177	652	854

Notes: Major Settlements are those involving 1,000 or more workers. Contract length is rounded to nearest year.
Source: Current Wage Developments, from cumulative totals published quarterly for each year.

for contracts with and without escalators. Clearly the increased dispersion between the deferred increases in indexed and nonindexed contracts in the late 1970's reflects an increase in inflationary expectations (there has been only a slight increase in indexation over this period). As workers and firms expect the escalator clause to take up a large part of future wage increases, the deferred increases are correspondingly reduced. This substitution is built into the model described below and should indicate that the relatively modest deferred increases reported in the late 1970's in Table 2 are at least partially due to the indexation clauses in many of these contracts.

It should also be noted that Table 2 does not include fringe benefits. For a smaller group of workers (settlements involving 5,000 or more workers), similar data are available on total compensation adjustments though these data are not available by contract length or by *annual* deferred increases. Table 4 reports a comparison of wage vs. compensation adjustments which indicates that the discrepancies between the two are of some potential significance.

In any given quarterly time period, the aggregate wage change for the group of workers in the major union sector can be divided into the *current* settlement component determined in the current quarter, and

TABLE 2—CURRENT AND DEFERRED WAGE CHANGE IN MAJOR UNION SETTLEMENTS BY CONTRACT LENGTH, 1974:I–1980:III

	One-Year Contracts	Two-Year Contracts		Three-Year Contracts		
		Year 1	Year 2	Year 1	Year 2	Year 3
1974: I	7.3	6.7	7.3	7.2	5.9	5.2
II	9.4	8.7	6.5	9.3	5.2	3.8
III	10.5	10.4	5.9	10.7	5.0	4.5
IV	12.2	11.1	6.9	9.9	5.7	4.8
1975: I	6.8	13.8	9.6	13.2	4.0	4.0
II	6.5	10.9	8.5	11.0	6.0	4.3
III	7.8	8.9	6.7	10.7	5.9	5.5
IV	7.3	10.6	7.2	9.8	5.3	4.8
1976: I	6.2	8.0	6.9	9.3	8.1	6.1
II	5.8	7.0	5.3	9.0	6.1	5.6
III	5.5	8.7	6.5	10.7	6.7	5.4
IV	6.2	7.0	5.2	7.2	4.1	2.8
1977: I	3.4	9.2	8.5	7.7	5.6	5.0
II	5.6	7.5	5.8	8.8	5.1	4.5
III	6.1	7.0	6.3	7.8	4.3	1.7
IV	3.8	9.2	6.7	8.2	5.4	3.9
1978: I	6.4	5.5	4.6	10.6	6.4	4.9
II	5.2	7.7	7.1	6.8	5.5	2.7
III	6.5	7.4	6.0	7.5	5.7	3.9
IV	6.2	8.0	5.8	7.2	5.4	4.2
1979: I	8.2	8.8	5.4	3.3	9.5	3.9
II	8.2	9.0	6.9	9.2	6.0	4.0
III	7.7	8.0	12.2	6.6	4.0	3.4
IV	7.3	9.4	7.5	6.4	4.8	6.2
1980: I	10.1	10.7	9.9	6.7	4.6	4.7
II	10.9	11.8	8.8	7.7	4.7	4.4
III	13.5	10.7	9.3	10.5	5.6	4.9

Source: Current Wage Developments.

TABLE 3—CONTRACT SETTLEMENTS WITH AND WITHOUT ESCALATOR CLAUSES

	1977	1978	1979	1980[a]
First-Year Adjustment	7.8	7.6	7.4	9.1
Contracts with Escalator	8.0	7.1	6.2	7.4
Contracts without Escalator	7.6	8.0	9.1	11.6
Adjustment Over Life of Contract	5.8	6.4	6.0	6.8
Contracts with Escalator	5.0	5.3	4.6	4.7
Contracts without Escalator	6.9	7.1	8.0	9.2

Source: Current Wage Developments.
[a]First three quarters.

TABLE 4—CONTRACT SETTLEMENTS WITH AND WITHOUT FRINGE BENEFITS

	Wage Change in Settlements with 1,000 or More Workers		Compensation Change in Settlements with 5,000 or More Workers	
	1978	1979	1978	1979
First-Year Adjustment	7.6	7.4	8.3	9.0
Average Over Life of Contract	6.4	6.0	6.3	6.6

Source: Current Wage Developments.

TABLE 5—CONTRACT COHORTS AND DISTRIBUTION OF WORKERS USED IN UNION WAGE MODEL
(Thousands of workers)

One-Year Contracts		Two-Year Contracts		Three-Year Contracts		Last Period	Example
Cohort	Workers	Cohort	Workers	Cohort	Workers	of Observation	Settlement
1	10	1	60	1	299	1980: I	Tobacco
2	80	2	167	2	693	1980: II	Aluminum
3	99	3	203	3	1325	1980: III	Steel
4	25	4	177	4	625	1980: IV	Aerospace
		5	31	5	338	1978: I	Railroads
		6	164	6	380	1978: II	Coal
		7	49	7	599	1978: III	Mail
		8	135	8	378	1978: IV	Airlines
				9	186	1979: I	Trucking
				10	836	1979: II	Rubber
				11	1166	1979: III	Electrical
				12	667	1979: IV	Automobile

the *prior* settlement component determined by previous deferred wage increases, plus an adjustment for indexation, the escalator component. The sum of these gives the total effective wage change for this sector and corresponds closely to other measures of aggregate compensation in the United States.

II. Aggregation Issues

An important consideration in designing a model of wage contracting is the appropriate level of aggregation. Some wages disaggregation is necessary because of the differences in the contracts signed at different dates. At any point in time, the aggregate wage is composed of contract wages set by workers at different times in the past, and hence with different information sets and with different remaining durations. Aggregating across such contracts could miss crucial features of the dynamics of inflation.

While it is possible to model each of the 5,000 settlements in the major union group separately, as the BLS data file has information on every settlement, for computational reasons I chose to aggregate these settlements into twenty-four groups of workers, and to focus on the average wage change for contracts negotiated in each quarter. Contracts are first grouped into three classes corresponding to their length: 6 months through 18 months, 19 months through 30 months, and 31 months and over. These correspond to the one-, two- and three-year grouping of contracts shown in Table 1. The twenty-four groups, or cohorts, of workers then correspond to the four groups of workers signing one-year contracts every four quarters, the eight groups of workers signing two-year contracts every eight quarters, and the twelve groups of workers signing three-year contracts every twelve quarters.

The relative importance of each of these twenty-four groups in the wage setting process can be obtained directly from the data on the number of workers by contract length reported in Table 1.

As mentioned above, however, the distribution of workers by contract length drifts gradually over time; that is, the one-, two-, and three-year cycles do not exactly repeat themselves every one, two, or three years. Hence, the composition of each of these twenty-four groups of workers gradually changes over time. For the purpose of illustrating the general properties of the model, this drift can be ignored. I use the most recent contract data reported in Table 1 and assume that this distribution repeats every one, two, or three years depending on the length of the contracts.[9] This distribution, organized into the twenty-four contract cohorts, is shown in Table 5, along with the

[9]For forecasting purposes, it might be useful to incorporate the actual distribution during the forecasting period.

year of observation upon which the distribution is based. As an aid in keeping track of the cohort groups, I have given a representative industry bargaining name to each cohort, which is also shown in Table 5.

In any given quarter, three of these groups will be negotiating wage changes: one of the one-year, one of the two-year, and one of the three-year contract groups. It is assumed that all wage changes occur at the start, and at yearly intervals after the start of each contract. Hence, the one-year contract group must determine a single wage level for the year. The two-year contract group must determine two wage levels: one for the first year, and one for the second year. The three-year contract group must determine three wage levels: one for each of the three years. The wage change for the first year of these contracts corresponds to the *current* settlement and the wage changes for the second and third year correspond to deferred settlements in Table 2.[10]

In order to summarize these assumptions and describe the behavioral relationships which underlie the model, some notation will be helpful. Let $n_j(t)=$ number of workers signing contracts of length j in quarter t, and $x_j(t,s)=$ log of the wage set in contracts of length j signed in quarter t to prevail in the sth quarter following quarter t. The aggregation assumption is that j equals either 4, 8, or 12, corresponding to the one-, two-, and three-year contracts. The assumption that wage changes occur only at yearly intervals is represented algebraically as

$$(1)\ x_j(t,s)=x_j(t,0),\ s=1,2,3,\ j=4,8,12$$

$$(2)\ x_j(t,4+s)=x_j(t,4),\ s=1,2,3,\ j=8,12$$

$$(3)\ x_{12}(t,8+s)=x_{12}(t,8),\qquad s=1,2,3.$$

Equation (1) states that the wage level is constant during the first year of the one-, two-, and three-year contracts ($j=4,8,12$), and equal to the value determined in the first quarter $x_j(t,0)$. Equation (2) states that the wage level is constant during the second year of the two- and three-year contracts ($j=8,12$), and equal to the value set in the first quarter of the second year $x_j(t,4)$. Finally, equation (3) states that the wage level is unchanged during the third year of three-year contracts ($j=12$).

During each quarter, six wage levels are determined; three current levels: $x_4(t,0)$, $x_8(t,0)$, and $x_{12}(t,0)$; and three deferred levels: $x_8(t,4)$, $x_{12}(t,4)$, and $x_{12}(t,8)$. Note that there is no presumption that the deferred wage levels are equal to the current levels so that deferred increases are possible according to this setup.

The aggregate wage is a weighted average of the contract wages and is given by the expression

$$(4)\quad w(t)=\frac{\sum_j\sum_{s=0}^{j-1}n_j(t-s)x_j(t-s,s)}{\sum_j\sum_{s=0}^{j-1}n_j(t-s)}.$$

My use of logarithms means that (4) should be interpreted as the log of a geometrically weighted index of contract wages.

III. Wage-Setting Assumptions

The wage determination process is analogous to that used in the theoretical staggered contract model described in my 1980 article. In particular, I assume that, in the absence of a need for a change in relative wages, it is natural for workers and firms to attempt to keep their own wages as close as possible to

[10]Although the data in Table 2 were used only as a general guide is designing the model, as a rough check on the adequacy of this aggregation procedure, I compared the behavior of the *effective wage* change as estimated using these aggregation assumptions and the data in Table 2 with the actual effective wage change compiled by BLS using the full file on individual union settlements. Although there were some discrepancies, my estimated series matched the major movements in the actual series. Preliminary work with an aggregation scheme which does not distinguish between contracts of different length (i.e., an aggregate of *all* settlements in a given quarter) and which lumped all deferred increases into a single change "over-the-life" of the contract, did not prove successful in generating a reasonable effective wage change series. Hence, it appears that a level of disaggregation at least as fine as that chosen here is necessary to achieve a satisfactory degree of accuracy.

the prevailing level of wages during the period of the contract, adjusted for skill and other differentials. If wage adjustments are thought to be necessary, because of a shift in labor market demand or supply conditions, then these adjustments will be made relative to this prevailing wage. Since we are interested in how union contracts should be adjusted during a general disinflation period, where there is no explicit need for relative wage change, I will focus on a behavioral assumption which maintains the relative wage structure.

Consider first the case of nonindexed contracts. Assume that one-year contracts will call for a wage adjustment to equal the average wage *expected* to prevail during the contract period. Similarly, the *first* year of two- and three-year contracts will have a wage adjustment to equal the prevailing wage during that same one-year period. Algebraically the current settlements are then given by

$$(5)\quad x_j(t,0)=\tfrac{1}{4}\sum_{s=0}^{3}\hat{w}(t+s),\qquad j=4,8,12,$$

where $\hat{w}(t)$ is the expectation of $w(t)$ the average wage defined in equation (4). For the deferred wage increases in the second year of two- and three-year contracts, assume

$$(6)\quad x_j(t,4)=\tfrac{1}{4}\sum_{s=4}^{7}\hat{w}(t+s),\qquad j=8,12,$$

and finally, for the deferred increase in the third year of three-year contracts,

$$(7)\qquad x_{12}(t,8)=\tfrac{1}{4}\sum_{s=8}^{11}\hat{w}(t+s).$$

Most theories of wage adjustment suggest that labor market conditions will influence wages and, in particular, that wages will be bid up relative to the prevailing wage during periods when the unemployment rate is low, and conversely when the unemployment rate is high. This, for example, is the explicit assumption used in my 1980 article. It would be appropriate, therefore, to add a negative function of the unemployment rate (measured relative to the natural or normal level of unemployment) to the right-hand side of equations (5)–(7). The fact that no additional terms are added, so that equations (5)–(7) hold at all times, is simply a way to ensure that full employment is maintained. As stated in the introduction, this is a convenient way to characterize how wage contracts constrain the movements of aggregate wages. Of course, it would be possible to modify the model by adding unemployment effects to the right-hand side of equations (5)–(7) in order to examine how much unemployment might rise if disinflation occurs too quickly.

The behavioral equations reflect a relative wage concern on the part of workers. It is possible to interpret these equations in terms of the wage imitation literature: each union imitates the behavior of other unions by establishing wages which meet the going wage. Note, however, that (skill-adjusted) wage levels, not rates of change, are what are imitated. Moreover, in terms of pattern bargaining terminology, the pattern must run in both directions. Because the aggregate wage $w(t)$ is comprised of past wage decisions (see equation (4)), each of equations (5)–(7) indicate that current wage decisions are "patterned" on previous wage decisions. But since the future contract decisions are also embedded in the future average wages, current wage decisions are also patterned on future wage decisions. The traditional pattern bargaining literature focused entirely on the former type of patterning. The behavioral equations used here are forward-looking, although the staggering of contracts naturally leads to backward-looking. These features have been emphasized in the recent theoretical overlapping contract literature.[11]

When contracts are indexed, the contracted adjustment in wages will reflect the expected increase or decrease in wage rates

[11] Note that wages are set to equal the prevailing wage *ex ante* in equations (5)–(7). Surprise movements in other workers' wages may disrupt this goal, so that *ex post* there may be relative wage gains or losses. An unsettled issue is whether workers might try to "overtake" rather than just "catch up" to other workers in order to make up these losses; such "overtaking" is ruled out by the behavioral assumptions in this model.

which will arise because of changes in the price level. Consider the following example. In a steady inflation of 10 percent, the above contracting arrangements would imply that a three-year contract *without* indexing would have a 10 percent increase in the first year, followed by a 10 percent increase in each of the second two years (10,10,10). Suppose, instead, that contracts are indexed at .3 in the second and third year, so that a 10 percent increase in the price level automatically adds 3 percent to the wage in the second and third year. Then in a steady 10 percent inflation where prices and wages are increasing at the same rate, the set wage increase would again be 10 percent in the first year, but only 7 percent in the second and third years (10,7,7). The remaining increase in wages of 3 percent in the second and third years would come from indexing; that is, (10,7,7)+(0,3,3) = (10,10,10).

These effects are incorporated into the model by adjusting down the set wage in equations (6) and (7) by the amount of increase which is *expected* from indexing. The exact size of the indexing is assumed to be a constant fraction of the increase in the aggregate price level during the previous four quarters. This constant is the same for all workers.[12] I assume, as in the example, that indexing reviews occur annually at the start of the second and third year of two- and three-year contracts. One-year contracts are not indexed. In the calculations reported in this paper, the real wage is assumed to be constant so that the indexing is assumed to be a fixed fraction of the increase in the aggregate wage.

IV. Solving the Model

I will use the rational expectations assumption for generating the forecasts of future expected wages. To do this, the model must be closed. The easiest way to do this is to assume a simple quantity-type relation for the demand for money. In particular, assume that deviations of real *GNP* from trend are proportional to deviations of real money balances from trend. The assumption of full employment used in these solutions corresponds to holding real *GNP* at a trend (full-employment) level, or equivalently to holding real money balances at a trend (full-employment) level. If real wages are constant, then we simply require that real balances measured in wage units do not deviate from a level consistent with full employment. Let $m(t)$ be the log of money, which is assumed to be exogenous. The model is closed by requiring that

$$m(t)-w(t)=k, \tag{8}$$

where k is the full-employment level of real balances.

I will only simulate the model for paths for which (8) is satisfied. The qualitative behavior of the economy when (8) is not satisfied is fairly clear, however. If $m(t)-w(t)>k$, then unemployment will fall below normal levels, because higher real balances will reduce interest rates and stimulate demand. Similarly, if $m(t)-w(t)<k$, then unemployment will rise above normal. In the first situation, the low unemployment will tend to bid up new wage settlements relative to the prevailing level, because a positive term would appear on the right-hand side of (5)–(7). In the second situation, wage settlements will be bid down.

The model, consisting entirely of equations (1)–(8), is a linear (in the logarithms) rational expectations model. At each date, six wage levels are determined and these depend on wage decisions made as far as eleven quarters in the past and on wage decisions to be made as far as eleven quarters in the future. The model has "accelerationist" properties in that any steady-state money growth path and corresponding wage inflation path satisfies the equations of the model, and is therefore consistent with full employment. In this paper, however, we are interested in disinflation—moving from a high rate of inflation to a low rate of inflation—without deviating from full employment. To

[12] Rather than assume that a fraction of workers have indexed contracts, I assume that all workers are indexed though at a lower rate. For example, if 50 percent of the workers have contracts indexed at .6, then this is treated in the model as if 100 percent of the workers have contracts indexed at .3.

calculate such disinflation paths, the model was solved using the *EP* algorithm discussed by Ray Fair and myself (1983). In all cases we found that there was only one full-employment disinflation path for a given parameter configuration of the model.[13] The properties of this path are described in the next section.

V. Patterns of Wage Settlements During a Disinflation

Consider a situation where the rate of wage inflation has been steady for a long period of time at 10 percent per year and where there is no indexation of contracts. Then, according to the equations of the model, the current wage adjustment and deferred wage adjustments in the only-term contracts would all be equal to 10 percent per year. For example, every three years the Coal Miners would sign a contract calling for 10 percent wage increase in each of the three years of their long-term contract, much as in the actual 1981 agreement discussed above. After the signing of such agreements, there would be a considerable overhang of deferred pay *increases* in future years. It is this overhang which makes it necessary for wage adjustments in other contracts to be gradual if subsequent to the coal settlement a general disinflation begins.

Suppose that, in the first quarter of a heavy bargaining year (for example, the Tobacco contract cohort), a general disinflation from 10 to 3 percent begins and is thereafter expected to continue.[14] The important policy issue about how such a disinflation is engineered through aggregate demand policy depends greatly on how union wage settlements might develop. Table 6 shows the settlement pattern which is consistent with the equations of the model and therefore with full employment. The first six columns of Table 6 show the contract wage settlements in percentage terms. These are simply the changes in the (logarithms of the) levels of the wages determined as explained above. The column labeled One-Year Contracts shows the current settlement for workers signing one-year contracts in that quarter; that is, $x_4(t,0)-x_4(t-4,0)$. Similarly the columns labeled Year 1 in Two-Year and Three-Year Contracts show the percentage change in the current settlement for those cohorts. The columns labeled Year 2 and Year 3 show the deferred increase in the longer-term contracts. The effective wage change is simply the first difference of the log of the aggregate wage $w(t)$ from quarter to quarter $(w(t)-w(t-1))$. Because of the seasonal pattern of workers negotiating each quarter, it is more informative to look at the change of $w(t)$ over four quarters which is shown in the Effective Wage Change column labeled Year.

The simulation begins in quarter I of year 1. Previous to this first quarter, the entries in Table 6 would have been 10 percent in all columns with the exception of the quarterly effective wage change which fluctuates seasonally.[15]

What is most striking about Table 6 is the gradual decline in the inflation rate, especially in the early periods of the disinflation. The effective wage change decline is barely noticeable for a full year. The decline is about one percentage point in the second year, a large five percentage points in the third year, and about one more percentage point in the fourth year. It is only after the new negotiations are well beyond the overhang of past deferred wage increases that noticeable declines in the inflation rate occur. Note, however, that in the long-term

[13] This corresponds to Phelps (1979) result for the elementary staggered contracts model. The details of the solution procedure are as follows. We added $m(t)-w(t)-k$ to the right-hand side of equations (5)–(7) and solved the model for a given $m(t)$ path. We then summed up the squared differences $[m(t)-w(t)-k]^2$ over the solution period, and searched over $m(t)$ paths using the *DFP* algorithm to minimize the sum of squares. The minimum value was always zero. Clearly when $m(t)-w(t)-k=0$, full-employment conditions hold.

[14] Specifically assume that this begins at the negotiation time for the first cohort of those signing one-year contracts, for the fifth cohort of those signing two-year contracts, and the first cohort of those signing three-year contracts. See Table 5.

[15] The entries in this last column were fluctuating seasonally according to the steady quarterly pattern 1.06, 2.66, 3.95, 2.33, before the disinflation began.

TABLE 6—CURRENT AND DEFERRED WAGE CHANGES DURING DISINFLATION
(No indexing)

Year/ Quarter	One-Year Contracts	Two-Year Contracts		Three-Year Contracts			Effective Wage Change	
		Year 1	Year 2	Year 1	Year 2	Year 3	Quarter	Year
1: I	10.0	10.0	9.6	10.0	9.6	6.4	1.06	10.00
1: II	10.0	10.0	9.3	10.0	9.3	5.1	2.66	10.00
1: III	9.9	9.9	8.7	9.9	8.7	4.0	3.92	9.98
1: IV	9.8	9.8	7.7	9.8	7.7	3.4	2.31	9.96
2: I	9.6	9.6	6.4	9.6	6.4	3.2	1.02	9.93
2: II	9.3	9.3	5.1	9.3	5.1	3.0	2.54	9.81
2: III	8.7	8.6	4.0	8.6	4.0	3.0	3.61	9.48
2: IV	7.7	7.5	3.4	7.5	3.4	3.0	1.96	9.13
3: I	6.4	6.4	3.2	6.0	3.2	3.0	0.67	8.77
3: II	5.1	5.1	3.0	4.4	3.0	3.0	1.29	7.52
3: III	4.0	4.0	3.0	2.7	3.0	3.0	1.40	5.32
3: IV	3.4	3.4	3.0	.9	3.0	3.0	0.60	3.97
4: I	3.2	3.2	3.0	3.2	3.0	3.0	0.34	3.64
4: II	3.0	3.0	3.0	3.0	3.0	3.0	0.81	3.15
4: III	3.0	3.0	3.0	3.0	3.0	3.0	1.18	2.93
4: IV	3.0	3.0	3.0	3.0	3.0	3.0	0.70	3.02
5: I	3.0	3.0	3.0	3.0	3.0	3.0	0.32	3.00
5: II	3.0	3.0	3.0	3.0	3.0	3.0	0.80	3.00
5: III	3.0	3.0	3.0	3.0	3.0	3.0	1.18	3.00
5: IV	3.0	3.0	3.0	3.0	3.0	3.0	0.70	3.00

TABLE 7—CURRENT AND DEFERRED WAGE CHANGE DURING DISINFLATION
(30 percent indexing)

Year/ Quarter	One-Year Contracts	Two-Year Contracts		Three-Year Contracts			Effective Wage Change	
		Year 1	Year 2	Year 1	Year 2	Year 3	Quarter	Year
1: I	10.0	10.0	6.6	10.0	6.6	3.6	1.06	10.00
1: II	10.0	10.0	6.3	10.0	6.3	2.5	2.66	10.00
1: III	9.9	9.9	5.7	9.9	5.7	1.8	3.93	9.98
1: IV	9.8	9.8	4.8	9.8	4.8	1.8	2.31	9.96
2: I	9.6	9.5	3.6	9.5	3.6	2.0	1.02	9.92
2: II	9.3	9.2	2.5	9.2	2.5	1.9	2.53	9.79
2: III	8.7	8.6	1.8	8.6	1.8	2.0	3.58	9.44
2: IV	7.6	7.4	1.8	7.4	1.8	2.1	1.93	9.07
3: I	6.3	6.3	2.0	5.9	2.0	2.1	0.66	8.71
3: II	5.1	5.1	2.0	4.3	1.9	2.1	1.28	7.46
3: III	4.0	4.0	2.0	2.6	2.0	2.1	1.40	5.27
3: IV	3.4	3.4	2.1	1.0	2.1	2.1	0.61	3.94
4: I	3.2	3.2	2.1	3.2	2.1	2.1	0.34	3.62
4: II	3.0	3.0	2.1	3.0	2.1	2.1	0.81	3.15
4: III	3.0	3.0	2.1	3.0	2.1	2.1	1.18	2.93
4: IV	3.0	3.0	2.1	3.0	2.1	2.1	0.70	3.02
5: I	3.0	3.0	2.1	3.0	2.1	2.1	0.32	3.00
5: II	3.0	3.0	2.1	3.0	2.1	2.1	0.80	3.00
5: III	3.0	3.0	2.1	3.0	2.1	2.1	1.18	3.00
5: IV	3.0	3.0	2.1	3.0	2.1	2.1	0.70	3.00

contracts there is a definite sign that disinflation is underway: the third-year deferred increases in the three-year contracts are down substantially relative to the previous settlement. The third-year deferred increase in the settlement negotiated in quarter II is about half the previous third-year deferred increase.

Table 7 shows the results of a similar disinflation in the case where the contracts are indexed according to the assumptions of the model. It is assumed that on average, contracts have 30 percent escalation. As one would expect, the actual effective wage change occurs less gradually in this case as the indexing formulas permit some change in the wage levels determined in previous contracts. However, the difference is very small. Recall that there is no indexing in the first year and that indexing reviews only occur annually. Alternative assumptions might make a greater difference.

It is useful to compare these results with the predictions of other models of wage and price dynamics. The rate of disinflation is considerably slower than what is implied by rational expectations models with perfectly flexible prices. As mentioned in the introduction, Sargent's finding that a quick disinflation occurred without significant real costs after the central European hyperinflation would not be expected in an economy with sticky prices or wages. The simulations of this model indicate in quantitative terms how large the difference in speed might be if the U.S. union wage contracting is the source of stickiness. On the other hand, the speed of disinflation is faster than what is implied by conventional expectations-augmented Phillips curve models which imply that the rate of inflation cannot be reduced at all by aggregate demand policy without an increase in unemployment. These models predict that inflation would remain at 10 percent if unemployment doesn't rise above the natural rate.

VI. Concluding Remarks

The simulations presented in this paper have focused on a possible scenario for union wage settlements during a disinflation in the context of three-year contracts. Although the scenario shows that it is possible in principle for such a disinflation to occur without any increase in unemployment, the path of the adjustments which I have calculated shows extremely gradual changes in the first two years of a disinflation program.

Under the assumption of a fairly stable relationship between money and nominal *GNP*, this implies a very gradual deceleration of money growth during the early stages of disinflation. The shape of the overhang of previously negotiated deferred wage increases implies that a gradual reduction in money growth would permit the economy to get past this overhang before starting the more rapid part of the disinflation program.[16] The difficulty with this in practice is that wage negotiators have to be convinced that the deceleration will come later even though it is not occurring today. (The last column in Tables 6 and 7 have to be rational forecasts.) This credibility problem is perhaps the central source of difficulty which is raised by long-term union contracts during a period of disinflation. At the heart of this credibility problem is a time-inconsistency problem that takes a particularly explicit form in this model of union wage settlements: if policymakers find it optimal to ratify the overhang of past deferred wage increases in the hope that negotiators will begin to adjust their wage demands in the future, they will also find it optimal to ratify the deferred wage increases in the future if these adjustments do not take place.

[16]Phelps (1980) has considered these issues in the context of theoretical models of wage contracting.

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