INCOME REDISTRIBUTION DURING A DISINFLATION

AND ITS EFFECT ON THE DISINFLATION PATH

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Comments from Orley Ashenfelter, Alan Blinder and John Taylor and participants of the Macro Workshop at Princeton University are greatly appreciated. All remaining errors are my own.
Abstract

It is often said that wage adjustment during a disinflation is sluggish because those who might initiate any downward movement fear a permanent real income loss. Yet there remains little empirical work on this subject.

This paper estimates the income redistribution among different sectors of society that results from a government disinflation policy. A model of wage setting in the U.S. economy is developed, then simulated for alternative money growth paths and private sector behavioral parameters. It is found that a sudden change in monetary policy can cause a significant amount of income redistribution. A slow monetary deceleration may take slightly longer to achieve a disinflation, but there will be significantly less redistribution, greater price stability, and perhaps greater responsiveness of wage setting to monetary policy.
INTRODUCTION

Two types of income redistribution influence aggregate wage and price dynamics: redistribution from unemployed workers to employed workers, and redistribution between employed workers. There is an extensive 'Phillips curve' literature on the theoretical and empirical underpinnings of the effects of unemployment on growth in nominal wages and the price level. Discussion of the second type of redistribution is only heuristic. It is often said that wage adjustment is sluggish because those who might initiate any downward movement fear a permanent real income loss.¹ This suggests that (perhaps temporary) redistribution of income inherent in a disinflation becomes an obstacle to the disinflation itself. Yet there remains little empirical work on this subject.

This paper estimates the income redistribution among different sectors of society that results from a government disinflation policy. In contrast to earlier work, income transfers between employed workers are concentrated on, to the exclusion of transfers from unemployed workers. The emphasis is on redistribution through wages rather than through prices, so the price level is taken to be determined by unit labor costs. Movements in the aggregate price level are derived from the behavior of disaggregate decision-making units. The overlapping wage contracts model

¹This point is made in Bosworth (1981), Gordon (1982) and Thurow (1982).
of Taylor (1980) is adopted as a useful paradigm in which to perform the analysis. This is a model that identifies individuals by the time at which they signed a wage contract, the minimum heterogeneity needed for the analysis.

Given the institutional structure that exists in the U.S. labor market, dynamic simulations are used to find the income redistribution between different negotiating cohorts generated by varying degrees of wage sensitivity to current and future economic conditions. It is shown that a sudden change in government policy can cause a significant amount of income redistribution. A slow monetary deceleration may take slightly longer to achieve a disinflation, but there will be significantly less redistribution, greater price stability, and perhaps greater responsiveness of wage setting to monetary policy.

The paper is organized as follows. Section one discusses the important features of wage determination in the U.S. economy and develops a model that usefully characterizes those facts. Numerical simulation results for the U.S. economy are reported in section two. A discussion of the underlying micro behavior and policy implications are in section three, followed by the concluding remarks.
1. WAGE DETERMINATION IN THE U.S. LABOR MARKET

1.1 The Facts

The majority of hours worked in the U.S. economy are on jobs that have a long duration. And while not all union contracts have a long duration, nor are all long-term agreements only in the union sector, the paradigm of union contracts will be adopted to analyze wage setting for the entire U.S. economy.

Frequently one collective bargaining unit tailors its contract on agreements reached at other employment locations. A number of different names have been given to this practice: pattern bargaining, wage contours, spillovers, wage rounds, or orbits of coercive comparison, each emphasizing a slightly different sequence of effects.

A number of economic and political reasons can be offered for this practice of pattern bargaining: (1) the costs of negotiation are high enough to encourage some labor leaders to link their wage requests in a casual or even contractual way to other settlements, (2) both union leaders and management will be concerned about alternative wages the rank and file could receive from other industries, the former to get reelected, the later to keep in business, and (3) the individual workers frequently

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2 Hall (1982) estimates the median job length to be 8 years. Of workers over 30 years old, 40% are in jobs that will last 20 or more years.
3 30% of the U.S. nonagricultural labor force is represented by collective bargaining agreements. The figures reported here and in the following paragraphs are in most cases for 1980. The sources are Department of Labor (1981a)(1981b), and Current Wage Developments, various issues.
4 For general references see Burton and Addison (1977) and Dunlop (1957).
have expectations of what they think is 'fair' which are conditioned by
negotiated increases in their own or in other industries. A relative wage
setting model is therefore a reasonable starting point for macroeconomic
analysis.

Typically the 'leaders' in wage setting are the more visible
agreements, covering large numbers of workers. So while the number of
workers covered by a single contract can range from a handful to 300,000,
for the purpose of aggregate analyses it is reasonable to concentrate on
only the largest union contracts. The Bureau of Labor Statistics in fact
collects detailed statistics on 'major' agreements that include 1000
workers or more, which cover 36% of the total organized work force.

There is significant variance in contract length even among the major
agreements. In 1980 less than 0.2% had contracts less than 12 months in
duration and 2.3% lasted more than 48 months. However the majority (64%)
of the agreements were exactly 36 months in length. If one aggregates the
number of workers covered by major contracts into three groups, 6-18
months, 18-30 months, and 30+ months, call them 1, 2, and 3 year contracts,
the historical breakdown for the 1970s is fairly stable at 4%, 11% and 85%,
respectively.

The timing of negotiations exhibits seasonal variability both within
years and between years. In any given year the third and second quarters
see the most activity. Of any three years, one will have significantly

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5The existence of private corporations that provide wage survey
information illustrates the concern businesses have over relative
wages, see Hewitt Associates (1982).
fewer negotiations than the other two. Early contract reopeners, over-long negotiations, exogenous shocks to the economy, as well as compositional changes in the labor force cause the distribution of contracts to shift over time.6

Salary increases are typically not spread evenly over the duration of the contract. There is a considerable degree of 'front-end loading' in which workers receive a large payment initially, with deferred but smaller increases in later periods. The Bureau of Labor Statistics reports figures for both first year and life of contract wage increases for major union contracts. Annual data for the five years prior to 1980 reveals an average first year increase of 8.1% and life of contract average of 6.3% while the average annual CPI increase was 9.0%.

The current and deferred fixed increases (which together give the life of contract figures) may not represent the entire compensation package. Deferred fixed increases typically are insensitive to short-run economic fluctuations. Most of the variance in contracts over time comes from first year increases (heavy front-end loading) and deferred increases contingent on economic behavior (typically the CPI). Cost-of-living adjustments are included in about 50% of the U.S. collective bargaining contracts, and can represent up to 10-20% of the total income a worker receives.7

6There were many changes in contract duration and inclusion of reopener provisions in response to wage/price controls in 1971-73. The settlement of the reopened Ford-UAW contract in February 1982, 8 months before the contract was to expire, is an example of another way in which the distribution can change.
7See Card (1983) for facts on wage escalation and a theory of how the degree of escalation might be determined.
1.2 The Model

Derivation of an analytically useful model of aggregate wage determination requires combining the salient characteristics of the facts just presented with a theory of wage setting. It is useful at first to consider only the major bargaining sector.

An important feature for time-series dynamics is the fact that contracts are multiperiod and staggered throughout the year. For the model let there be three different contract durations, one, two, and three years in length, with contracts of each type being negotiated in each quarter. This yields 24 separate negotiating cohorts, with 4, 8 and 12 cohorts covered by the 1, 2 and 3 year agreements, respectively. By assumption there will be no employment effects from wage policies to provide stability in the number of workers covered by each agreement. Because of the within year and between year seasonals, the (model) economy will follow a six year negotiating cycle.

Let the analytic model further simplify reality by restricting wage increases to occur once a year for each worker, rather than spread out over all four quarters of a year. Two and three year cohorts receive one and two years of deferred increases exactly four and eight quarters after the initial agreement, respectively. That is equivalent to saying that wage increases are fully front-end loaded in the first quarter of the negotiation year (with zero increases the next three quarters); there is no loading for the first year with respect to the second and third years of multiyear contracts.
Assume a wage setting rule for a one year cohort negotiating at
time $t$,

$$
\begin{align*}
X_t &= \frac{1}{4} (\hat{w}_t^* + \hat{w}_{t+1}^* + \hat{w}_{t+2}^* + \hat{w}_{t+3}^*) + \\
&\quad \frac{1}{4} (e_t + e_{t+1} + e_{t+2} + e_{t+3})
\end{align*}
$$

where $X_t$ is the natural logarithm of the negotiated wage, $w_{t+i}$ the log of
the aggregate wage in period (quarter) $t+i$, and $e_{t+i}$ an 'economic shock' in
period $t+i$.\(^8\) The asterisk indicates the trend level of wages, which is
defined to occur when the shock $e_t$ is zero. The expected aggregate wage to
prevail in period $t+m$ conditional on information at the negotiations in
period $t-1$ will be represented by

$$
E_{t-1} L^{-m} w_t = \hat{w}_{t+m|t-1}.\(^9\)
$$

For notational convenience, the convention will be adopted that if the
conditioning date is not explicit, the viewpoint date is assumed to be $t-1$.
Equation (1.1) is the behavioral rule followed by all wage setters in this
economy. It says that the negotiating cohort wants the (geometric)
average, without discounting, of what everybody else gets during its
contract period if there were no shocks, corrected for some measure of the
economic conditions expected to prevail in the economy.\(^10\)

\(^8\)In the simulation model all wage setters use the same negotiation for-
mula. The 'leaders' and 'followers' issue in the spillover literature
is not captured.

\(^9\) $L^m$ is the lag operator taken to the $m$th power.

\(^10\) One could equally well have the wage rate expected to actually prevail
(with no asterisk) and with no $e_{t+i}$ in equation (1.1). It will be
useful to differentiate between these two sources of wage growth.
The aggregate wage at any point in time will be the (geometric) average of the wages each worker receives:

\[
\omega_t = \frac{\sum_{j=1}^{24} (n_{jt} x_{jt})}{\sum_{j=1}^{24} n_{jt}}
\]

where \( j \) indexes the 24 cohort groups (4 one year, 8 two year, and 12 three year), and \( n_{jt} \) is the number of workers in cohort \( j \) at time \( t \). If the number of workers in each cohort were independent of time (\( n_{jt} = n_j \), for all \( t \)) and all \( e_t \) were zero so that \( \omega_t^* = \omega_t \), then substituting (1.2) into (1.1) makes the wage setting equation a difference equation with 12 quarter leads and lags in negotiated wages. The negotiated wage \( x_t \) would depend on both previously signed wage contracts, and expected future wage contracts, see Taylor (1980).

A reasonable candidate for \( e_t \) is a function of \((u_t^* - u_t^*)\), deviations of unemployment from some average (natural) rate. Let that function be linear and use Okun's Law with a simple quantity theory formula for the determination of real output. Then with appropriate normalization one can express \( e_t \) as proportional to real balances, giving

\[
e_t = d (\omega_t - \omega_t^*), \quad d > 0,
\]

for some parameter \( d \).\(^{11}\) The parameter \( d \) is the product of a behavioral parameter (the relative importance of \((u_t^* - u_t^*)\) in the wage setting

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\(^{11}\) The appendix contains a formal derivation of the wage setting equation for an analytically tractable version of this model. The substance of this paragraph is also discussed in more detail.
equation) and a technological parameter (Okun's Law relationship between output and employment). Equation (1.3) says that when $m_t$ increases at a faster rate than the trend growth in the aggregate wage, real balances increase, this stimulates demand, putting upward pressure on newly negotiated wages.\(^{12}\) Combining equations (1.1) and (1.3) yields an expression for the currently negotiated wage as a convex combination of observed aggregate wages and the money supply,

\[
(1.4) \quad x_t = \frac{(1-g)}{4}(\hat{w}_t + \hat{w}_{t+1} + \hat{w}_{t+2} + \hat{w}_{t+3}) +
\]

\[
\frac{g}{4}(m_t + m_{t+1} + m_{t+2} + m_{t+3}),
\]

where $g$ is an increasing function of $d$.\(^{13}\) The first year wage level for all three cohorts negotiating at any one time is assumed to be the same.\(^{14}\)

The formulas for deferred increases in multiyear contracts are identical to the initial year formula except for the date of the expectation. If we now let $\hat{x}_t$ be the second year deferred increase from a two or three year contract also negotiated in period $t$, the wage setting formula is

\(^{12}\)An appropriate normalization will make $x_t$ dependent only on the growth rates of $\hat{w}_t$ and $m_t$, even though these numbers are logarithms of the levels.

\(^{13}\)The relationship between $\hat{w}_{t+1}$, the expected aggregate wage, and $\hat{w}_{t+1}$*, the expected aggregate trend wage, is crucial here. If $\hat{w}_{t+1} = \hat{w}_{t+1}$* then $d=g$. For equation (1.4) it is assumed there is a linear relationship between the two and $e_{t+1}$. See the appendix.

\(^{14}\)In reality there are wage differentials between groups of workers in society. Auto workers and textile workers negotiating at the same time may get the same percentage increase, but start out from considerably different levels. In the simulations reported below, which are additive in the logarithms, as long as the differentials are stable through time the analysis goes straight through.
\( (1.5) \quad \hat{x}_t = \frac{(1-g)}{4} (\hat{w}_{t+4|t-1} + \hat{w}_{t+5|t-1} + \hat{w}_{t+6|t-1} + \hat{w}_{t+7|t-1}) + \)

\[
\frac{g}{4} (\hat{\omega}_{t+4|t-1} + \hat{\omega}_{t+5|t-1} + \hat{\omega}_{t+6|t-1} + \hat{\omega}_{t+7|t-1}).
\]

The deferred increase received in the third year of a three year contract, \( \hat{x}_t \), has the same formula four quarters advanced but with the same expectations set,

\[ \hat{x}_t = \frac{(1-g)}{4} (\hat{w}_{t+8|t-1} + \hat{w}_{t+9|t-1} + \hat{w}_{t+10|t-1} + \hat{w}_{t+11|t-1}) + \]

\[
\frac{g}{4} (\hat{\omega}_{t+8|t-1} + \hat{\omega}_{t+9|t-1} + \hat{\omega}_{t+10|t-1} + \hat{\omega}_{t+11|t-1} ).
\]

Given this set of structural wage setting equations, it remains to describe an expectations mechanism that can be used to solve the model empirically. A system of 'almost' perfect foresight will be used. The solution methodology is as follows: wage setting is assumed to be initially conducted under a known monetary policy that is expected to last forever. With no unforecasted shocks, the perfectly forecasted money supply changes are the only force driving the wage setting equation. In a steady-state the \( \varepsilon_t \) shocks are zero. For simplicity, assume a steady-state of constant money supply growth of 10% per year, yielding a growth in each negotiated wage of 10%.

Now permit a single unforecasted shock: at a particular point in time the monetary authorities announce a new long-run growth path to which the wage setters must eventually conform; let it be a 3% long-run (nominal)
growth rate. However there are numerous short-run disinflation paths the authorities could announce that would achieve the same long-run growth. One could imagine a 'cold turkey' plan in which money increases at 3% starting immediately, a 'stepped disinflation' plan in which money growth is slowed steadily over a few years before stopping at 3%, or even a delayed 'cold turkey' plan in which 10% growth is maintained for a time, before then instituting 3% growth, or any plan in between.

Prior to the regime change all workers expected to receive 10% wage increases each year. A new (deterministic) money path cannot alter the backward-looking component of wage determination, but does alter the forward-looking component. Taking the prior settlements as fixed, perfect foresight is again imposed on all wage setting after the policy change. Numerically this entails iteratively solving the wage setting equations and the aggregate wage identity.

The precise set of equations used in the simulations are:

(1.6a) \( x_t = \frac{(1-g)}{4} (x_{t+1} + x_{t+2} + x_{t+3}) + \frac{g}{4} (x_{t+4} + x_{t+5} + x_{t+6} + x_{t+7}) \)

(1.6b) \( x_t = \frac{(1-g)}{4} (x_{t+4} + x_{t+5} + x_{t+6} + x_{t+7}) + \frac{g}{4} (x_{t+8} + x_{t+9} + x_{t+10} + x_{t+11}) \)

(1.6c) \( x_t = \frac{(1-g)}{4} (x_{t+8} + x_{t+9} + x_{t+10} + x_{t+11}) + \frac{g}{4} (x_{t+12} + x_{t+13} + x_{t+14} + x_{t+15}) \)

along with the equation defining the aggregate wage as a weighted average of the cohort wages,
(1.7) \[ w_t = \frac{\sum_{j=1}^{24} a_j x_{j,t}}{\sum_{j=1}^{24} a_j} \].

The first year wages for all cohorts negotiated at time \( t \) are found from (1.6a), the second year deferred increases for two and three year contracts with (1.6b) and the final year of three year contracts from (1.6c).

Given the future money path and a set of initial estimates of \( \{ w_t \} \), values for the negotiated wage are computed using (1.6). The new \( \{ x_t \} \)s are used to solve for a new set of \( \{ w_t \} \) from (1.7) and so on until convergence.

There were no problems with stability. This is essentially the EP algorithm of Fair and Taylor (1981).

2. SIMULATED DISINFLATIONS OF THE U.S. ECONOMY

2.1 Aggregate Wage Dynamics

Table 1 reports the path of the (change in the logarithm of the geometric) average wage for a 'cold turkey' monetary policy in which no advance notice is given of a fall from 10% to 3% in the growth rate of the money supply. The simulation paths for several different values of \( g \) are given. In all cases the new steady-state is not achieved until at least the fourth year after the policy change. The disinflation paths are slow to start, with only a three point reduction in the first four quarters, then significant over-shooting in the third and fourth years leading to negative nominal increases.
Table 1

Path for the Average Wage, Cold Turkey Disinflation From 10% to 3% Money Growth, Major Union Settlements, By Various Values of g, Per cent change from previous Period, Four Quarter Moving-Average

<table>
<thead>
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<th>Quarter</th>
<th>g=0.3</th>
<th>g=0.7</th>
<th>g=1.0</th>
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<td>1.6</td>
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There are two features of these simulations that make it difficult to interpret the results. First, the number of workers for each cohort (the \( n_j \) weighting) was taken to be the actual figure for 1980-fourth quarter. There are seasonals in these data, so that it is important from which quarter one takes the weights. The dynamics will be different if the disinflation program is initiated just before or just after a heavy bargaining year. More importantly, one might expect the aggregate wage dynamics to be influenced by spillovers between organized and unorganized workers in the economy.

The simulations reported later in this section are with a model designed to answer these criticisms. First, the seasonals were removed so that an identical number of workers negotiate in each quarter: one fourth of the one year cohorts, one eighth of the two year cohorts, and one twelfth of the three year cohorts. Second, it was assumed that all non-major union wage setting could be represented by one year contracts. Therefore, the number of workers signing 1, 2, and 3 year contracts was taken to be not 47, 11 and 85, but 75, 5 and 20 of the labor force, respectively, approximately duplicating the observed ratios in the entire U.S. economy.

Table 2 reports the cold turkey disinflation paths for the aggregate economy for different values of \( g \). The completely forward-looking contract \( (g=1.0) \) institutes the new steady-state immediately after the expiration of all contracts signed under the old regime. As \( g \) falls, the serial correlation in wages increases. With a \( g=0.1 \) the new steady-state is not achieved even after five years. Because all paths will reach a steady-state with
Table 2

Path for the Average Wage, Cold Turkey Disinflation From 10% to 3% Money Growth, U.S. Economy, By Various Values of g, Per cent change from previous Period, at Annual Rates

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</table>
the same money growth, all columns must eventually sum to the same total wage growth. The columns with smaller values of \( g \) do not decline as fast, and hence will also have growth below 3% for longer periods. Comparing the paths of with those in table 1, the heavy concentration of one year contracts does not appear to significantly speed up the disinflation process, but they do stabilize the process considerably.\(^{15}\)

Figure 1 plots the disinflation paths for the aggregate economy under different types of short-run monetary policies (\( g=0.3 \)).\(^{16}\) The cold turkey path (a) drops quite rapidly, to a 3.4% annual rate after only four quarters. There is considerable instability with the path, as it significantly undershoots the 3% path for several years. Path b results from a more leisurely stepped disinflation, with money growth falling at an annual rate of 0.5% per quarter, a 14 period rather than an immediate decline. This path takes the same amount of time to reach a steady-state, but with considerably less instability. Coincidentally it is close to path c, the unique path in which all \( \varepsilon_c \) are zero and is hence invariant to the choice of \( g \). The assumption of perfect foresight permits solely a change in expectation, consistent with the new monetary policy, to accomplish this disinflation. This simulation corresponds to that discussed in Phelps (1978) and Taylor (1983). The final path reported in Figure 1 is one in which negotiators are given 12 quarters advance notice about a then sudden

---

\(^{15}\)These tables are not directly comparable because table 1 reports four quarter moving-averages instead of the current average wage change because of the seasonals in the second number.

\(^{16}\)Much of the discussion will focus on the \( g=0.3 \) simulations. Values of \( g \) in the range of 0.2 to 0.4 are roughly equivalent to a \( \gamma \) of 0.2 in Taylor's paper, the value he adopts for his empirical check of the model in his table 2.
Figure 1

ALTERNATE DISINFLATION PATHS FOR
MOVEMENT FROM 10% TO 2% STEADY STATE
WAGE GROWTH, FOR DIFFERENT PATHS OF
THE MONEY SUPPLY, g = 0.3

Quarterly per cent change in aggregate wage at annual rates

Time periods after the policy change
drop in the growth rate of the money supply. A very smooth path, it still
takes only two or three periods longer to achieve the new steady-state than
the other short-run paths.

2.2 Income Redistribution

Deriving Useful Summary Statistics

To measure income redistribution between negotiating cohorts, one
would ideally want to compare the lifetime earnings of workers that differ
only in their wage rate negotiation dates. However, as long as the focus
is over a multiple of four periods, within a steady-state there will be no
redistribution. Therefore, to measure income changes during a disinflation
one can count each cohort's income during the transition only, truncating
it after the new steady-state is achieved to leave only the period over
which the sums should differ. The differences between these sums can be
interpreted as the amount one group gained or lost relative to another.
However the redistribution measure is not invariant to which period is cho-

en to start counting, so there will be an irreducible margin for error of
the loss of one group with respect to another of ±0.5% for each point of
disinflation.\textsuperscript{17} This is identical to the problem of which groups deserve
'catch-up' after a wage control policy in initiated.

\textsuperscript{17}To illustrate the problem, consider the case with two negotiating
groups (A and B) with g=0, but add a random component \( z_t \) so that

\[ x_t = x_{t-1} + z_t. \]

Assume \( x_t \) initially increases at 5% a period so that each group gets
a 10% increase over its previous level. Then starting in period 4
To incorporate discounting the cohort sums are taken as deviations from the aggregate wage, so the reported numbers indicate how well a particular group did relative to the geometric mean of the population (in percent). Two sets of these numbers are reported in tables 3 and 4 for different disinflation paths.

Summary statistics for the 24 (cohort) redistribution windfalls are reported in table 5 to aid in comparing the distributional effects across different paths. The figures in this table are per point of disinflation. One need simply multiply the figures in table 5 by seven to derive the statistics for the simulations discussed in tables 2, 5, and 6. The maximum and minimum differentials give an idea of the windfall distribution. The sum of the absolute value of all windfalls divided by two describes the absolute extent of the redistribution taking place. The 3.28% in the third row of table 5 says that if the government were able to pinpoint the gainers and losers, and intended to tax the gainers to compensate the losers, it would have to tax the equivalent of 3% of a year's total wage-bill for each point of disinflation to make the redistribution.

group B get a 3% increase over its earlier wage, followed the next period by a 3% increase for group A, etc. The redistribution between the two groups can be calculated by comparing the total income each receives over a period of time that includes the regime change from 5% to 1.5%. If the sum is initiated in an odd numbered period, group B loses 7% with respect to A. But if the sum is initiated in an even numbered period they come out equal.

18 The technique of rational expectations has been adopted as a convenient way of solving the theoretical model. A different expectations mechanism could change (probably increase) the size of the redistribution, but the general message of the paper is likely to be the same. The assumption of perfect foresight in the empirical work means that I side-step the issue of credibility of the monetary authorities. Rather than believe an announced path, agents might more reasonably
Table 3

Cumulative Loss in Total Income for Each Point of Disinflation, as a Per cent of the Average Wage by Cohort, for Cold Turkey Simulation, g=1.0

<table>
<thead>
<tr>
<th>Cohort Number</th>
<th>1 Year Cohorts</th>
<th>2 Year Cohorts</th>
<th>3 Year Cohorts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.5</td>
<td>-1.5</td>
<td>-1.5</td>
</tr>
<tr>
<td>2</td>
<td>-1.6</td>
<td>-1.6</td>
<td>-1.6</td>
</tr>
<tr>
<td>3</td>
<td>-1.2</td>
<td>-1.2</td>
<td>-1.2</td>
</tr>
<tr>
<td>4</td>
<td>-0.4</td>
<td>-0.4</td>
<td>-0.4</td>
</tr>
<tr>
<td>5</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1.9</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3.3</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>5.1</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>7.5</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>9.4</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>11.8</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td>14.6</td>
</tr>
</tbody>
</table>

* Number of periods after the regime change in which the cohort negotiated.
Table 4

Cumulative Loss in Total Income for Each Point of Disinflation, as a Per cent of the Average Wage by Cohort, for Cold Turkey Simulation, $g=0.3$

<table>
<thead>
<tr>
<th>Cohort Number</th>
<th>1 Year Cohorts</th>
<th>2 Year Cohorts</th>
<th>3 Year Cohorts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.0</td>
<td>-1.0</td>
<td>-1.0</td>
</tr>
<tr>
<td>2</td>
<td>-1.3</td>
<td>-1.3</td>
<td>-1.3</td>
</tr>
<tr>
<td>3</td>
<td>-1.1</td>
<td>-1.1</td>
<td>-1.1</td>
</tr>
<tr>
<td>4</td>
<td>-0.5</td>
<td>-0.5</td>
<td>-0.5</td>
</tr>
<tr>
<td>5</td>
<td>0.7</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1.3</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2.4</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4.0</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>6.2</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>7.8</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>10.1</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td>12.8</td>
</tr>
</tbody>
</table>

* Number of periods after the regime change in which the cohort negotiated.
Table 5
Summary Statistics for Income Redistribution
For Different Money Growth Paths and Wage Elasticities,
Per Point of Disinflation

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Wage Sensitivity to Money Shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g=0.3</td>
</tr>
<tr>
<td>a. Cold Turkey</td>
<td></td>
</tr>
<tr>
<td>Maximum differential</td>
<td>12.82</td>
</tr>
<tr>
<td>Minimum differential</td>
<td>-1.27</td>
</tr>
<tr>
<td>Sum of absolute differentials/2</td>
<td>3.28</td>
</tr>
<tr>
<td>Sum of employment shocks</td>
<td>-1.03</td>
</tr>
<tr>
<td>b. Staggered Deceleration</td>
<td></td>
</tr>
<tr>
<td>Maximum differential</td>
<td>4.53</td>
</tr>
<tr>
<td>Minimum differential</td>
<td>-0.47</td>
</tr>
<tr>
<td>Sum of absolute differentials/2</td>
<td>0.96</td>
</tr>
<tr>
<td>Sum of employment shocks</td>
<td>-0.03</td>
</tr>
<tr>
<td>c. 'No unemployment'</td>
<td></td>
</tr>
<tr>
<td>Maximum differential</td>
<td>4.40</td>
</tr>
<tr>
<td>Minimum differential</td>
<td>-0.44</td>
</tr>
<tr>
<td>Sum of absolute differentials/2</td>
<td>0.86</td>
</tr>
<tr>
<td>Sum of employment shocks</td>
<td>0.00</td>
</tr>
<tr>
<td>d. Delayed Cold Turkey</td>
<td></td>
</tr>
<tr>
<td>Maximum differential</td>
<td>0.30</td>
</tr>
<tr>
<td>Minimum differential</td>
<td>-0.07</td>
</tr>
<tr>
<td>Sum of absolute differentials/2</td>
<td>0.24</td>
</tr>
<tr>
<td>Sum of employment shocks</td>
<td>0.30</td>
</tr>
</tbody>
</table>
The total amount of shocks necessary to achieve the disinflation is also computed for each simulation,

$$\sum_{t=1}^{36} g(e_t - \bar{w}_t),$$

where period 1 is the first period of the policy change. As illustrated in figure 1, the new steady-state is reached within 4-5 years (well within the nine year horizon of the summation) after which point the errors will be zero. The last row of numbers for simulation a say that about a third again more shocks are necessary to bring down the inflation rate for the wage setting equation g=1.0 than for g=0.3.

The Redistribution Results

Simulation a is a cold turkey policy starting with a decline in monetary growth immediately upon announcement of the new policy. Tables 3 and 4 report income windfalls per point of disinflation for g=0.3 and g=1.0. The windfall distribution is highly disperse, with the three year cohort negotiating the period before the policy change receiving a cumulative windfall over five years of 13-15% of a year's wages for each percentage point drop in prices. For the 7% decline in figure 1, three cohorts (one from each contract group) lose around 10% of a year's wage while one receives close to a 100% bonus.

Condition their behavior on their estimate of the path made through observing real economic behavior. Use of an adaptive learning model, such as discussed in Taylor (1975), would give estimates that converge to the rational expectations path.
The total magnitude of the redistribution is surprisingly large. The average tax necessary on the gainers to finance transfer payments to erase the redistribution is just under 1% a year for 5 years for each inflation point. For the winningest group in a 7% disinflation, the tax would have to be 17% \( \frac{7x.128}{(5+7x.128)} \). Clearly it would not be feasible for the government to collect windfall gains after they were received by workers.

The unemployment shock is largest for \( g=1.0 \) since the transition lasts only 11 periods. When \( g=1.0 \) the backward-looking component in equations (1.6) disappears entirely. Negotiated wages depend only on the announced money supply. The aggregate wage is still affected by settlements fixed before the policy change, but for only 11 periods. As \( g \) decreases and the transition period is longer but with a smoother decline, both the amount of redistribution and the amount of the shock necessary decline. This suggests the existence of an 'unemployment multiplier' similar to the observed concavity in the short-run Phillips curve. If one is willing to wait and derive the full effect of previous wage reductions on current wages through the backward-looking effect, fewer external shocks are needed to reduce wage growth.

The redistribution that accompanies the other monetary rules discussed earlier are also reported in table 5. Simulation b, the decreasing step function on money growth, has significantly less income redistribution than simulation a. While one cohort still receives a windfall of 5% of the average wage per point, the total amount of redistribu-
tion is cut by a third to a fourth. The redistribution in simulation c comes out quite close to that in b. The final simulation gives the expected result that when agents have advance notice of monetary rule changes, they can insulate themselves from the potentially harmful effects. For all values of g the income redistribution is very small, well within the margin of error of the summations.

Indexation

To examine the sensitivity of the results to specification changes, an annual indexation rule was introduced that lessened deferred increases by q% of the expected four quarter wage growth before the wage payment, and then returned q% of the observed wage growth. For example, this changes the second year formula (1.6b) to

$$\hat{x}_t = \frac{(1-s)}{4}(\hat{w}_{t+4} + \hat{w}_{t+5} + \hat{w}_{t+6} + \hat{w}_{t+7}) + \frac{s}{4}(\hat{w}_{t+4} + \hat{w}_{t+5} + \hat{w}_{t+6} + \hat{w}_{t+7})$$

$$- q (\hat{w}_{t+3} - \hat{w}_{t-1}) + q (\hat{w}_{t+3} - \hat{w}_{t-1})$$

and the formula for the third year (1.6c) to

$$\hat{x}_t = \frac{(1-s)}{4}(\hat{w}_{t+8} + \hat{w}_{t+9} + \hat{w}_{t+10} + \hat{w}_{t+11}) + \frac{s}{4}(\hat{w}_{t+8} + \hat{w}_{t+9} + \hat{w}_{t+10} + \hat{w}_{t+11})$$

$$- q (\hat{w}_{t+7} - \hat{w}_{t+3}) + q (\hat{w}_{t+7} - \hat{w}_{t+3})$$

With perfect foresight this is significant only for the settlements that breached the period in which the policy was announced (when increases were
not perfectly anticipated).

Table 6 reports the disinflation paths for alternative indexation levels for a cold turkey disinflation with \( g=0.3 \). As indexation increases, the disinflation path drops much faster but with a reasonable degree of stability. Some cohorts must take large nominal wage cuts. The magnitude of \( g \) becomes increasingly unimportant to redistribution. With 90% indexation in simulation \( a \), even with a fall of 7 points the total redistribution divided by two is around 4%. One year cohorts closely follow the average wage, with 2 and 3 year cohorts more or less splitting down the middle creating a large variance between minimum and maximum windfalls of \(-40\%\) to \(+50\%\). The sum of employment shocks drops to 0.88 per point of disinflation for \( g=1.0 \) and 0.51 for \( g=0.3 \).

3. WORKER BEHAVIOR DURING A DISINFLATION

The motivation for an overlapping contract structure, as described in the first section, was a desire by both firms and workers to preserve the workers' position in the historical wage hierarchy.\(^{19}\) Both parties are interested, to a degree, in 'relative wage insurance'. The workers are fearful of negative wage shocks and the employers of positive shocks.

Examination of the wage setting equations (1.6) makes it clear that the

\(^{19}\)This is consistent with a premise of the General Theory. Keynes wrote 'the struggle about money-wages primarily affects the distribution of the aggregate real wage between different labour-groups.... The effect of combination on the part of a group of workers is to protect their relative real wage. The general level of real wages, depends on
Table 6

Path for the Average Wage, Cold Turkey Disinflation
From 10% to 3% Money Growth, U.S. Economy, g=0.3
By Various Levels of Indexation, Per cent change from
Previous Period, at Annual Rates

<table>
<thead>
<tr>
<th>Quarter</th>
<th>0%</th>
<th>10%</th>
<th>70%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>7.5</td>
<td>7.5</td>
<td>7.4</td>
<td>7.3</td>
</tr>
<tr>
<td>1:2</td>
<td>6.2</td>
<td>6.1</td>
<td>6.0</td>
<td>5.9</td>
</tr>
<tr>
<td>1:3</td>
<td>4.9</td>
<td>4.7</td>
<td>4.4</td>
<td>4.2</td>
</tr>
<tr>
<td>1:4</td>
<td>3.4</td>
<td>3.2</td>
<td>2.6</td>
<td>2.3</td>
</tr>
<tr>
<td>2:1</td>
<td>3.6</td>
<td>3.3</td>
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</tr>
<tr>
<td>2:2</td>
<td>3.1</td>
<td>2.9</td>
<td>2.1</td>
<td>1.8</td>
</tr>
<tr>
<td>2:3</td>
<td>2.6</td>
<td>2.4</td>
<td>2.0</td>
<td>1.6</td>
</tr>
<tr>
<td>2:4</td>
<td>2.2</td>
<td>2.1</td>
<td>1.9</td>
<td>1.7</td>
</tr>
<tr>
<td>3:1</td>
<td>1.4</td>
<td>1.6</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>3:2</td>
<td>1.1</td>
<td>1.4</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>3:3</td>
<td>1.0</td>
<td>1.3</td>
<td>1.8</td>
<td>2.1</td>
</tr>
<tr>
<td>3:4</td>
<td>1.0</td>
<td>1.3</td>
<td>1.9</td>
<td>2.2</td>
</tr>
<tr>
<td>4:1</td>
<td>2.2</td>
<td>2.4</td>
<td>2.9</td>
<td>3.2</td>
</tr>
<tr>
<td>4:2</td>
<td>2.5</td>
<td>2.6</td>
<td>3.0</td>
<td>3.2</td>
</tr>
<tr>
<td>4:3</td>
<td>2.7</td>
<td>2.7</td>
<td>2.9</td>
<td>3.2</td>
</tr>
<tr>
<td>4:4</td>
<td>2.8</td>
<td>2.9</td>
<td>3.0</td>
<td>3.1</td>
</tr>
<tr>
<td>5:1</td>
<td>2.9</td>
<td>2.9</td>
<td>3.0</td>
<td>3.1</td>
</tr>
<tr>
<td>5:2</td>
<td>2.9</td>
<td>3.0</td>
<td>3.0</td>
<td>3.1</td>
</tr>
<tr>
<td>5:3</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>5:4</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>
parameter $g$ indexes the degree of serial correlation and insurance against shocks in the wage setting formula. A high value of $g$ will heavily weight current and future economic conditions. A low value of $g$ will insulate workers from economic surprises by setting wages based on past negotiated increases. In general one would expect the parameter to vary across employment situations. However, for simplicity, a constant $g$ has been assumed.

Identifying the feedback effect from redistribution (or threat of redistribution) back onto the model for the disinflation process itself goes beyond the mathematics. The simulations have been nonstochastic, with comparisons over different fixed monetary disinflation paths. But it is possible to make inferences to a stochastic model in which nominal GNP is not perfectly controlled. Consider the problem of a wage setter during the initial steady-state period. He knows the future will bring stochastic shocks and government disinflationary policies, he is just not sure when. He also has some costs (not developed in this paper) for setting a low degree of wage responsiveness (e.g. threat of unemployment). The adoption of an 'appropriate' rule by the monetary authorities might make it possible to convince him to adopt a high responsiveness in his wage setting formula.

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20 An analytic example that shows this explicitly is worked through in chapter two of Abraham (1983).
An abrupt policy change may meet with resistance from economic agents. They will reduce their value of \( g \) in order to prolong the disinflationary transition and minimize the income redistribution.\(^{21}\) If one prefers to think of \( g \) as a long-run parameter, then its choice will be conditioned by the perceived variance in the economic environment. This can be frustrating to policymakers with a given disinflation objective.

If the government wants to encourage high responsiveness of wages to economic policy, following the arguments in this paper, it would need an announced policy geared towards smoothing economic shocks. But exactly which rule should be chosen depends on one's perception of the macroeconomy. An accommodating policy which smooths interest rates may be necessary to reduce uncertainty from 'real' shocks. Alternatively, if one believes the government is destabilizing, a \( k \) rule would be more desirable.

Not having a policy that will stabilize the economic fluctuations relevant to wage setters may make it necessary to have high rates of unemployment today to dampen future expectations of price increases in order to reduce wage growth today. The lost output will have no direct effect on reducing wage growth today. Rather than buying wage reductions with unemployment, we are changing expectations and buying time until those expectations are realized.

\(^{21}\)This suggests that it may not be so much the new Federal Reserve policy announced in October 1979 that caused the current recession, but the abrupt manner in which it was implemented.
CONCLUSION

One issue of intense importance for any government policy - and in particular for disinflation - is the distributional effect: who gains and who loses. A model of wage-setting in the U.S. economy was developed and used to illustrate that the potential income redistribution between employed workers during an disinflation can be quite substantial.

It was found that the degree of wage responsiveness to economic shocks can significantly affect short-run wage dynamics, but will not affect wage movements into the future more than twice the length of the longest contract in operation. Analysis of the wage pattern of the negotiating groups showed that a sudden change in monetary policy can cause a significant amount of income redistribution, even for small degrees of wage responsiveness to economic policy. A disinflationary policy that is phased in slowly (preannounced) will take only slightly more time in achieving a new steady-state, with more price stability and less income redistribution. Contingent contracts can greatly increase the rate of disinflation with less aggregate redistribution and lower output effects, but with greater price instability.

Since the focus of this study is on the effect of income redistribution on wage dynamics perhaps a few comments should be made on the lost income of unemployed workers. Clearly the major policy concerns during a recession are for the unemployed, and not income losses of the employed. But that may not be of overriding importance when considering wage dynamics. There are two items to consider.
First, what is the importance of the unemployed worker to the wage dynamics process? Going back to the Phillips curve literature we can say that the 'tightness' of the labor market is affected. Indeed, that is the motivation for inclusion of the $e_t = f(u_t - u^*_t)$ term in the wage setting rule. In addition, one might observe that as workers are laid-off the $n_j$ weights will change, with perhaps the high wage workers laid-off first. In practice this effect is small. In several experiments with the model unrealistically high labor demand elasticities were needed to get a sizable effect on the dynamics from an increased weighting on newly negotiated contracts over the older (higher wage) contracts.

The second point is the question of the comparative size of income transfers during a recession. The analysis has just shown that there can be a 3% transfer for a 1 percentage point fall in nominal unit labor costs. The rule-of-thumb from the Phillips curve literature is that it takes 0.5 points of unemployment to achieve a one point fall in the inflation rate. Assuming the unemployed receive the economy-wide average wage (an over estimate), income transfers between employed workers could be six times the transfer from unemployed workers. This is not to minimize the problem of unemployment, but to emphasize the importance of the current topic.

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22Okun (1978) provides a summary of price-output trade-offs. This argument, of course, says nothing about output effects since cyclical productivity changes are ignored.
APPENDIX

This appendix works through a slightly modified version of Taylor's contracting model, and derives the reduced-form wage setting equation (1.4).

Consider an economy at full employment in which all wages are set through multiperiod contracts of length \( n \). The total labor force is arbitrarily divided into \( n \) equal groups, only one of which negotiates each period. A new wage level for the negotiating cohort is determined, and then fixed for the following \( n \) periods until its next negotiation. The following wage setting rule is:

\[
\text{w}_t^* = \frac{a(L^{-1})}{2} \left( \text{w}_t + \epsilon_t \right) + z_t,
\]

with the aggregate wage given by

\[
\text{w}_t = b(L) \text{w}_t^*.
\]

If wage setters follow a simple (undiscounted) weighting of the relative importance of each aggregate wage over the contract period, then

\[
a(L) = b(L) = \frac{1}{n} (1 + L + \ldots + L^{n-1}).
\]

Taylor has shown that if the forcing variable is zero and the stochastic error has expectation zero, the reduced-form solution for \( x_t \) is an autoregressive formula in \( x_t \):
where $A(L)$ is a determinate function of $a(L)$.

Close the economy with a simple quantity theory model of the goods sector (all in logarithms):

\[(A.5) \quad y_t = m_t - p_t + v_t,\]

\[(A.6) \quad p_t = \frac{1}{n} \sum_{i=0}^{n-1} z_{t-i} = v_t,\]

where $y_t$ is real output, $m_t$ the money supply, $p_t$ the aggregate price level and $v_t$ a velocity shock (which will be set equal to zero). It is assumed that the price level moves one for one with the aggregate wage, implying no redistribution between capital and labor. This full front-end loading introduces spurious seasonal variation in the real wage of any individual cohort.

The shock $e_t$ is taken to be deviations of the unemployment rate $u_t$ from a full employment 'natural rate' of $u_t^*$,

\[(A.7) \quad e_t = f (u_t - u_t^*), \quad f < 0.\]

Okun's Law suggests the existence of a stable numerical relationship between unemployment and real output. Using (A.5), (A.7) can be rewritten

\[f (u_t - u_t^*) = d(y_t - y_t^*) = d [ (m_t - p_t) - (m_t^* - p_t^*) ]\]
\[ x_t = \frac{a(L^{-1})}{2} \hat{\omega}_t^* + \frac{da(L^{-1})}{2}(m_t - \omega_t) + z_t. \]

To express (A.8) in only one wage variable, a forecasting equation for \( \hat{\omega}_{t+1} \) (the expected wage) as a function of \( \hat{\omega}_{t+1}^* \) and \( \hat{\omega}_{t+1} \) must be chosen. Adopting the simplest formula,

\[ \hat{\omega}_{t+1} = \hat{\omega}_{t+1}^* + b\hat{\omega}_{t+1}, \quad b > 0, \]

gives

\[ x_t = (1-g) a(L^{-1}) \hat{\omega}_t + g a(L^{-1}) \hat{\omega}_t + z_t, \quad g = \frac{d}{2}(1-b). \]

The negotiated wage is a linear combination of the structural wage setting rule and the expected path of the money supply.
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