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Wage Indexation and Macroeconomic Stability: The Gray-Fischer Theorem Revisited

Prepared by Esteban Jadresic*

Authorized by Peter Wickham

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Abstract

Since the seminal papers by Gray (1976) and Fischer (1977) were published, the major theorem of the wage indexation literature has been that indexing wages stabilizes output when shocks are nominal and destabilizes output when shocks are real. This paper reexamines the validity of this proposition taking into account the lags in actual indexation practices in an economy similar to that originally considered by those authors. It shows that in such a setup, wage contracts indexed to lagged inflation tend to destabilize output regardless of whether shocks are nominal or real.

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SUMMARY

Since the seminal papers by Gray (1976) and Fischer (1977) were published, the major theorem of the wage indexation literature has been that indexing wages stabilizes output when shocks are nominal and destabilizes output when shocks are real. The standard argument in support of this proposition hinges on the assumption that wage indexation is contemporaneous with the price level. Nonetheless, typical cost of living adjustments are determined according to lagged inflation rather than current inflation.

This paper reexamines the macroeconomic effects of wage indexation in a closed economy similar to that originally considered by Gray and Fischer, but taking into account the lags in actual indexation practices. In addition to exploring what these authors would have concluded had they taken those lags into account, this paper examines whether the Gray-Fischer theorem may be approximately valid in countries that have a small external sector or that are poorly integrated with international capital markets. By exploring the matter in a simple economy, the analysis also provides a well-focused example of why actual and contemporaneous wage indexation can have very different consequences.

The main result of the paper is that, in an economy such as that studied by Gray and Fischer, wage indexation tends to destabilize output regardless of whether shocks are nominal or real. This is true both when indexed wage contracts are compared with short-term fixed wage contracts and, under plausible parameters, when they are compared with preset time-varying wage contracts. In addition, the paper shows that, although indexing the money supply when contracts are indexed can reduce output instability to the same level implied by preset time-varying wage contracts, such a policy destabilizes inflation dramatically and cannot reduce output instability to the level implied by short-term fixed wage contracts.

I. INTRODUCTION

Since the mid 1970s, there has been considerable research on the macroeconomic consequences of wage indexation. Starting with two seminal papers by Gray (1976) and Fischer (1977), the academic literature has studied the effects of wage indexing on the behavior of the economy in response to alternative types of shocks, the effects of wage indexing on the costs of disinflation and the level of inflation, the relationship between wage indexation and exchange rate policy, the type of indexation indicators best suited for macroeconomic stability, and several other issues.[1] Despite the sizable literature that has accumulated on the topic, the major theorem on wage indexation has continued to be that originally stated by Gray and Fischer: that indexing wages stabilizes output when shocks are nominal and destabilizes output when shocks are real.

The standard argument in the literature in support of the Gray-Fischer proposition hinges on the assumption that wage indexation is contemporaneous with the price level. This assumption implies that wage indexing helps to stabilize the real wage, which in standard macroeconomic models helps to maintain full employment when shocks are nominal and exacerbates employment and output fluctuations when shocks are real. Nonetheless, it is well known that wage indexation as seen in practice is not contemporaneous with the price level. Actual indexed wage contracts adjust wages to the evolution of prices infrequently and only with a lag, so that typical cost of living adjustments are determined according to lagged inflation rather than current inflation. In view of this fact, actual wage indexation defines a nominal rather than a real type of wage rigidity; consequently, there is no a priori reason why

[1]The wage indexation literature has been reviewed by Carmichael, Fahrer and Hawkins (1985), Aizenman (1987), Devereux (1994), and Van Gompel (1994); also see Turnovsky (1995, chapter 8) and the introduction to Jadresic (1996a).

its consequences should necessarily resemble those implied by the assumption of contemporaneous wage indexation.[2],[3]

In a parallel paper (Jadresic (1996b)), I have found that in an open economy that is fully integrated with the international capital markets, the Gray-Fischer proposition does not hold when the lags in actual indexation practices are taken into account. In a model à la Mundell-Fleming solved by simulation for plausible parameter values, it appears that the effects on output of wage contracts indexed to lagged inflation depend not only on the type of shocks impinging on the economy, but also on the nature of the exchange rate regime in place, the type and length of the contracts being compared, and the criterion used to measure output stability. Under a particular specification of these parameters, wage indexation stabilizes output when shocks are nominal and destabilizes output when shocks are real--as asserted by the Gray-Fischer proposition--but under alternative parameter values, wage indexation destabilizes output when shocks are nominal and stabilizes output when shocks are real--exactly the opposite result. The general implication is that a definite evaluation of whether wage indexation hampers or enhances output stability in an open economy requires a precise specification of the economy under consideration.

The original analysis of Gray and Fischer, however, focused on a closed economy in where the exchange rate plays no important role. They probably had in mind the consequences of wage indexing in the U.S. economy and believed that its large size rendered it irrelevant to consider the impact of the fluctuations of the exchange rate on output and prices. They might have also had in mind that in other economies where wage indexation had been an issue, capital mobility often had been limited because of government controls or poor access to the international capital markets. Under the assumption that the nominal exchange rate is adjusted

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[2]Although many authors have emphasized that actual wage indexation is lagged, the most influential on this respect has been Simonsen (1983). He disputed Friedman's (1974) view that wage indexing reduces the cost of disinflation and conjectured that because of the lags in actual indexation rules, wage indexing increases the cost of disinflation. Jadresic (1996a) has shown recently that both Friedman's and Simonsen's points of view can be correct depending on the yardstick used to evaluate the effects of wage indexing: contracts that index wages to lagged inflation reduce the cost of disinflation in comparison to contracts that specify time-varying wages, but tend to increase them in comparison to contracts that specify fixed wages.

[3]Admittedly, Fischer (1977) was concerned about the lack of realism of the assumption of contemporaneous wage indexation and, in a section of his paper that he considered to provide the major theoretical innovation, he studied formally the effects of a certain type of lagged indexation rule. Nonetheless, the formula he studied is not the usual indexation rule by which current wages are adjusted according to past inflation; rather, it is a rule by which current wages are adjusted according to the difference between the one-period-ahead expectations on the current and past price level. Fischer, indeed, warned explicitly that the indexing formulae used in practice may be a far cry from the indexation rule he studied.

to keep the real exchange rate approximately constant, they could have considered that these economies could be conveniently treated as closed economies. Simplicity of analysis was probably also one of their considerations.

This paper reexamines the macroeconomic effects of indexing wages taking into account the lags in actual indexation practices in an economy similar to that considered originally by Gray and Fischer. In addition to exploring what these authors would have concluded had they taken those lags into account, this paper examines whether the Gray-Fischer theorem may be approximately valid in countries that have a small external sector or that are poorly integrated with the international capital markets. By exploring the matter in a simple economy like the one they considered, the analysis also provides a well-focused example of why actual and contemporaneous wage indexation can have very different consequences.

In order to study the effects of wage indexation taking into account the lags in actual indexation practices, indexing wages is modeled in this paper explicitly as a contract clause that grants periodic adjustments according to a lagged value of inflation incurred since the last wage revision (as in Jadresic (1996a)). Also, the consequences of wage contracts with indexation clauses are gauged against two alternative standards of reference. One is provided by the behavior of an economy with contracts of the same duration as the indexed contracts, but that specify preset time-varying wages during the life of each contract (i.e., contracts in which the sequence of each contract's nominal wage can vary according to the information that was available when the agreement was signed). The other standard of reference is provided by the behavior of an economy with short-term contracts that specify fixed wages during the life of each contract.

Following the Gray-Fischer analysis, Sections II to IV of this paper examine the behavior of output and inflation in a closed economy with and without indexation under the assumption that money supply is held constant. Section V briefly considers the effects of indexing money supply. The last section concludes.

II. An Economy with Alternative Wage Contracts

We consider an economy in which the rate of change of aggregate output y_t is determined by the rate of change of real money balances and a nominal shock v_t that is independent and serially uncorrelated with mean zero and variance σ_v^2 (rate of change variables are measured in this paper as first differences of log levels and are represented by lower case letters; level variables are measured in logs and are represented by capital letters). Under the assumption that the monetary authority follows a fixed money supply rule, this specification implies that

$$y_t = -\pi_t + v_t , \qquad (1)$$

where π_t is the rate of inflation at period t. It is most natural to interpret this equation as a money-market equilibrium condition, so that the nominal shock v_t can be understood as an unexpected and permanent reduction in money demand (or an unexpected and permanent increase in money supply).

Inflation is determined by the relationship

$$\pi_t = w_t - u_t + \alpha (y_t - u_t), \tag{2}$$

where w_t is the rate of change of the aggregate wage at period t and u_t a real shock in the same period, assumed to be independent and serially uncorrelated with mean zero and variance σ_u^2. By construction, the real shock can be interpreted as an unexpected and permanent increase in the level of productivity; i.e., a positive shift in the underlying production function, given the level of employment. The parameter α measures the elasticity of current prices with respect to the level of output, given wages. This elasticity is assumed to be finite and larger than minus one. Since the empirical evidence does not point to a significant effect of output on prices, given wages, below we often use $\alpha=0$ as a benchmark case.[4]

As in Jadresic (1996a), the aggregate wage is modeled as an average of individual wages determined according to one of three alternative types of contracts. The first type are **indexed wage contracts**, which contain a clause that grants a cost of living adjustments in every period according to 100 percent of the inflation rate in the previous period. The second type are **preset time-varying wage contracts**, which are nonindexed but specify a sequence of time-varying nominal wages during the life of each contract. The third type are **short-term fixed wage contracts**, which specify a fixed nominal wage during the life of each contract, and have a duration half as long as the duration of the other contracts. In order to keep the analysis as simple as possible, we assume that indexed and preset time-varying wage contracts have a duration of two periods, while fixed wage contracts have a duration of one period.[5] As mentioned in the introduction, the consequences of wage indexation are studied below by comparing the behavior of the economy under these alternative type of contracts.

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[4]The stylized fact is that in practice there is no significant effect of output on prices, given wages. Most empirical studies are consistent with the notion that marginal costs are roughly constant or perhaps even declining. In addition, there are several theoretical reasons why imperfectly competitive firms may choose countercyclical mark-ups. See Blanchard and Fischer (1989, pp. 464-7).

[5]I do not consider explicitly two-period fixed wage contracts because, in practice, fixed wage contracts tend to be shorter in duration than indexed and preset time-varying wage contracts. Besides, considering them explicitly is irrelevant in the context of the model being presented, because it can be shown that with fixed money supply, the behavior of the economy with two-period fixed wage contracts is exactly the same as with two-period preset time-varying wage contracts.

We assume that the contracts are revised periodically with a uniform distribution of negotiations, and settled on the basis of the information available at the end of the previous period. Using hereafter the superscripts I, P, and S to denote variables associated with the indexed, preset time-varying and short-term fixed wage contracts, respectively, the rate of change of the aggregate wage at period t for each type of contract can be written as

$$w_t^I = \frac{1}{2}\pi_{t-1} + \frac{1}{2}\,{}_{t-1}x_t^I, \tag{3}$$

$$w_t^S = {}_{t-1}x_t^S, \tag{4}$$

$$w_t^P = \frac{1}{2}\left({}_{t-1}x_t^P + {}_{t-2}x_t^P\right), \tag{5}$$

where ${}_{t-s}x_t^I$, ${}_{t-s}x_t^P$ and ${}_{t-s}x_t^S$ represent fixed wage increases agreed for period t in contracts settled with information available at the end of period (t-s) (for contract type I, P and S respectively).

In order to model the fixed wage increases negotiated in the different type of contracts, we assume that wage setters target a real wage that is proportional to the expected level of output.[6] Given the different contract structures, wage setters are taken to be concerned with the average level of output during each contract in the case of indexed contracts, and with period-specific levels of output in the case of preset time-varying wage contracts. In the case of short-term fixed wage contracts, wage setters are taken to target the single expected level of output during the life of each contract.

This specification for the behavior of wage setters can be used together with the structure of the contracts to obtain expressions for ${}_{t-s}x_t^I$, ${}_{t-s}x_t^P$ and ${}_{t-s}x_t^S$ as functions of past and current expectations about output and inflation in different dates, and of past inflation (as in Jadresic (1996a)). Replacing the resulting expressions in equations (3), (4) and (5) yields

$$w_t^I = \pi_{t-1} + \frac{1}{2}(1-L^2)\,E_{t-1}\left[\frac{Y_t + Y_{t+1} + \pi_t + \pi_{t+1}}{2}\right], \tag{6}$$

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[6]This implies that wage setters attempt to keep constant the functional distribution of income. Empirically, this assumption is supported by the results of Blanchflower and Oswald's (1995) extensive research on the "wage-curve". Indeed, their central finding from data for a number of regions and periods is that a 1 percent increase in the unemployment rate typically reduces the real wage by 0.1 percent. With standard estimates for Okun's Law coefficient (between 2 and 3; for example, see Adams and Coe (1990)), it follows that a 1 percent increase in GDP would raise the real wage by the order of 1 percent (given a 5 percent unemployment rate).

$$w_t^P = \frac{1}{2}(E_{t-1}+E_{t-2})[y_t+\pi_t] + \frac{1}{2}(1-E_{t-3})[y_{t-1}+y_{t-2}+\pi_{t-1}+\pi_{t-2}], \quad (7)$$

$$w_t^S = \pi_{t-1} + (1-L)E_{t-1}[Y_t+\pi_t]. \quad (8)$$

where Y_t is level of output in period t, L is the lag operator, and E_{t-s} the mathematical expectations operator given information available at the end of period (t-s).

Since equations (6), (7) and (8) are at the center of the analysis in the following sections, it is worth examining them in certain detail.

Equation (6) shows that aggregate wage behavior when wage contracts are indexed can be characterized by two components. The first one is purely inertial and stems from the indexation rule that links current wage adjustments to previous period inflation and a catch-up adjustment in the case of wages recently negotiated to compensate for the inflation observed in the previous period. The second component measures the aggregate effect of the recent wage negotiations above or below past inflation. This effect depends on the wage setters' expectations about the average output and inflation during the life of the new contracts, compared with the expectations of the same variables that they held when the contracts just ended were signed.

According to equation (7), aggregate wage behavior when contracts establish preset time-varying wages can also be characterized according to two components. The first one contains the adjustment of current wages stemming from the change in expected prices and output, according to the information that was available at the time the different vintages of current contracts were signed. The second component captures the effect of the updating of wages in the recently negotiated contracts, which depends on the discrepancy between the inflation rates and target real wages forecasted in the previous negotiation with respect their actual values.

Equation (8) indicates that aggregate wage behavior with short-term fixed wage contracts can also be characterized by two components. As in the case of indexed contracts, the first one is inertial, while the second component measures the effect of the most recent wage negotiations above or below past inflation. However, in this case the inertial component originates fully in a catch-up wage increase that compensates for the depreciation of the real value of the wages while they were fixed. The second component, in turn, depends exclusively on the output and inflation rate expected for period t, as compared with the output and inflation rate expected one period earlier.

III. Wage Indexation and the Impact of Shocks on the Output Gap

In order to study the effects of wage indexation, we evaluate output fluctuations with respect to their distance from the frictionless level of output. We define the latter as the level of output that would be observed if wages were fully flexible and all current shocks were observable, which in the model studied here moves with the level of productivity.[7] Thus our focus of attention is on an output gap (Gap_t) which fluctuates according to

$$Gap_t - Gap_{t-1} = y_t - u_t. \tag{9}$$

Putting together equations (1), (2) and (9) with equation (6), (7) or (8) (depending on the type of contracts being considered) provides a set of equations systems that can be solved under the assumption of rational expectations. After some algebra, the dynamics of the output gap for each type of contracts can be shown to be described by respectively.[8]

$$Gap_t^I - \frac{2}{5+4\alpha} Gap_{t-1}^I + \frac{1}{5+4\alpha} Gap_{t-2}^I = \frac{1}{1+\alpha} v_t + \frac{1}{(1+\alpha)(5+4\alpha)} v_{t-1} + \frac{2}{5+4\alpha} u_{t-1} \tag{10}$$

$$Gap_t^P = \frac{1}{1+\alpha} v_t + \frac{1}{2(1+\alpha)} v_{t-1}, \tag{11}$$

$$Gap_t^S = \frac{1}{1+\alpha} v_t, \tag{12}$$

We now use equations (10) to (12) to examine the effects of given real and nominal shocks on the output gap for the different type of contracts under consideration. These effects are summarized in Table 1 for an arbitrary α, and in Figures 1 and 2 for the benchmark case $\alpha=0$. For the sake of concreteness, the shocks are taken to be unitary and positive.

A. Nominal Shock

The initial impact of a nominal shock is the same whatever the type of wage contracts prevailing in the economy. Since in any given period wages are predetermined, independently of the type of contracts being considered, a positive shock v_t tends to increase real money balances and output by the same amount. In the benchmark case in which prices do not respond directly to output ($\alpha=0$), inflation is not modified at the time of the impact and output increases precisely by the amount of the shock. On the other hand, if prices change when

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[7]With fully flexible wages and perfect information, wage setters would set $w_t = \pi_t + y_t$; it follows from equation (2) that the rate of change of the frictionless level of output is u_t.

[8]To derive these equations, a common unit root in the output gaps and the shock terms were eliminated from the system by backward integration; the arbitrary constants resulting from the integration process were normalized to zero for convenience.

Figure 1. Effects of a Unit Nominal Shock with Alternative Wage Contracts

(Fixed Money Supply)

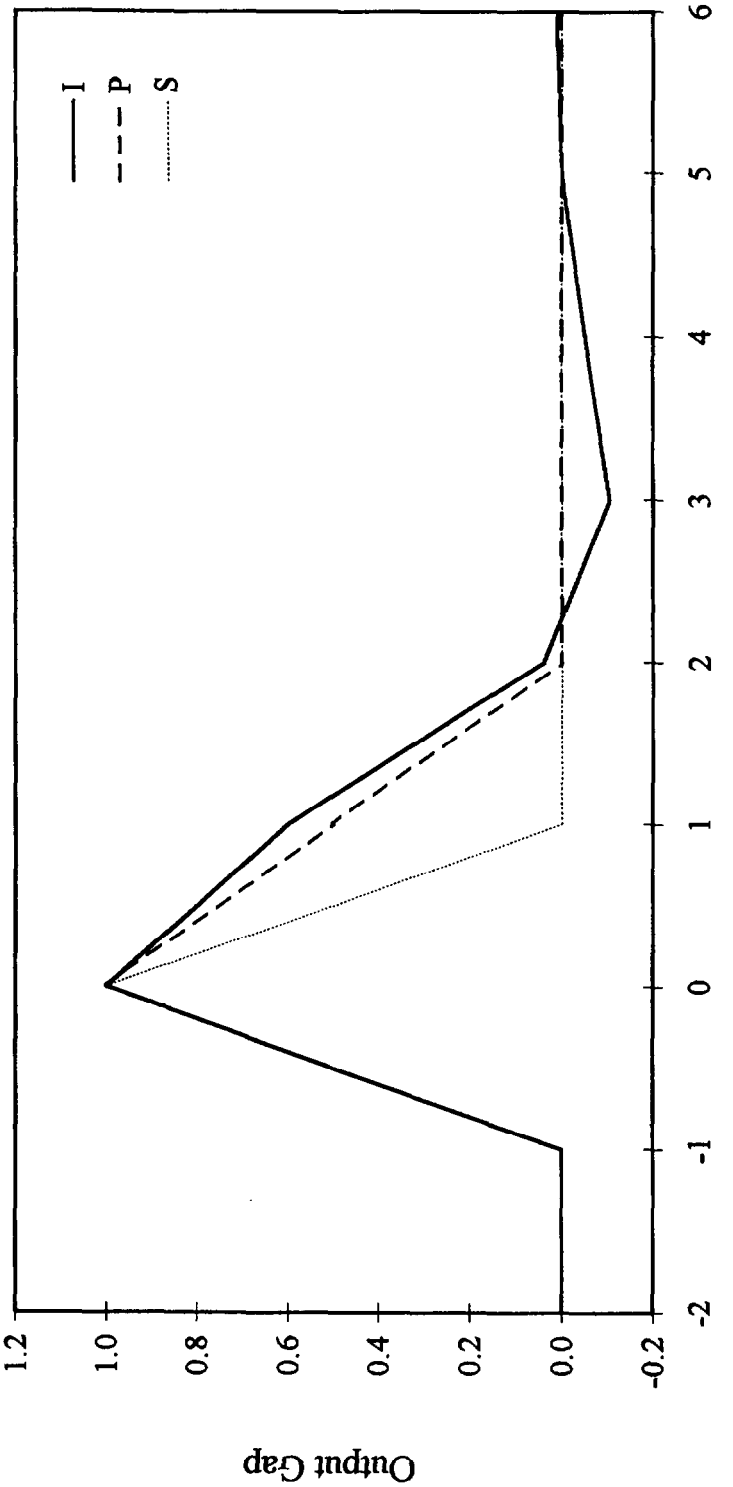

Figure 2. **Effects of a Unit Real Shock with Alternative Wage Contracts**
(Fixed Money Supply)

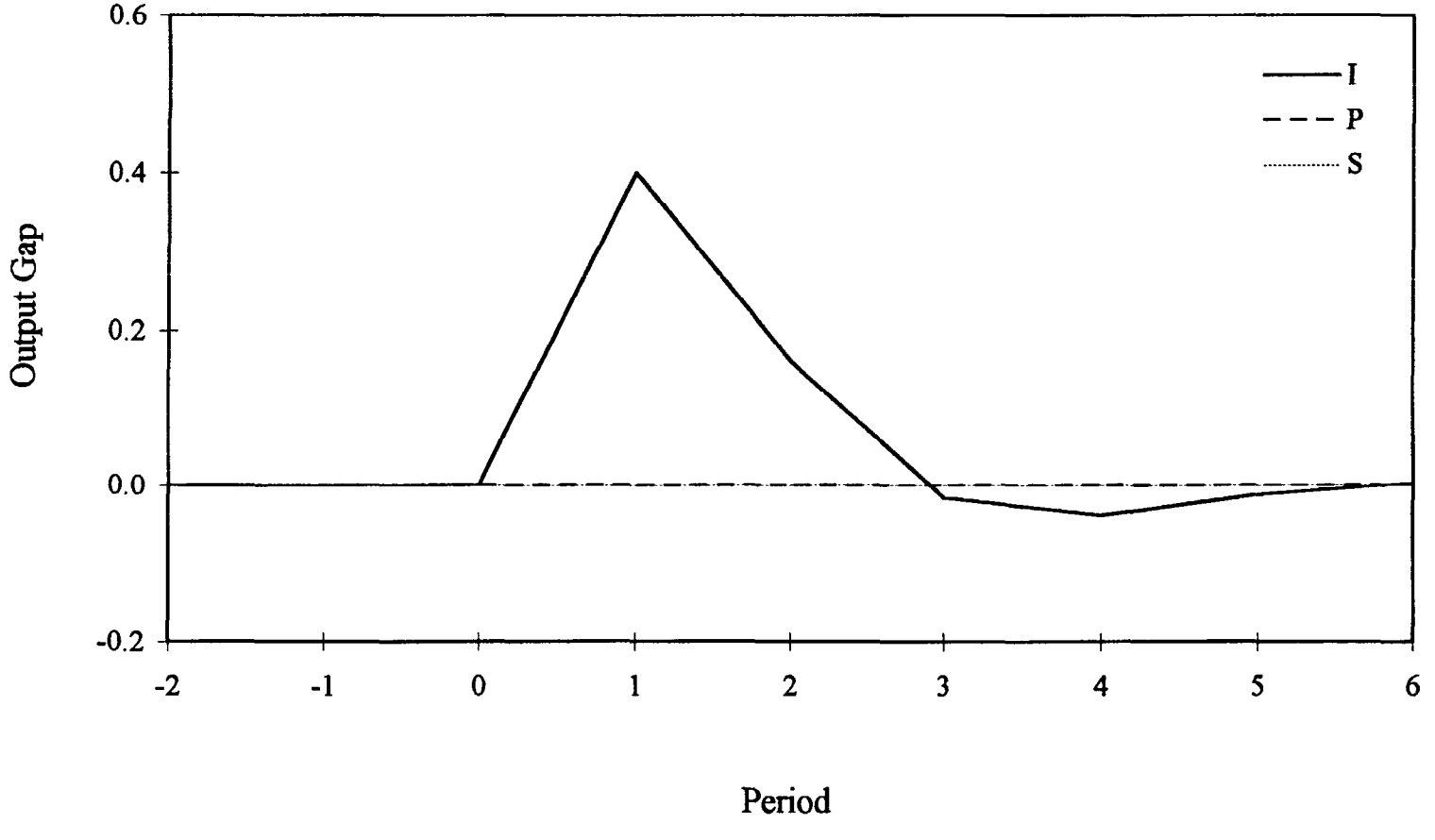

Table 1. Effects of Unit Shocks on the Output Gap

(Fixed Money Supply)

Period	Type of Shock and Wage Contracts: Real Shock		Nominal Shock		
	I	P, S	I	P	S
Zero	0	0	$\frac{1}{(1+\alpha)}$	$\frac{1}{(1+\alpha)}$	$\frac{1}{(1+\alpha)}$
One	$\frac{2}{(5+4\alpha)}$	0	$\frac{3}{(5+4\alpha)(1+\alpha)}$	$\frac{1}{2(1+\alpha)}$	0
Two	$\frac{4}{(5+4\alpha)^2}$	0	$\frac{(1-4\alpha)}{(5+4\alpha)^2(1+\alpha)}$	0	0
Three	$\frac{-2(1+4\alpha)}{(5+4\alpha)^3}$	0	$\frac{-(13+20\alpha)}{(5+4\alpha)^3(1+\alpha)}$	0	0
...	...	...	...	...	...
Sum	$\frac{1}{2(1+\alpha)}$	0	$\frac{(3+2\alpha)}{2(1+\alpha)^2}$	$\frac{3}{2(1+\alpha)}$	$\frac{1}{(1+\alpha)}$
Sum of Squares	$\frac{(3+2\alpha)}{8(2+5\alpha+4\alpha^2+\alpha^3}$	0	$\frac{(22+45\alpha+32\alpha^2+8\alpha^3)}{8(2+5\alpha+4\alpha^2+\alpha^3)(1+\alpha)^2}$	$\frac{5}{4(1+\alpha)^2}$	$\frac{1}{(1+\alpha)}$

output increases ($\alpha \neq 0$), inflation is affected by the increase in output and the net expansion of output during the first period is $(1+\alpha)^{-1} v_t$.

In subsequent periods, the effects of a nominal shock depend on the nature of the contracts in the economy. The quickest adjustment of the economy to its equilibrium occurs if short-term fixed wage contracts prevail; in this case the initial expansion of output lasts only during the period of the impact. If instead preset time-varying wage contracts prevail, 1/2 of the initial expansion of output persists one period following the impact; thereafter the economy rests in equilibrium. Finally, in the case of indexed contracts, a proportion $3(5+4\alpha)^{-1}$ of the initial expansion of output persists one period after the shock; thereafter output converges to its equilibrium through an oscillatory process that rapidly fades away.[9]

Given the behavior of output implied by the different type of contracts in the periods following a nominal shock, it is clear that indexed wage contracts and preset time-varying wage contracts destabilize output relative to short-term fixed wage contracts when those shocks occur. But how do the effects of indexed wage contracts compare to those of preset time-varying wage contracts?

The proportion of the initial expansion of output that persists during the first period after a nominal shock occurs is larger with indexed wage contracts than with preset time-varying wage contracts if α is smaller than 1/4 (in this case $3(5+4\alpha)^{-1}$ is larger than 1/2). Intuitively, since the indexation clauses transmit automatically part of the increase in wages and inflation from one period to the other, after a positive nominal shocks hits the economy, wage setters anticipate that in subsequent periods inflation will stay temporarily above the trend and that real money balances and output will continue falling; the anticipation of falling output moderates the adjustment of wages and inflation during the first period after the impact, slowing down the adjustment of the economy and causing the initial expansion of output to persist. However, for α larger or equal to 1/4, this result is reversed: if prices rise at the period of the impact, the indexation clauses contained in the indexed contracts transmit those price increases automatically to the next period, helping to stabilize output in the first period after the impact. If the adjustments of prices at the time of impact is large enough (α is larger than 1/4), this effect can cause output to adjust faster with indexed contracts than with preset time-varying wage contracts.

To compare indexed with preset time-varying wage contracts one has to take into account the consequences that these contracts have both in the first period after the impact and in subsequent periods. Taking into account these subsequent effects and using the

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[9]The oscillatory and convergent nature of the evolution of output can be verified by computing the roots of the characteristic equation associated with equation (10), which are both imaginary and have the property that the multiplication of their inverses is smaller than one. The associated damping factor can be shown to be $(5+4\alpha)^{-1}$, implying that increasing α speeds up the adjustment of the economy.

standard criteria by which aggregate output fluctuations are measured according to the sum of squared output gaps, it can be shown that indexed wage contracts raise or reduce output instability relative to preset time-varying wage contracts depending on whether α is larger or smaller than 0.2728 respectively.[10]

To summarize, when indexed wage contracts are compared with short-term fixed wage contracts, as well as with preset time-varying wage contracts and α is not too large, wage indexation destabilizes output when a nominal shock hits the economy. This result contradicts Gray and Fischer's hypothesis that wage indexation stabilizes output when nominal shock occurs.

B. Real Shock

A real shock such as the one considered here has no effect on the output gap at the period it impacts on the economy, whatever the type of contracts being considered. Indeed, given that in any single period wages are predetermined, a positive real shock u_t reduces prices proportionally and increases real money balances and output exactly by the same magnitude as the size of the shock. Since output and the frictionless level of output increase by the same amount, the output gap thus remains unaltered.

In the first period after the real shock occurs, however, while output with short-term fixed and preset time varying wage contracts remains in equilibrium if there are no further shocks, output with indexed wage contracts increases. The reason is that with indexation the reduction in the inflation rate that occurred in the period of the shock is transmitted automatically into an inflation rate lower than the trend in the next period. This effect raises real money balances and expands output despite the fact that no additional shocks have occurred. This effect can be quite significant; for instance, in the benchmark case in which $\alpha=0$, the size of the output gap in the period following the shock is 40 percent of the magnitude of the shock. More generally, this proportion equals $2(5+4\alpha)^{-1}$.

In the second period following the real shock, the boom in the indexed economy materialized during the previous period puts upward pressure on wages, which increases inflation and moves real money balances and output towards their equilibrium levels. Thereafter, due to a dynamics that is driven by the cost of living adjustments mandated by the

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[10]This result can be derived from equations (13) and (14) obtained below by using the property that the sum of squared output gaps caused by a single nominal shock is equivalent to the unconditional variance of the output gap caused by infinitely repeated nominal shocks (this equality holds because the nominal shocks are uncorrelated). The number 0.2728 is an approximation to a number with more decimals.

indexed contracts, output converges to its equilibrium after a sequence of oscillations that gradually fade away.[11]

To summarize, wage indexation in this model destabilizes output when a real shock hits the economy. This result is broadly similar to the one implied by the contemporaneous indexation approach to wage indexation (see Gray (1976) and section one in Fischer (1977)) but its logic is substantially different. The reasoning here is not that indexation prevents real wages from adjusting, but rather that with wage indexation the initial impact of a real shock on inflation is transmitted mechanically to wage adjustments and inflation in subsequent periods; with a fixed money supply, this feedback effect from past to current inflation destabilizes output.

IV. Wage Indexation and Macroeconomic Stability

In order to evaluate the overall implications of the alternative type of wage contracts on the stability of output and inflation, we now compute and compare the unconditional variances of the output gap and inflation for the different contracts when both real and nominal shocks coexist and occur repeatedly through time.

A. Variance of the Output Gap

Using equations (10), (11), and (12) and a little algebra provides the following expressions for the unconditional variance of the output gap under the alternative type of contracts:

$$Var(Gap_t^I) = \frac{1}{8}\frac{(3+2\alpha)}{(2+5\alpha+4\alpha^2+\alpha^3)}\sigma_u^2 + \frac{1}{8}\frac{(22+45\alpha+32\alpha^2+8\alpha^3)}{(2+5\alpha+4\alpha^2+\alpha^3)(1+\alpha)^2}\sigma_v^2, \quad (13)$$

$$Var(Gap_t^P) = \frac{5}{4}\frac{1}{(1+\alpha)^2}\sigma_v^2, \quad (14)$$

$$Var(Gap_t^S) = \frac{1}{(1+\alpha)^2}\sigma_v^2. \quad (15)$$

The comparison of equation (13) with equation (15) shows that indexed wage contracts unambiguously increase the instability of output relative to short-term fixed wage contracts. Indeed, for feasible values for α, σ_u^2 and σ_v^2 ,the first term of the right hand side of equation (13) is always positive, while the second term is always larger than the right hand

[11]As in the case of a real shock, this process of adjustment can be verified by computing the roots of the characteristic equation associated with equation (10).

side of equation (15). This result is not surprising, since in comparison with short-term fixed wage contracts, as found above, indexed wage contracts always destabilize output when the economy is hit by either real or nominal shocks.

The comparison of equation (13) with equation (14), in turn, reveals that indexed wage contracts destabilize output relative to preset time-varying wage contracts if

$$\frac{\sigma_u^2}{\sigma_v^2} > \frac{(-2+5\alpha+8\alpha^2+2\alpha^3)}{(3+8\alpha+7\alpha^2+2\alpha^3)}. \qquad (16)$$

This condition is depicted in Figure 3 for the range $-1<\alpha<2$. In the benchmark case in which $\alpha=0$, as well as for any α smaller than 0.2728 this condition is satisfied whatever the relative variances of real and nominal shocks. On the other hand, even if α larger than 0.2728, there is a wide range for which the inequality described by equation (16) holds whatever the relative variances of real and nominal shocks; for instance, if $\alpha=0.5$ it suffices that σ_u^2/σ_v^2 is larger than 0.3056, and if α tends to infinity it suffices that σ_u^2/σ_v^2 is larger than one. Therefore, it seems reasonable to conclude that under plausible parameters, indexed wage contracts destabilize output also relative to preset time-varying wage contracts. Only if α and the relative variance of nominal shocks are large enough this result can be reserved.

To summarize, indexed contracts in a closed economy unambiguously augment output instability relative to short-term fixed wage contracts and, under plausible parameters, also augment output instability relative to contracts that specify preset time-varying wages. This result contradicts Gray and Fischer's hypothesis that wage indexation has an ambiguous effect on output stability in a similar economy.

B. Variance of the Inflation Rate

Gray and Fischer analyses imply that, with a fixed money supply, wage indexation increases price instability. Here we briefly reexamine the issue, but focusing on the inflation rate, which usually captures the attention more in practical discussions.

Solving the equations of the model for the inflation rate rather than for the output gap provides a set of difference equations which can be used to compute the unconditional variances of the inflation rate for the different contracts. These calculations yield

$$Var(\pi_t^I) = \frac{1}{2}\frac{(5+11\alpha+8\alpha^2+2\alpha^3)}{(2+5\alpha+4\alpha^2+\alpha^3)}\sigma_u^2 + \frac{1}{2}\frac{(2+5\alpha+9\alpha^2+12\alpha^3+8\alpha^4+2\alpha^5)}{(2+5\alpha+4\alpha^2+\alpha^3)(1+\alpha)^2}\sigma_v^2, \qquad (17)$$

$$Var(\pi_t^S) = \sigma_u^2 + \frac{(1+\alpha^2)}{(1+\alpha)^2}\sigma_v^2. \qquad (18)$$

$$Var(\pi_t^P) = \sigma_u^2 + \frac{1}{2}\frac{(1+2\alpha^2)}{(1+\alpha)^2}\sigma_v^2, \quad (19)$$

These equations imply that the variance of inflation with indexed wage contracts is larger than with preset time-varying wage contracts, but can be either larger or smaller than the variance of inflation with short-term fixed wage contracts. Regarding the former comparison it is easy to verify with the help of numerical simulations that for any acceptable value for α, the coefficients on σ_u^2 and σ_v^2 in equation (17) are both larger than the corresponding coefficients in equation (18). Regarding the latter, while the simulations show that the coefficient on σ_u^2 in equation (17) is also larger than the analogous coefficient in equation (19), they indicate that the coefficient on σ_v^2 in equation (17) is smaller than the same coefficient in equation (19) for α larger than approximately -0.666. Therefore, it is possible that an economy with indexed wage contracts displays lower inflation variability than an economy with short-term fixed wage contracts if the variance of nominal shocks is large enough. Figure 4 depicts the precise conditions under which this and the alternative result can happen.

V. Effects of Wage Indexation with Indexed Money Supply

Following the Gray and Fischer analysis, we have assumed until now that the monetary authority follows a fixed money supply rule. In applied discussions, however, it is often argued that monetary authorities in indexed economies tend to accommodate inflationary shocks in order to avoid the output costs of resisting them. Moreover, the hypothesis has often been advanced that inflation in indexed economies have a unit root. Of course, this kind of behavior of inflation can only be observed over a lengthy period of time if money growth adjusts endogenously to inflationary shocks.

We explore now how the results of the previous section for the case of indexed wage contracts change when monetary policy indexes money supply to lagged inflation rather than keeping money supply constant. For this purpose, we replace equation (1) by

$$y_t = \pi_{t-1} - \pi_t + v_t, \quad (20)$$

which maintains the assumption that output is proportional to real money balances but assumes that money supply is adjusted according to the inflation rate of the previous period.

If contracts are indexed, one obtains now:

$$Gap_t^I = \frac{1}{1+\alpha}v_t + \frac{1}{2(1+\alpha)}v_{t-1}, \quad (21)$$

This is the same expression obtained earlier for the output gap in the case of preset time-varying wage contracts and fixed money supply (compare equation (21) with equations (11)). Therefore, the following results are straightforward. First, indexing money

Figure 3. Comparing Output Gap Variances with Alternative Wage Contracts
(Fixed Money Supply)

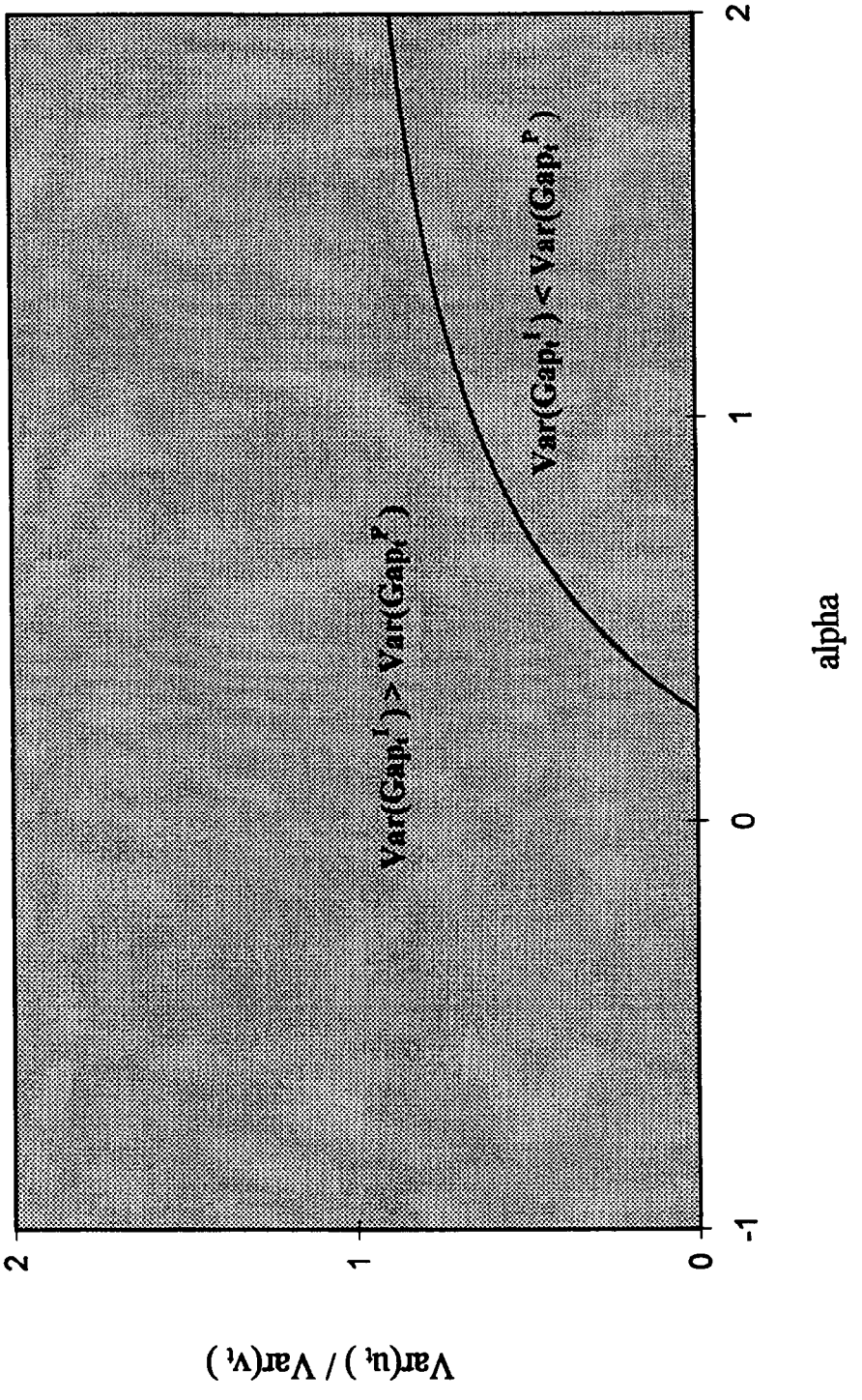
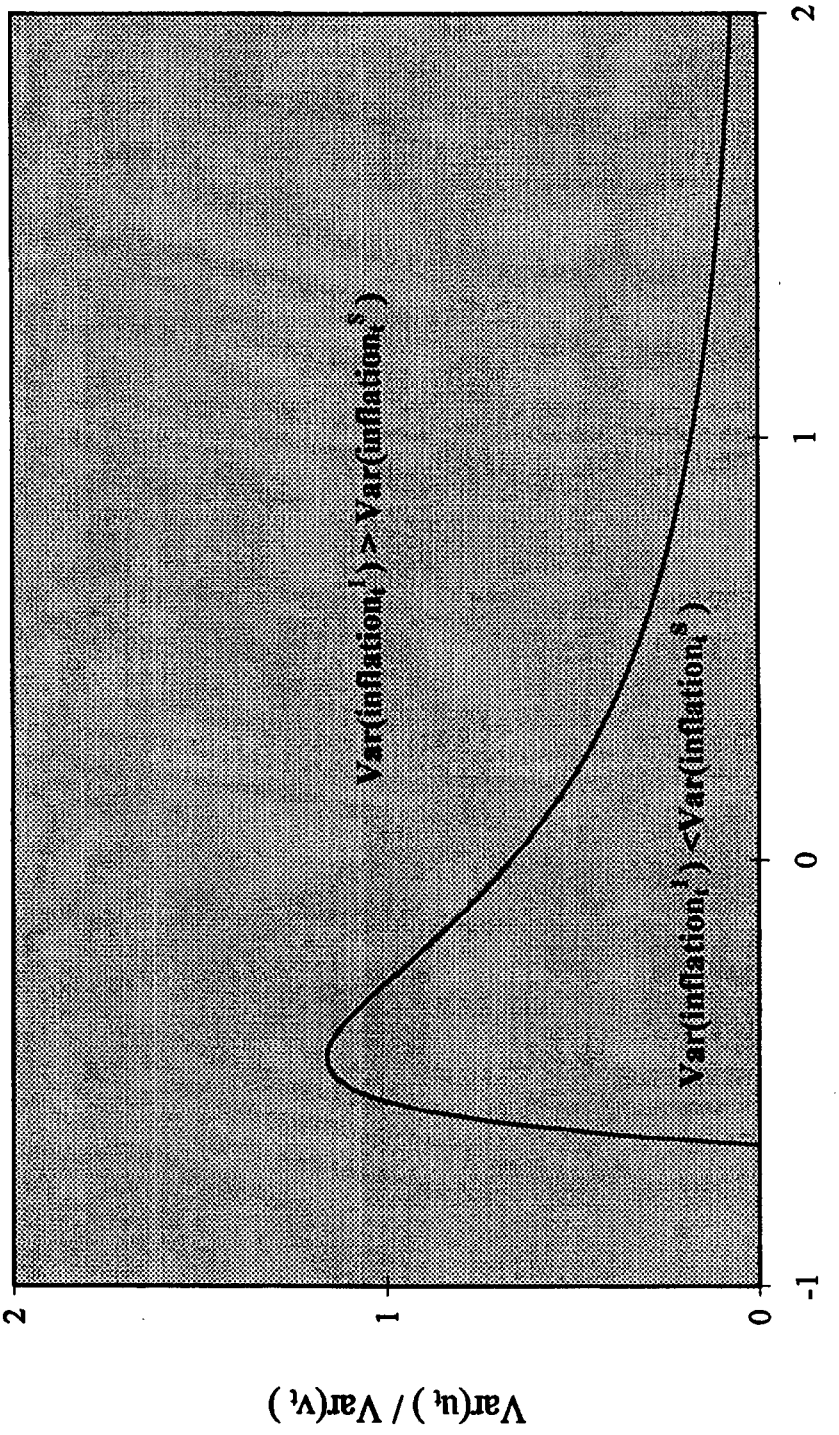


Figure 4. Comparing Inflation Variances with Alternative Wage Contracts
(Fixed Money Supply)



supply when contracts are indexed reduces the variance of output (under plausible parameters: those that satisfy condition (16)). Second, indexing money supply when contracts are indexed enables them to match the variance of output observed under preset time-varying wage contracts with fixed money supply. Third, indexing money supply when contracts are indexed is not enough to reduce the variance of output to levels that are similar or smaller than the variance of output under short-term fixed wage contracts with fixed money supply.

These results imply that indexing money supply when contracts are indexed can help to reduce output instability. However, by depriving the economy of a nominal anchor, indexing money supply has dramatic consequences on the variability of inflation. Indeed, under such a policy rule, inflation with indexed wage contracts is determined by the equation

$$\pi_t^I = \pi_{t-1}^I + \frac{\alpha}{(1+\alpha)} v_t + \frac{1}{2(1+\alpha)} (v_{t-1} + v_{t-2}) - u_t. \qquad (22)$$

Since inflation in this equation has a unit root, it follows that the variance of inflation now is infinite.

Finally, note that in the right hand side of equation (21) only nominal shocks appear. In words, by indexing money supply, a real shock has now no effect on the output gap despite the fact that wages are indexed. This illustrates the crucial importance of the fixed money supply assumption we made earlier in deriving the result that wage indexation destabilizes output when real shocks occur. It also illustrates how misleading it can be to use the contemporaneous indexation approach to wage indexation, according to which wage indexation destabilizes output when a real shock occurs independently of the type of monetary policy being followed.

VI. Conclusions

This paper reexamined the macroeconomic consequences of wage indexation in an economy similar to that considered by Gray and Fischer but taking into account the lags in actual indexation rules. The main result is that, in such an economy, wage contracts indexed to lagged inflation tend to destabilize output regardless of whether shocks are nominal or real. This is true both when indexed wage contracts are compared with short-term fixed wage contracts and, under plausible parameters, when they are compared with preset time-varying wage contracts. In addition, the paper shows that, although indexing money supply when contracts are indexed can reduce output instability to the same level implied by preset time-varying wage contracts, such a policy destabilizes inflation dramatically and cannot reduce output instability to the level implied by short-term fixed wage contracts.

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