# Is There a Persistence Problem? Part 2: Maybe Not

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*Explaining persistence may not be that difficult after all. If there are labor-market frictions, monetary policy can be expected to have long-lasting real effects even if final-goods prices are completely flexible.*

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Empirical studies suggest that monetary policy shocks have real economic effects that continue for many quarters after a policy change is implemented.[1] These persistent real effects have sometimes been attributed to price contracts that are staggered across firms. In principle, staggered price setting can substantially delay the aggregate price level's response to policy shocks even if each individual price is fixed for only a short period. However, this result depends on the assumption that each firm seeks to keep its price close to the prices others charge. Recently, Chari, Kehoe, and McGrattan (2000)—hereafter CKM—have questioned the validity of this assumption. For a wide range of technology and taste specifications, CKM demonstrate that staggered price adjustment speeds up—rather than slows down—the economy's response to policy shocks.

Part 1 in this series of two articles develops the intuition underlying the CKM result (Koenig 1999). It runs as follows: The prices its competitors charge are relevant to the pricing decisions of a profit-maximizing firm only indirectly, through their impact on the firm's unit labor costs. If, say, the money stock has unexpectedly increased, unit labor costs will rise for two reasons. First, since most firms' prices are preset, the policy surprise will lead to an increase in real cash balances that stimulates aggregate sales and, hence, the demand for labor. Second, households, feeling wealthier, will be less inclined to work. For reasonable values of the wage and wealth elasticities of the labor supply, these two forces exert such a strong upward pressure on the market-clearing wage rate that any firm with the chance to adjust its price will increase it more than proportionately to the change in the money stock—not less than proportionately, as required to generate persistence.

This discussion suggests that what occurs in the labor market is critical for determining whether output prices adjust slowly toward long-run equilibrium following a monetary policy shock. If a labor-market friction were to short-circuit the wage increase that accompanies a monetary expansion in the CKM analysis, firms would feel less immediate pressure to raise their prices and monetary policy might have longer lasting effects on the real economy. This article uses a simple model to illustrate that labor-market frictions are, indeed, a potentially important part of the solution to the persistence problem.

The model economy developed here can be interpreted in two ways. Under one interpretation, hours of labor supplied by different households (or groups of households) are imperfect substitutes in production. This imperfect substitutability gives workers a measure of monopoly power. Each worker (or worker group) acts as a wage setter, announcing a time path for the wage at which he is willing to supply labor.[2] This path is periodically revised to reflect new information on demand and supply conditions. The timing of the wage revisions is staggered across workers. Essentially, the staggered price setting of Part 1 is replaced by staggered wage setting.

An alternative interpretation of the model is that each household acts as an independent intermediate-goods producer. The intermediate goods different households produce are imperfect substitutes for one another. Price adjustment in the intermediate-goods market is staggered. Under this interpretation of the model, the key difference from the previous analysis is that intermediate-goods producers do not compete with one another for labor.[3]

Under either interpretation, the model captures important aspects of reality. Wage rates are commonly specified well in advance—by as much as three years in union labor contracts.[4] At the same time, transportation costs, imperfect information, and workers' investments in firm-specific skills limit employee mobility.

The article's bottom line is that explaining persistence may not be that difficult after all. Indeed, if there are labor-market frictions, monetary policy can reasonably be expected to have long-lasting real effects even if final-goods prices are completely flexible.[5] If final-goods prices are set in overlapping contracts, persistence is further enhanced.

## THE MODEL ECONOMY

This section describes a simple, log-linear economy with labor-market frictions. I arbitrarily emphasize the sticky-wage interpretation of the model rather than the immobile-labor interpretation. As in Part 1 of this series, several simplifying assumptions are convenient. For example, I ignore capital investment. Labor contracts specify a path for the nominal wage rather than a fixed wage level.[6] Also, most of the analysis is limited to the case in which output prices are completely flexible.[7]

### Household Decisionmaking

As in my earlier analysis, I assume that a typical household—call it household $i$—has a utility function of the form

$$(1) \qquad U(C_i, L_i) = (C_i^{1-\sigma} - 1)/(1 - \sigma) - L_i^{1+1/\xi}/(1 + 1/\xi)$$

each period, where $C_i$ and $L_i$ are the levels of output consumed and labor supplied, respectively, and where $\sigma$ and $\xi$ are positive constants. The first of these parameters is the inverse of the elasticity of intertemporal substitution, which measures households' willingness to shift consumption over time. The second parameter would be the wage elasticity of the labor supply if the labor market were competitive. Realistically, $\sigma \geq ½$ and $\xi < 1$.[8]

A wage-taking, utility-maximizing household would supply labor up to the point where the marginal rate of substitution between leisure and consumption equals the real wage: $-U_L/U_C = W/P$. However, I assume each household faces a downward-sloping demand curve for its labor:

$$(2) \qquad l_i = l - (w_i - w)/(1 - E),$$

where $l$ and $w$ are the (logarithms of the) average aggregate employment level and money wage, respectively, $w_i$ is the (logarithm of the) wage charged by household $i$, and $0 < E < 1$ is a parameter that is an inverse measure of the household's monopoly power.[9] (Throughout this article, lowercase characters denote logarithms of the corresponding uppercase variables.) Confronting a labor demand schedule like that in Equation 2, household $i$ will want to be paid a premium over the competitive wage. In particular, taking $l$ and $w$ as given, household $i$ will want to charge a wage rate that satisfies the equation

$$(3) \qquad W_i/P = -(U_L/U_C)/E.$$

Taking logarithms,

$$(3') \qquad w_i - p = (1/\xi)l_i + \sigma c_i - \epsilon,$$

where $\epsilon \equiv \ln(E)$. The desired wage exceeds the competitive wage to the extent that $E$ is less than 1.

My objective is to see whether staggered wage setting can help explain the persistent real effects of monetary policy. Accordingly, I assume each household must specify in advance a path for its wage rate. The length of time for which the wage path is preset is the same for every household, but the timing of their decisions differs. As a practical matter, to assume that households prespecify their wages means Equations 3 and 3′ will not hold for every household at every instant. However, whenever it has a chance to reset its wage path, household $i$ will choose a path that it *expects* will satisfy Equations 3 and 3′ at each point in the future. Firms decide how much of household $i$'s labor is hired at the specified wage. Households will be content to cede short-run control of hours to firms as long as the real wage continues to exceed the marginal rate of substitution between leisure and consumption.[10]

As in Part 1, I assume households' desired money balances are determined by their consumption expenditures:

$$(4) \qquad m_i - p = c_i .$$

It greatly simplifies the analysis to assume households are able to fully insure consumption against idiosyncratic differences in the timing of wage decisions. In other words, it is convenient to assume all households end up with the same level of consumption and, hence, the same level of real money balances, regardless of when they are able to reset their wage paths. Accordingly, I henceforth drop the subscripts from $c$ and $m$ in Equations 3′ and 4.

### Firm Decisionmaking

Firms use the labor of a cross section of households to produce output, which is then sold back to households. I use the same, simple, linear production technology as in Part 1:

$$(5) \qquad y_f = l_f ,$$

where $y_f$ is the amount of output firm $f$ produces using $l_f$ units of labor. It follows that the firm's marginal cost schedule is horizontal and that its height equals the prevailing average wage rate, $w$.

In general, the products of different firms are imperfect substitutes, so that each firm has some monopoly power in the output market. In particular, I assume the demand for firm $f$'s output is given by

$$(6) \qquad y_f = y - (p_f - p)/(1 - \Theta),$$

where $y$ and $p$ are the average aggregate output level and price level, respectively, $p_f$ is the price charged by firm $f$, and $0 < \Theta < 1$. Equation 6 says the higher firm $f$'s price is relative to the economywide average, the lower the firm's sales will be relative to economywide-average sales.[11] Perfect competition is obtained in the limit as $\Theta \rightarrow 1$. The firm is assumed to be small enough that it takes $y$ and $p$ as given. It follows that the firm's marginal revenue is $p_f + \theta$, where $\theta \equiv \ln(\Theta) < 0$.

Profit is maximized when marginal revenue equals marginal cost:

$$(7) \qquad p_f = w - \theta.$$

In contrast to CKM (and my earlier article), output prices are perfectly flexible, so that Equation 7 holds at every instant for every firm. (This assumption is relaxed in the box that accompanies this article.) If the price level responds sluggishly to monetary policy shocks, it is only because the average aggregate wage responds sluggishly to such shocks.

### Short-Run and Long-Run Equilibrium Conditions

For notational convenience, I assume there is one household per firm. Then $y$ denotes both the output each firm produces and average household income. The variable $l$ denotes both the amount of labor each firm hires and the average amount of labor each household supplies. At every instant, $l = y = c = m - p$, where (recall) the variables $c$ and $m$ are the amounts of output consumed by and money held by each household, respectively. It follows that if we can determine how the price level moves over time in response to a monetary policy shock, we will also know how employment, output, and consumption move over time. Monetary policy shocks have persistent real effects only to the extent that the price level reacts sluggishly to changes in the money supply.

Once every household has adjusted its wage path in response to a policy shock, all households will charge the same wage and work the same number of hours. If we use an asterisk to denote the value each endogenous variable takes on in this long-run, market-clearing equilibrium,

$$(8) \qquad y^* = c^* = l^* = (\theta + \epsilon)\xi/(1 + \sigma\xi),$$

$$(9) \qquad w^* = m + \theta - (\theta + \epsilon)\xi/(1 + \sigma\xi),$$

and

$$(10) \qquad p^* = m - (\theta + \epsilon)\xi/(1 + \sigma\xi).$$

Money is neutral in the long run. An increase in the money stock eventually drives up the nominal wage and the price level and leaves real variables unchanged.

## SHORT-RUN WAGE AND PRICE ADJUSTMENT

Equation 7 implies that the average wage and the price level always move together. Thus, whether the price level reacts sluggishly to policy shocks is determined by how the average wage moves over time in response to unexpected changes in the stock of money. How the average wage moves over time is, in turn, determined by how aggressively households that are able to adjust their wages do so. Do these households have an incentive to keep their

Table 1
## Overshooting Unlikely with Overlapping Wage Contracts

Possible values of the overshooting parameter in an economy with flexible prices and overlapping wage contracts ($\omega'$) and in an otherwise identical economy with flexible wages and overlapping price contracts ($\omega$).

**A. The case in which $\sigma = 1$.**

| | $\omega$ | $\omega'$ | | | | |
|---|---|---|---|---|---|---|
| | | $E$ = .99 | $E$ = .95 | $E$ = .90 | $E$ = .85 | $E$ = .80 |
| $\xi$ = 1/5 | 6 | .01 | .06 | .12 | .17 | .23 |
| $\xi$ = 1/4 | 5 | .01 | .06 | .12 | .18 | .24 |
| $\xi$ = 1/3 | 4 | .01 | .07 | .13 | .19 | .25 |
| $\xi$ = 1/2 | 3 | .01 | .07 | .14 | .21 | .27 |

**B. The case in which $\sigma = 2$.**

| | $\omega$ | $\omega'$ | | | | |
|---|---|---|---|---|---|---|
| | | $E$ = .99 | $E$ = .95 | $E$ = .90 | $E$ = .85 | $E$ = .80 |
| $\xi$ = 1/5 | 7 | .01 | .07 | .14 | .20 | .27 |
| $\xi$ = 1/4 | 6 | .01 | .07 | .15 | .22 | .29 |
| $\xi$ = 1/3 | 5 | .02 | .08 | .16 | .24 | .31 |
| $\xi$ = 1/2 | 4 | .02 | .10 | .19 | .28 | .36 |

wages close to the average wage? If so, the average wage will move slowly toward its market-clearing level and policy shocks will have long-lasting real effects.

### An Individual Household's Wage Demands

Consider a household ($i$) that is updating its wage demands in response to the latest economic data. Using Equation 2 to eliminate $l_i$ from Equation 3′, and using the fact that $l = c = m - p$:

(11) $$w_i = w + \alpha[(1/\xi + \sigma)(m - p) - (\theta + \epsilon)],$$

where $\alpha \equiv \xi(1 - E)/[1 + \xi(1 - E)] < 1$. This equation becomes

(11′) $$0 = \alpha[(1/\xi + \sigma)(m - p^*) - (\theta + \epsilon)]$$

in long-run, market-clearing equilibrium. By subtracting Equation 11′ from Equation 11, we obtain

(12) $$w_i = w + \alpha(1/\xi + \sigma)(p^* - p),$$

or (recalling that Equation 7 holds for every firm at every instant)

(12′) $$w_i = w + \alpha(1/\xi + \sigma)(w^* - w).$$

Equation 12′ is the key formula relating the wage demands of household $i$ to the current average wage and the market-clearing wage. If $\alpha(1/\xi + \sigma) < 1$, households with a chance to respond to a policy shock choose a wage partway between the market-clearing wage and the average wage; they don't want their wages to move too far from the wages others charge. If, on the other hand, $\alpha(1/\xi + \sigma) > 1$, households with a chance to respond to a policy shock pick a wage that *exceeds* the market-clearing wage rate. Below, I refer to $\omega' \equiv \alpha(1/\xi + \sigma)$ as the overshooting parameter for an economy with staggered wage contracts.

### A Comparison with Price Adjustment in the CKM Model

In the simple version of the CKM model developed in Part 1 of this series, price adjustment is governed by an equation very similar to the wage-adjustment equation derived above. In particular,

(13) $$p_f = p + (1/\xi + \sigma)(p^* - p),$$

where $p_f$ is the price chosen by a firm able to respond to the policy shock, $p^*$ is the market-clearing price level, and $p$ is the average current price level. The key difference between Equations 12′ and 13 is the $\alpha$ parameter, which appears in the former equation but is absent from the latter. This parameter acts unambiguously to make wage (and hence, price) adjustment in the staggered-wage-contract model slower than price adjustment in the CKM staggered-price-contract model. In the staggered-price economy, the overshooting parameter is $\omega \equiv 1/\xi + \sigma$. In the staggered-wage economy, the overshooting parameter is $\omega' = \alpha\omega < \omega$.

Is the contribution of staggered wage setting to persistence likely to be quantitatively significant? Table 1 compares the values of $\omega$ and $\omega'$ implied by a range of reasonable values for the inverse of the elasticity of intertemporal substitution ($\sigma$), the wage elasticity of the labor supply ($\xi$), and the ratio of the competitive to the monopolistically competitive wage ($E$).[12] The table suggests that $\omega$ can reasonably be expected to fall somewhere between 3 (when $\sigma = 1$ and $\xi = 1/2$) and 7 (when $\sigma = 2$ and $\xi = 1/5$). (Note that the competitiveness of the labor market is irrelevant for $\omega$.) In any event, the overshooting parameter in an economy with flexible wages and overlapping price contracts is well above 1—a result consistent with CKM. In sharp contrast, the overshooting parameter in an economy with flexible prices and overlapping wage contracts ranges from a low of 0.01 (when the labor supply is highly inelastic and the labor market is nearly competitive) to a high of only about 1/3 (when $\xi = 1/2$ and $E = .8$). In other words, the overshooting parameter is at least an order of magnitude smaller in an economy with staggered wage setting than it is in an economy with staggered price setting. If workers don't have much bargaining leverage, it may well be several orders of magnitude smaller. The implication is that staggered wage contracts are far more likely to generate persistence than are staggered price contracts of the same length.

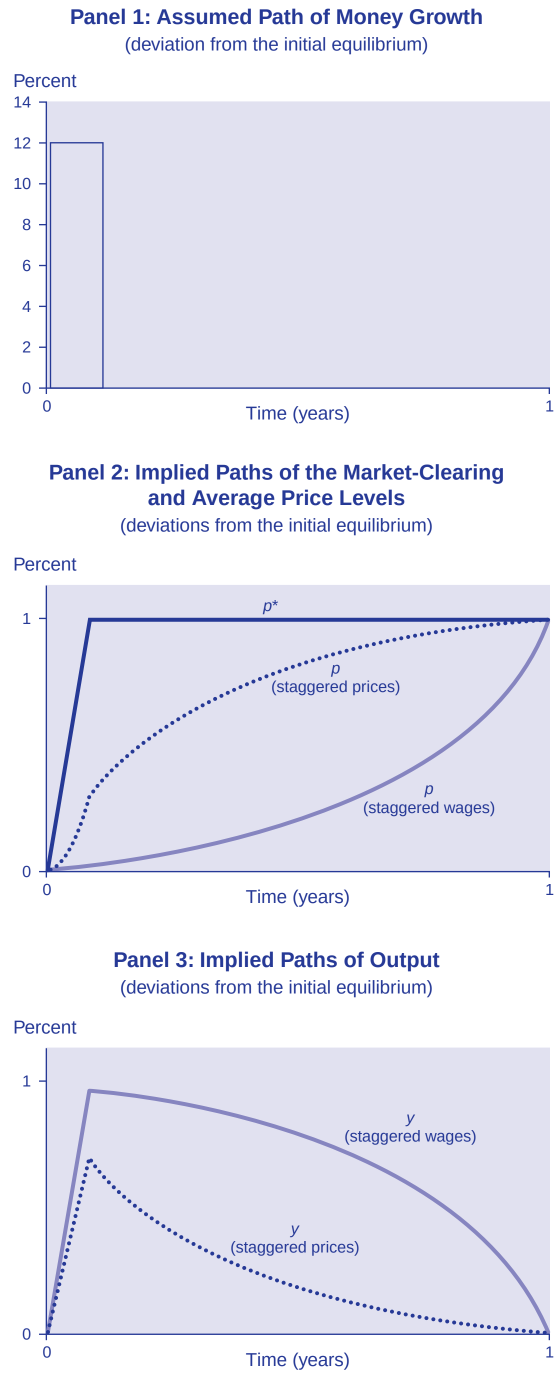
### Tracking the Economy Over Time

In this section, I use a series of figures to illustrate the impact labor-market imperfections can have on the economy's response to a monetary policy shock. (For a more general treatment, see the box entitled "The Short-Run Dynamics of an Economy with Labor-Market Frictions.") These figures assume that $\omega' = .25$—an overshooting parameter that is toward the upper end of the range in Table 1 and that, accordingly, may understate persistence. For comparison, the figures also show the policy responses of an economy with flexible wages and overlapping price contracts. For this economy, I assume $\omega = 4.5$—the same value my earlier article uses and near the middle of the range in Table 1.

The policy shock I consider is a surprise, temporary increase in the money growth rate that permanently raises the level of the money stock 1 percent above what the public had expected. I arbitrarily assume the money-growth surge lasts one-twelfth as long as contracts do. So if contracts specify the wage path for a year at a time, money growth remains elevated for only one month.[13] (See Panel 1 of Figure 1.) The market-clearing price, $p^*$, rises with the money stock, reaching a new, permanently higher level in one month (Panel 2).

Panels 2 and 3 show the paths of the average price level and rate of production in the economy with overlapping wage contracts (assuming $\omega' = .25$) and the economy with overlapping price contracts (assuming $\omega = 4.5$). Clearly, price and output adjustment take substantially longer in the staggered-wage economy than in the staggered-price economy. (As the box discusses, price and output adjustment are even further delayed if staggered wage and staggered price setting are combined.) With staggered wages, it takes 9.6 months for the price level to move halfway to its long-run, market-clearing level, compared with 2.2 months with staggered prices.[14] Similarly, the output response is larger and longer lasting in the staggered wage economy than in the staggered-price economy. These results are consistent with the view that persistent real monetary policy effects are much easier to obtain in an economy with labor-market imperfections than in an economy without such imperfections.

Figure 1
**Response to a Monetary Policy Shock**




It is important to note that the differences between the staggered-price and staggered-wage economies seen in Figure 1 are not due to any difference in contract length between the two economies: in both, contract length is one year. Price adjustment and output adjustment are slower in the staggered-wage economy than in the staggered-price economy solely because households' incentive to keep their wages close to the average wage in the former economy is stronger than firms' incentive to keep their prices close to the average price in the latter

## The Short-Run Dynamics of an Economy with Labor-Market Frictions

Consider an economy that is initially in long-run, market-clearing equilibrium, with (for notational convenience) a constant money stock. Suddenly, at $t = 0$, a change in the money stock's path is announced. The announcement is a complete surprise but fully credible. Without any loss of generality, we can define the unit time interval to equal the length of a labor contract. Then, by $t = 1$ every household will have had a chance to reset its wage path, and the economy will be back in market-clearing equilibrium. This box derives the formulas that govern the behavior of output, wages, and the price level over the interval from $t = 0$ to $t = 1$. I begin with the case in which final-goods prices are completely flexible, then briefly discuss how the analysis would differ in an economy with overlapping price contracts.

**Flexible Final-Goods Prices.** The basic building blocks for the analysis are the equations

(B.1) $$w^*(t) = m(t) + \theta - (\theta + \epsilon)\xi/(1 + \sigma\xi),$$

(B.2) $$w_i(t) = w(t) + \omega'[w^*(t) - w(t)],$$

and

(B.3) $$w(t) = tw_i(t) + (1 - t)w(0).$$

Equation B.1 gives the market-clearing wage as a function of the current money stock. It restates Equation 9 from the main text. Similarly, Equation B.2 is a restatement of Equation 12′. It gives the wage rate that will be chosen at time $t$ by any household that has had a chance to react to the new monetary policy. Finally, Equation B.3 is a formula for the average wage that follows from the assumption that wage adjustment is evenly staggered over the unit interval. At any given time $t$, $0 < t < 1$, the fraction $t$ of households will have had a chance to reset their wage paths and will be charging $w_i(t)$. The fraction $1 - t$ of households will be charging the wage that prevailed in the initial market-clearing equilibrium, $w(0)$.[1]

Together, Equations B.2 and B.3 imply that

(B.4) $$w(t) = w(0) + \left[\frac{\omega' t}{\omega' t + (1-t)}\right][w^*(t) - w(0)].$$

Since every firm sets its price as a markup over the average wage (compare Equation 7), we also have

(B.5) $$p(t) = p(0) + \left[\frac{\omega' t}{\omega' t + (1-t)}\right][p^*(t) - p(0)],$$

where the market-clearing price level is proportional to the current money stock (*Equation 10*). This equation is the same as that governing price adjustment in an economy with staggered price setting, except $\omega'$ has replaced $\omega$. (Compare Equation B.5, above, with Equation B.4 in Part 1 of this series.) Price adjustment is one-half complete when $\omega' t/[\omega' t + (1 - t)] = 1/2$, or $t = 1/(1 + \omega')$. So the smaller the overshooting parameter, $\omega'$, the slower the aggregate price adjustment.

Recall that our units of measurement are chosen so that average employment and output both equal real money balances at every instant: $l(t) = y(t) = m(t) - p(t)$. Using Equations 10 and B.5, it follows that

(B.6) $$l(t) = y(t) = m(t) - p(t) = [m(0) - p(0)] + \left[\frac{1-t}{\omega' t + (1-t)}\right][m(t) - m(0)].$$

Equations B.5 and B.6 are the basis for Panels 2 and 3 of Figure 1 in the main text.

**Staggered Final-Goods Prices.** Staggered price setting adds to persistence when present in an economy with labor-market frictions. It also causes the real wage to vary procyclically. I illustrate these facts in the special case where price contracts have the same length as wage contracts.

When there are staggered final-goods price contracts, Equation 7 applies only to firms that have had a chance to reset their price paths following the monetary shock. While Equation 12 remains valid, Equation 12′, in general, does not. Hence, we must go back a step and replace Equation B.2 with

(B.7) $$p_f(t) = w(t) - \theta$$

and

(B.8) $$w_i(t) = w(t) + \omega'[p^*(t) - p(t)],$$

which are simply restatements of Equations 7 and 12, respectively, in the main text. While previously we had $p(t) = p_f(t)$, now

(B.9) $$p(t) = tp_f(t) + (1 - t)p(0).$$

Equation B.9 governs the evolution of the average price level in much the same way that Equation B.3 governs the evolution of the average wage.[2]

Equations B.3 and B.7–B.9 can be solved for the paths of the wage rate and price level:

(B.10) $$w(t) = w(0) + \left[\frac{\omega' t}{\omega' t^2 + (1-t)}\right][w^*(t) - w(0)];$$

(B.11) $$p(t) = p(0) + \left[\frac{\omega' t^2}{\omega' t^2 + (1-t)}\right][p^*(t) - p(0)].$$

From Equations 9 and 10, $w(0) - p(0) = w^*(t) - p^*(t) = \theta$. Hence, subtracting B.11 from B.10,

(B.12) $$w(t) - p(t) = \theta + \left[\frac{\omega' t(1-t)}{\omega' t^2 + (1-t)}\right][m(t) - m(0)].$$

It follows that the real wage is procyclical to the extent that the business cycle is driven by monetary policy shocks.

Straightforward algebraic manipulations establish that

(B.13) $$l(t) = y(t) = m(t) - p(t) = [m(0) - p(0)] + \left[\frac{1-t}{\omega' t^2 + (1-t)}\right][m(t) - m(0)].$$

Since $t^2 < t$ for $0 < t < 1$, output and employment are more sensitive to monetary shocks in this economy than they are in an economy with flexible final-goods prices. (Compare Equations B.6 and B.13.)

What of persistence? According to Equation B.11, price adjustment is half completed when $\omega' t^2 = 1 - t$ in the economy examined here. With flexible final-goods prices, the corresponding condition is $\omega' t = 1 - t$. The left-hand side of each of these equations is an increasing function of $t$, but since $t^2 < t$ for $0 < t < 1$, it takes a larger $t$ to satisfy the first equation than the second. In other words, monetary shocks have more persistent real effects in an economy where both wages and prices are preset in overlapping contracts than in an otherwise identical economy in which only wages are preset.

### NOTES

[1] Equation B.3 is an approximation of the exact formula, which can be found using the definition of $W$ given in Note 9 to the main text:

$$w(t) = [(E - 1)/E]\ln\{t\cdot\exp[w_i(t)E/(E - 1)] + (1 - t)\cdot\exp[w(0)E/(E - 1)]\}.$$

The approximation will be good as long as $w_i(t)$ is not too different from $w(0)$.

[2] Like Equation B.3, Equation B.9 is a log-linear approximation.

economy. The staggered-wage economy would generate even more persistence than is displayed in Figure 1 if our analysis recognized that some real-world labor contracts are renegotiated only once every three years.[15]

## SUMMARY AND CONCLUSION

If the labor market is frictionless—if wages are flexible and workers can move freely from one employer to another—it is difficult to understand how monetary policy changes can have long-lasting effects on output and employment. The problem is that any policy that stimulates real activity will also drive the wage rate sharply higher in such an economy. This higher wage rate gives firms that are free to adjust their prices a powerful incentive to raise them. Consequently, for realistic contract lengths the average price level moves quickly toward its market-clearing level, and the stimulus to aggregate output and employment is short-lived.

Staggered wage contracts are a possible solution to this persistence problem. Workers—fearful of pricing themselves out of the market—will not press their wage demands aggressively in response to stimulatory monetary policy. Consequently, the average wage level adjusts slowly. Since cost pressures are muted, firms feel little need to raise their prices and the stimulus to aggregate output and employment persists. This argument applies even if final-goods prices are completely flexible. (If they are sticky, persistence is further enhanced.)

Labor immobility across employers is another possible explanation for persistence. With immobile labor, the wage a firm must pay is tied as much to its own labor demand as to the economywide employment level.[16] A firm that is able to raise its price relative to others' following monetary stimulus will find that its marginal labor costs tend to decline along with the demand for its output. Consequently, a smaller price increase is chosen than would be optimal in an otherwise identical economy with mobile labor. Since firms with an opportunity to adjust their prices choose to stay fairly close to the average price, the average price moves slowly and output and employment effects persist.

The results this article reports suggest that labor-market frictions are potentially significant quantitatively as well as qualitatively. A key parameter that measures the speed with which the price level moves toward its market-clearing level is likely between one and three orders of magnitude smaller in an economy with labor-market frictions than in a similar economy with staggered price setting, flexible wages, and mobile labor. The effect is to increase the amount of time required for the price level to complete half its adjustment by a factor of four or more.

## NOTES

1 For example, see Leeper, Sims, and Zha (1996). The evidence is not definitive. There is always a danger that such studies attribute to monetary policy real fluctuations that are, in fact, caused by unobserved changes in tastes and technology to which policymakers are reacting—a point Sims (1992) emphasizes.

2 Blanchard and Kiyotaki (1987) develop the basic framework. An alternative approach would be to model the bargaining that takes place between workers and their employers. For an example, see Benabou and Bismut (1988).

3 Gust (1997) and Ascari (2000) take this approach.

4 See Taylor (1983) for a detailed look at the length of union labor contracts and the timing of negotiations. Even in the nonunion sector, evidence suggests that wage rates are typically prespecified for a year or more. For a nice summary of the empirical evidence, see Taylor (1999).

5 See Koenig (1997) and Andersen (1998) for early developments of this argument. Ascari (2000) reaches a superficially different conclusion with regard to persistence. He is interested in whether labor-market imperfections similar to those examined here are able to generate a near-random walk in output in response to monetary policy shocks—a very high degree of persistence indeed. A near-random walk in response to money shocks is required only if one wants to claim that changes in the money stock are the *principal* source of output variation in the economy. These days, few economists would take so extreme a position.

6 Hence, the analysis presented here is more closely related to that of Fischer (1977) than to that of Taylor (1980).

7 If anything, relaxing these assumptions would make it easier to obtain persistent real monetary effects. For example, it is well known that when contracts specify a wage path, real monetary effects cannot last longer than the longest contract, whereas when contracts specify a fixed wage, policy shocks are propagated beyond the longest contract (Taylor 1980). Similarly, Erceg's (1997) analysis suggests that making investment endogenous contributes to persistence, provided the demand for money is linked to consumption rather than to income. That moving from a world of sticky wages and flexible prices to a world of sticky wages and prices tends to add to persistence is discussed in the box that accompanies this article.

8 Empirical estimates Pencavel (1986) reviews suggest $\xi \approx .25$. It is often assumed utility is logarithmic in

consumption ($\sigma$ = 1)—an approximation consistent with estimates Beaudry and van Wincoop (1996) obtain. On the other hand, Attanasio and Weber (1994) and Ogaki and Reinhart (1998) report $\sigma \approx 2$.

9 A labor demand curve of this form is consistent with profit maximization by firms if the labor variable that enters firm $f$'s production function is a composite of the labor different households supply. In particular, if there is a continuum of households indexed by $i \in [0, 1]$, Equation 2 is obtained if

$$L_f = (\int L_{fi}^{E} di)^{1/E}$$

and

$$W \equiv (\int W_i^{E/(E-1)} di)^{(E-1)/E},$$

where $L_{fi}$ is the amount of household $i$'s labor used by firm $f$ (Blanchard and Kiyotaki 1987).

10 Erceg (1997) takes another approach. In his analysis, monetary policy is non-neutral because of staggered price contracts, as in CKM. Labor contracts preset wages—short-circuiting the rise in unit labor costs that is responsible for rapid price adjustment in CKM—but hours of employment vary as if wages were perfectly flexible.

11 A demand curve of this form is consistent with household utility maximization if the output variable, $C_i$, that enters household $i$'s utility function is a composite of the goods different firms produce. In particular, if there is a continuum of firms indexed by $f \in [0, 1]$, Equation 6 is obtained if

$$C_i = (\int C_{fi}^{\Theta} df)^{1/\Theta}$$

and

$$P \equiv (\int P_f^{\Theta/(\Theta-1)} df)^{(\Theta-1)/\Theta},$$

where $C_{fi}$ is the amount of firm $f$'s output consumed by household $i$.

12 As Note 8 mentions, recent studies suggest $\sigma$ = 1 or 2 and $\xi \approx .25$. Unfortunately, empirical evidence concerning $E$ is almost nonexistent. Studies that examine the substitutability of one type of labor for another usually divide workers into only a few broad classes, such as skilled and unskilled. In the present context, however, the relevant elasticity of substitution $[1/(1 - E)]$ is that between the labor supplied by different individual bargaining units. One would expect this elasticity to be much greater than that between skilled laborers as a group and unskilled laborers as a group. A high elasticity of substitution means a low monopoly wage premium (a value of $E$ close to 1).

13 While three-year contracts are typical in unionized industries, currently only about 10 percent of workers are union members. Moreover, CKM examine one-year price contracts and it seems desirable to compare like with like. The reader is free to reinterpret the unit time interval.

14 When both wage adjustment and price adjustment are staggered, 9.9 months are required for the average price level to adjust halfway toward its new market-clearing level.

15 To generate a realistically persistent economic response to monetary shocks, it is sufficient that only a small fraction of labor contracts be renegotiated infrequently (Koenig 1997).

16 Recall that I assume households are able to insure their consumption against idiosyncratic shocks. Consequently, a higher average level of economic activity raises everyone's standard of living and, through the resultant wealth effect, tends to lower everyone's willingness to work.

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