Thus, the monetary policy that is consistent with a permanent drop in inflation is a sudden upward jump in the money supply, followed by low growth. And, in fact, the clearest examples of declines in inflation—the ends of hyperinflations—are accompanied by spurts of very high money growth that continue for a time after prices have stabilized (Sargent, 1982).\(^2\)

**The Case of Incomplete Price Flexibility**

In the preceding analysis, an increase in money growth increases nominal interest rates. In practice, however, the immediate effect of a monetary expansion is to lower short-term nominal rates. This negative effect of monetary expansions on nominal rates is known as the *liquidity effect*.

The conventional explanation of the liquidity effect is that monetary expansions reduce real rates. If prices are not completely flexible, an increase in the money stock raises output, which requires a decline in the real interest rate. In terms of the model of Section 6.1, a monetary expansion moves the economy down along the *IS* curve. If the decline in the real rate is large enough, it more than offsets the increase in expected inflation.\(^3\)

If prices are fully flexible in the long run, then the real rate eventually returns to normal following a shift to higher money growth. Thus if the real-rate effect dominates the expected-inflation effect in the short run, the shift depresses the nominal rate in the short run but increases it in the long run. As Friedman (1968) pointed out, this appears to provide an accurate description of the effects of monetary policy in practice. The Federal Reserve’s expansionary policies in the late 1960s, for example, lowered nominal rates for several years but, by generating inflation, raised them over the longer term.

### 11.2 Monetary Policy and the Term Structure of Interest Rates

In many situations, we are interested in the behavior not just of short-term interest rates, but also of long-term rates. To understand how monetary policy affects long-term rates, we must consider the relationship between short-term and long-term rates. The relationship among interest rates over different horizons is known as the *term structure of interest rates*, and the

\(^2\) This analysis raises the question of why expected inflation falls when the money supply is exploding. We return to this issue in Section 11.9.

\(^3\) See Problem 11.2. In addition, if inflation is completely unresponsive to monetary policy for any interval of time, then expectations of inflation over that interval do not rise. Thus in this case short-term nominal rates necessarily fall.
standard theory of that relationship is known as the *expectations theory of the term structure*. This section describes this theory and considers its implications for the effects of monetary policy.

### The Expectations Theory of the Term Structure

Consider the problem of an investor deciding how to invest a dollar over the next \( n \) periods, and assume for simplicity that there is no uncertainty about future interest rates. Suppose first the investor puts the dollar in an \( n \)-period zero-coupon bond—that is, a bond whose entire payoff comes after \( n \) periods. If the bond has a continuously compounded return of \( i^n_t \) per period, the investor has \( \exp(ni^n_t) \) dollars after \( n \) periods. Now consider what happens if he or she puts the dollar into a sequence of 1-period bonds paying continuously compounded rates of return of \( i^1_t, i^1_{t+1}, \ldots, i^1_{t+n-1} \) over the \( n \) periods. In this case, he or she ends up with \( \exp(i^1_t + i^1_{t+1} + \cdots + i^1_{t+n-1}) \) dollars.

Equilibrium requires that investors are willing to hold both 1-period and \( n \)-period bonds. Thus the returns on the investor’s two strategies must be the same. This requires

\[
i^n_t = \frac{i^1_t + i^1_{t+1} + \cdots + i^1_{t+n-1}}{n}. \tag{11.5}
\]

That is, the interest rate on the long-term bond must equal the average of the interest rates on short-term bonds over its lifetime.

In this example, since there is no uncertainty, rationality alone implies that the term structure is determined by the path that short-term interest rates will take. With uncertainty, under plausible assumptions expectations concerning future short-term rates continue to play an important role in the determination of the term structure. A typical formulation is

\[
i^n_t = \frac{i^1_t + E_t i^1_{t+1} + \cdots + E_t i^1_{t+n-1}}{n} + \theta_n, \tag{11.6}
\]

where \( E_t \) denotes expectations as of period \( t \). With uncertainty, the strategies of buying a single \( n \)-period bond and a sequence of 1-period bonds generally involve different risks. Thus rationality does not imply that the expected returns on the two strategies must be equal. This is reflected by the inclusion of \( \theta \), the *term premium* to holding the long-term bond, in (11.6).

The expectations theory of the term structure is the hypothesis that changes in the term structure are determined by changes in expectations of future interest rates (rather than by changes in the term premium). Typically, the expectations are assumed to be rational.

As described at the end of Section 11.1, even if prices are not completely flexible, a permanent increase in money growth eventually increases the short-term nominal interest rate permanently. Thus even if short-term rates
fall for some period, (11.6) implies that interest rates for sufficiently long maturities (that is, for sufficiently large $n$) are likely to rise immediately. Thus our analysis implies that a monetary expansion is likely to reduce short-term rates but increase long-term ones.

**Empirical Application: The Term Structure and Changes in the Federal Reserve’s Funds-Rate Target**

The Federal Reserve typically has a target level of a specific interest rate, the Federal funds rate, and implements monetary policy through discrete changes in its target. The Federal funds rate is the interest rate that banks charge one another on one-day loans of reserves; thus it is a very short-term rate. Cook and Hahn (1989) investigate the impact of changes in the target level of the funds rate on interest rates on bonds of different maturities.

Cook and Hahn focus on the period 1974–1979, which was a time when the Federal Reserve was targeting the funds rate closely. During this period, the Federal Reserve did not announce its target level of the funds rate. Instead, market participants had to infer the target from the Federal Reserve’s open-market operations. Cook and Hahn therefore begin by compiling a record of the changes in the target over this period. They examine both the records of the Federal Reserve Bank of New York (which implemented the changes) and the reports of the changes in *The Wall Street Journal*. They find that despite the absence of announcements, the *Journal*’s reports are almost always correct. Thus it is reasonable to think of the changes in the target reported by the *Journal* as publicly observed.

As Cook and Hahn describe, the actual Federal funds rate moves closely with the Federal Reserve’s target. Moreover, it is highly implausible that the Federal Reserve is changing the target in response to factors that would have moved the funds rate in the absence of the policy changes. For example, it is unlikely that, absent the Federal Reserve’s actions, the funds rate would move by discrete amounts. In addition, there is often a lag of several days between the Federal Reserve’s decision to change the target and the actual change. Thus arguing that the Federal Reserve is responding to forces that would have moved the funds rate in any event requires arguing that the Federal Reserve has advance knowledge of those forces.

The close link between the actual funds rate and the Federal Reserve’s target thus provides strong evidence that monetary policy affects short-term interest rates. As Cook and Hahn describe, earlier investigations of this issue mainly regressed changes in interest rates over periods of a month or a quarter on changes in the money supply over those periods; the regressions produced no clear evidence of the Federal Reserve’s ability to influence
Monetary Policy and the Term Structure of Interest Rates

interest rates. The reason appears to be that the regressions are complicated by the same types of issues that complicate the money-output regressions discussed in Section 5.9: the money supply is not determined solely by the Federal Reserve, the Federal Reserve adjusts policy in response to information about the economy, and so on.

Cook and Hahn then examine the impact of changes in the Federal Reserve’s target on longer-term interest rates. Specifically, they estimate regressions of the form

\[ \Delta R_i^t = b_1^t + b_2^t \Delta FF_t + u_i^t, \]  

(11.7)

where \( \Delta R_i^t \) is the change in the nominal interest rate on a bond of maturity \( i \) on day \( t \), and \( \Delta FF_t \) is the change in the target Federal funds rate on that day.

Cook and Hahn find, contrary to the predictions of the analysis in the first part of this section, that increases in the funds-rate target raise nominal interest rates at all horizons. An increase in the target of 100 basis points (that is, 1 percentage point) is associated with increases in the 3-month interest rate of 55 basis points (with a standard error of 6.8 basis points), in the 1-year rate of 50 basis points (5.2), in the 5-year rate of 21 basis points (3.2), and in the 20-year rate of 10 basis points (1.8).

Kuttner (2001) extends this work to later data. A key difference between the period studied by Cook and Hahn and the more recent period is that there has been a Federal-funds futures market since 1989. Under plausible assumptions, the main determinant of rates in the futures market is market participants’ expectations about the path of the funds rate. Kuttner therefore uses data from the futures market to decompose changes in the Federal Reserve’s target into the portions that were anticipated by market participants and the portions that were unanticipated.

Since long-term rates incorporate expectations of future short-term rates, movements in the funds rate that are anticipated should not affect long-term rates. Consistent with this, Kuttner finds that for the period since 1989, there is no evidence that anticipated changes in the target have any impact on interest rates on bonds with maturities ranging from 3 months to 30 years. Unanticipated changes, in contrast, have very large and highly significant effects. As in the 1970s, increases in the funds-rate target are associated with increases in nominal rates at all horizons. Indeed, the effects are larger than those that Cook and Hahn find for changes in the overall target rate in the 1970s. A likely explanation is that the moves in the 1970s were partially anticipated.

The idea that contractionary monetary policy should immediately lower long-term nominal interest rates is intuitive: contractionary policy is likely to raise real interest rates only briefly and to lower inflation over the longer term. Yet, as Cook and Hahn’s and Kuttner’s results show, the evidence does not support this prediction.
One possible explanation of this anomaly is that the Federal Reserve often changes policy on the basis of information that it has concerning future inflation that market participants do not have. As a result, when market participants observe a shift to tighter monetary policy, they do not infer that the Federal Reserve is tougher on inflation than they had previously believed. Rather, they infer that there is unfavorable information about inflation that they were previously not aware of.

C. Romer and D. Romer (2000) test this explanation by examining the inflation forecasts made by commercial forecasts and the Federal Reserve. Because the Federal Reserve’s forecasts are made public only after 5 years, the forecasts provide a potential record of information that was known to the Federal Reserve but not to market participants. Romer and Romer ask whether individuals who know the commercial forecast could improve their forecasts if they also had access to the Federal Reserve’s. Specifically, they estimate regressions of the form

\[ \pi_t = a + b_C \hat{\pi}_C^t + b_F \hat{\pi}_F^t + e_t, \]

(11.8)

where \( \pi_t \) is actual inflation and \( \hat{\pi}_C^t \) and \( \hat{\pi}_F^t \) are the commercial and Federal Reserve forecasts of \( \pi_t \). Their main interest is in \( b_F \), the coefficient on the Federal Reserve forecast.

For most specifications, the estimates of \( b_F \) are close to 1 and overwhelmingly statistically significant. In addition, the estimates of \( b_C \) are generally near 0 and highly insignificant. These results suggest that the Federal Reserve has useful information about inflation. Indeed, they suggest that the optimal forecasting strategy of someone with access to both forecasts would be to discard the commercial forecast and adopt the Federal Reserve’s.

For the Federal Reserve’s additional information to explain the increases in long-term rates in response to contractionary policy moves, the moves must reveal some of the Federal Reserve’s information. Romer and Romer therefore consider the problem of a market participant trying to infer the Federal Reserve’s forecast. To do this, they estimate regressions of the form

\[ \hat{\pi}_F^t = \alpha + \beta \Delta FF_t + \gamma \hat{\pi}_C^t + \varepsilon_t, \]

(11.9)

where \( \Delta FF \) is the change in the Federal-funds-rate target. A typical estimate of \( \beta \) is around 0.25: a rise in the funds-rate target of 1 percentage point suggests that the Federal Reserve’s inflation forecast is about \( \frac{1}{4} \) percentage points higher than one would expect given the commercial forecast. In light of the results about the value of the Federal Reserve forecasts in predicting inflation, this suggests that the rise should increase market participants’ expectations of inflation by about this amount; this is more than enough to account for Cook and Hahn’s findings. Unfortunately, the estimates of \( \beta \) are not very precise: typically the two-standard-error confidence interval ranges from less than 0 to above 0.5. Thus, although Romer and Romer’s results are consistent with the information-revelation explanation of policy
actions’ impact on long-term interest rates, they do not provide decisive evidence for it.\footnote{The most recent work in this area takes advantage of another institutional development since the period studied by Cook and Hahn. Since 1997, the United States has issued not just conventional nominal bonds, whose payoffs are fixed in dollar terms, but also inflation-indexed bonds; in addition, the United Kingdom has issued inflation-indexed bonds since 1981. By logic like that underlying equation (11.6), the interest rate on an $n$-period inflation-indexed bond reflects expected one-period real interest rates over the $n$ periods and a term premium. If changes in term premia are small, one can therefore study the impact of unexpected changes in the funds-rate target and other developments not just on nominal rates, but on real rates and expected inflation separately. Examples of such analyses include Gürkaynak, Sack, and Swanson (2005), Gürkaynak, Levin, and Swanson (2008), and Beechey and Wright (2009).}

\section*{11.3 The Microeconomic Foundations of Stabilization Policy}

We now turn to stabilization policy—that is, how policymakers should use their ability to influence the behavior of inflation and output. Discussions of stabilization policy often start from an assumption that policymakers’ goal should be to keep inflation low and stable and to minimize departures of output from some smooth trend. Presumably, however, their ultimate goal should be to maximize welfare. How inflation and output affect welfare is not obvious. Thus the appropriate place to start the analysis of stabilization policy is by considering the welfare effects of inflation and output fluctuations. We begin with inflation, and then turn to output.

\subsection*{The Costs of Inflation}

Understanding the costs of inflation is a significant challenge. In many models, steady inflation just adds an equal amount to the growth rate of all prices and wages and to nominal interest rates on all assets. As a result, it has few easily identifiable costs.

The cost of inflation that is easiest to identify arises from the fact that, since the nominal return on high-powered money is fixed at zero, higher inflation causes people to exert more effort to reduce their holdings of high-powered money. For example, they make smaller and more frequent conversions of interest-bearing assets into currency. Since high-powered money is essentially costless to produce, these efforts have no social benefit, and so they represent a cost of inflation. They could be eliminated if inflation were chosen so that the nominal interest rate—and hence the opportunity cost