How Should Monetary Policy Be Conducted in an Era of Price Stability?

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For several decades, high inflation has been the main threat to monetary stability. During the 1990s, low and stable inflation has been achieved in many countries. This may be the start of a new era of price stability. This paper discusses some issues related to how monetary policy should be conducted in such an era.

Before we can talk about an era of price stability, we need to be clear on the definition of price stability. In Section 2, I discuss two definitions, low (and stable) inflation, which implies base drift in the price level, and price-level stability, which does not imply such a base drift. Most current discussion and monetary-policy formulations involve the first definition, low inflation. Price-level stability has the advantage of reducing long-term price-level uncertainty, which should be beneficial for long-term planning and investment decisions. According to conventional wisdom, however, it has the drawback of increasing short-term variability of inflation and output, and is, therefore, not to be recommended. I argue that this conventional wisdom is ill founded, and that the relative advantages of the two kinds of price stability are a rather open issue warranting further study. Instead, in a decade or so, when central banks (hopefully) master maintaining low and stable inflation, the time may be ripe for seriously considering price-level stability as a goal for monetary policy. Accumulated experience and research may then allow a more reliable evaluation of the relative advantages of the two regimes. The rest of the paper is mainly

concerned with low inflation, although some of the discussion also applies to price-level stability. The rest of Section 2 discusses the choice of suitable objectives for monetary policy.

This boils down to specifying a loss function corresponding to "flexible inflation targeting." That is, stabilizing inflation around an inflation target, but also putting some weight on stabilizing the real economy by stabilizing the real output around potential output. I also briefly discuss the choice of a suitable index and target level for inflation.

An era of price stability will, obviously, only arise if central banks succeed in maintaining price stability. In Section 3, I discuss how central banks can best maintain price stability. I discuss three alternative ways: (1) a commitment to a simple "instrument rule," a rule for setting the instrument, like the Taylor (1993) Rule for the federal funds rate or the Meltzer (1997) and McCallum (1988) rules for the monetary base; (2) "forecast targeting," setting the instrument such that the central bank's conditional forecasts for inflation and the output gap approach the inflation target and zero, respectively; and (3) "monetary targeting," where the instrument is set such as to achieve a target growth rate for a broad monetary aggregate, like M2 or M3. Although simple instrument rules prominently figure in current research and policy discussions, and the research on simple instrument rules has contributed important insights, I find that a commitment to these rules is neither a desirable nor a practical way of maintaining price stability. Furthermore, in line with most previous research, I find that monetary targeting is an inferior way of maintaining price stability. Instead, forecast targeting, which is, indeed, already practiced by successful central banks, seems to be the best way of maintaining price stability.[1]

An era of price stability will not only bring low and stable inflation but also low and stable inflation expectations, that is, credibility for a low-inflation policy. Central bankers often seem obsessed with credibility. In Section 4, I argue that there are good reasons for this and discuss the benefits of credibility (in the sense of private inflation expectations anchored on the inflation target). I show that credibility makes the trade-off between inflation variability, output-gap variability and instrument variability more favorable, and that it puts the economy

increasingly on automatic pilot, such that less control and activism need to be exercised by the central bank. These circumstances make it easier for the central bank to meet is targets. Furthermore, credibility helps avoid deflation and a liquidity trap, the topic of the next section.

Current inflation is lower than in many decades, which, together with the situation in Japan, has brought the potential threat of sustained deflation and a liquidity trap into focus. In Section 5, I discuss the threat of deflation and a liquidity trap. More precisely, I specify what a liquidity trap is and discuss how it is avoided, and how to get out of it if already trapped. A liquidity trap is a situation with zero nominal interest rates and persistent deflation and deflationary expectations. Since money and nominal bonds are then perfect substitutes, monetary policy becomes ineffective and has no effects on nominal and real prices and quantities. I argue that transparent inflation targeting of an announced moderately positive inflation target is the best way of avoiding a liquidity trap. I also argue that central banks should make advance contingency plans for emergency measures to be used if a series of unfortunate shocks were to push the economy close to or into a liquidity trap. These measures include increasingly aggressive and unorthodox open-market operations, as well as preparations for coordinated fiscal and monetary expansions. These measures also serve a role in escaping from a liquidity trap if already trapped.

Since monetary policy may be ineffective on its own, fiscal policy, both with regard to a fiscal expansion and to nominal public debt management, is likely to have an important role in escaping from a liquidity trap.

Section 6 presents some conclusions. Appendices A and B present some technical details on inflation variability under inflation targeting and price-level targeting (related to Section 2.1) and on monetary and fiscal policy in a liquidity trap (related to Section 5).

Defining price stability[2]

Before we can talk about an era of price stability, we need to be clear on how to define "price stability." In this section, I discuss this defini-

tion, in particular the distinction between price-level stability and low inflation. I also discuss how to formulate the appropriate loss function for a policy aiming at price stability, including any concern for stability of the real economy, as well as the choice of price index and target level.

Price-level stability vs. low inflation

What is the appropriate definition of "price stability?" The most obvious meaning of price stability would seem to be a stable price level, "price-level stability." Nevertheless, in most current discussions and formulations of monetary policy, price stability instead means a situation with low and stable inflation, "low inflation" (including zero inflation). The former definition implies that the price level is stationary (or at least trend-stationary, stationary around a deterministic trend). The latter definition implies base drift in the price level, so that the price level will include a unit root and be non-(trend-)stationary. Indeed, the price-level variance increases without bound with the forecast horizon. Thus, referring to low inflation as price stability is, indeed, something of a misnomer.

Let me refer to a monetary-policy regime as price-level targeting or inflation targeting, depending on whether the goal is a stable price level or a low and stable inflation rate. Note that if arguments in favor of a small positive inflation rate are accepted, an upward-sloping price-level target path may be preferable to a constant price-level target, and still achieve the desired trend-stationarity.

In the real world, there are currently an increasing number of monetary-policy regimes with explicit or implicit inflation targeting, but no regimes with explicit or implicit price-level targeting. Whereas the Gold Standard may be interpreted as implying implicit price-level targeting, so far the only regime in history with explicit price-level targeting occurred in Sweden during the 1930s (see Fisher (1934) and Berg and Jonung (1999); this regime was quite successful in avoiding deflation).

Even if there are no current examples of price-level targeting

regimes, price-level targeting has been subject to an increasing interest in the monetary policy literature.[3] A frequent result, which has emerged as the conventional wisdom, is that the choice between price-level targeting and inflation targeting involves a trade-off between low-frequency price-level variability on one hand and high-frequency inflation and output variability on the other. Thus, price-level targeting has the advantage of a reduced long-term variability of the price level, which should be beneficial for long-term nominal contracts and intertemporal decisions, but would come at the cost of increased short-term variability of inflation and output. The intuition is straightforward: In order to stabilize the price level under price-level targeting, higher-than-average inflation must be succeeded by lower-than-average inflation. This would seem to result in higher inflation variability than under inflation targeting, since base drift is accepted in the latter case and higher-than-average inflation need only be succeeded by average inflation. Via nominal rigidities, the higher inflation variability would then seem to result in higher output variability.[4]

However, this intuition may be misleadingly simple. In more realistic models of inflation targeting and price-level targeting with more complicated dynamics, the relative variability of inflation in the two regimes becomes an open issue. As shown in Appendix A (which reproduces some results in the appendix of the working-paper version of Svensson [1999g]), this is the case if there is serial correlation in the deviation between the target variable and the target level. For instance, if the price level displays mean reversion toward the price-level target under price-level targeting and inflation displays mean reversion toward the inflation target under inflation targeting. Svensson (1999g) and Vestin (1999) give examples where the absence of a commitment mechanism implies that the trade-off between inflation variability and output variability becomes more favorable under price-level targeting than under inflation targeting.[5] For some empirical macro models (both small and large), reaction functions with responses of the instrument to price-level deviations from a price-level target lead to as good or better overall performance (in terms of inflation and output variances) than with responses to inflation deviation from inflation targets.[6] Interestingly, a price-level target may have special advantages relative to an inflation target in avoiding persistent deflation, because

an unanticipated deflation that makes the price level fall below the price-level target will, if the price-level target is credible, result in increased inflation expectations. These increased inflation expectations will, by themselves, reduce the real interest rate and stabilize the economy, even if the nominal interest rate remains unchanged.[7]

I believe these results show that the relative properties of price-level targeting and inflation targeting are far from settled. In particular, the potential benefits from reduced long-term price-level variability and uncertainty are not yet well understood. Still, I believe that low and stable inflation may be a sufficiently ambitious undertaking for central banks at present. However, once central banks have mastered inflation targeting, in perhaps another decade, it may be time to increase the ambitions and consider price-level targeting. By then, research and experience may provide better guidance about which regime is preferable.[8]

The rest of the paper will refer to "low inflation," which allows base drift in the price level, rather than "price-level stability," which does not allow such base drift. Reluctantly, I will occasionally refer to "low inflation" as "price stability," even without using quotation marks. Some of the discussion below is applicable to both price-level stability and low inflation, though.

Specifying the loss function

What is the appropriate loss function for a central bank aiming at low inflation? As substantiated below, there is considerable agreement among academics and central bankers that the appropriate loss function both involves stabilizing inflation around an inflation target and stabilizing the real economy, represented by the output gap. This can be represented by a quadratic loss function,

$$L_t = \frac{1}{2}\left[(\pi_t - \pi^*)^2 + \lambda(y_t - y_t^*)^2\right], \tag{2.1}$$

where the subscript t refers to the period, π_t is an index of inflation, π^* is an inflation target, y_t is (log) output, y_t^* is potential output (so that $y_t - y_t^*$ is the output gap), and $\lambda > 0$ is the relative weight on out-

put-gap stabilization.[9] As in Svensson (1999d and 1999f), I find it practical to refer to this loss function with $\lambda > 0$ (or concern about stability of the real economy in general) as *flexible* inflation targeting, and $\lambda = 0$ as *strict* inflation targeting.[10]

Because current inflation and output are, in practice, predetermined, current monetary-policy actions can only affect future inflation and output. Furthermore, inflation, output, and, in particular, potential output are observed (or estimated) with measurement errors. Then, the objectives of monetary policy need to be expressed as an intertemporal loss function of expected discounted future losses,

$$E_t \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+\tau}, \tag{2.2}$$

where E_t denotes expectations conditional on the central bank's information in period t and δ $(0 < \delta < 1)$ is a discount factor.

Whereas, there may previously have been some controversy about whether inflation targeting involves concern about real variability, represented by output-gap variability and corresponding to the second term in (2.1), there is now considerable agreement in the literature that this is, indeed, the case: Inflation-targeting central banks are not what King (1997) referred to as "inflation nutters."[11] As shown by Ball (1999a) and Svensson (1997a), concern about output-gap stability translates into a more gradualist policy (at least in standard simple models of the transmission mechanism). Thus, if inflation moves away from the inflation target, it is more gradually brought back to target. Equivalently, inflation-targeting central banks lengthen their horizon and aim at meeting the inflation target further in the future. In contrast, strict inflation targeting would involve meeting the inflation target at the shortest possible horizon and, thereby, generate considerable output-gap volatility.[12] As further discussed in Svensson (1999d), concerns about output-gap stability, simple forms of model uncertainty, and interest rate smoothing all have similar effects under inflation targeting, namely a more gradualist policy. Sveriges Riksbank has expressed similar views.[13] The Chancellor's remit to Bank of England

mentions "undesired volatility of output."[14] The minutes from Bank of England's Monetary Policy Committee are also explicit about stabilizing the output gap.[15] Several contributions and discussions by central bankers and academics in Lowe express similar views. Ball (1999b) and Svensson (1998) give examples of the gradualist approach of the Reserve Bank of New Zealand. Indeed, a quote from the ECB (ECB Monthly Bulletin, January 1999, p. 47) also gives some support for an interpretation with $\lambda > 0$ (as well as some weight on minimizing interest rate variability):

> ... a medium-term orientation of monetary policy is important in order to permit a gradualist and measured response [to some threats to price stability]. Such a central bank response will not introduce unnecessary and possibly self-sustaining uncertainty into short-term interest rates or the real economy...

Thus, it seems non-controversial that real-world inflation targeting is actually flexible inflation targeting with some concern for variability in the real economy, corresponding to $\lambda > 0$ in (2.1). Furthermore, as discussed in some detail in Svensson (1999c), there is general agreement that the output target under inflation target should equal potential output, so as to avoid any average inflation bias.[16]

What index and which level?

Which price index would be most appropriate? Stabilizing the CPI, interpreted as a cost-of-living index for the average consumer, should simplify the consumers' economic calculations and decisions. The CPI also has the advantage of being easily understood, frequently published, published by authorities separate from central banks, and very rarely revised. Interest-related costs cause well-known problems with the CPI, though: An interest-rate increase to lower inflation has the perverse short-term effect of increasing inflation. This presents a pedagogical problem in the central bank's communication with the general public. To avoid this problem, Bank of England and Reserve Bank of New Zealand have inflation targets defined in terms of CPIX (RPIX in Britain), the CPI less interest-related costs.[17] The Eurosystem has

defined price stability in terms of the HICP, which also excludes interest costs. Furthermore, changes in indirect taxes and subsidies can have considerable short-run effects on the CPI. Different measures of underlying inflation, core inflation, try to eliminate such effects. Eliminating components over which monetary policy has little or no influence serves to avoid misleading impressions of the degree of control. The disadvantage of subtracting components from the CPI is that the remaining index becomes more remote from what matters to consumers and less transparent to the general public. It may also be difficult to compute in a well-defined and transparent way. Opinions generally differ on what components to deduct from the CPI. My own view is that deducting interest-related costs and using CPIX, together with transparent explanation of index movements caused by changes in indirect taxes and subsidies, is an appropriate compromise.

Critics of inflation targeting and proponents of monetary targeting sometimes criticize inflation targeting for being concerned about short-run inflation and temporary changes in inflation, and argue that monetary targeting would indirectly imply targeting permanent components of inflation only.[18] It seems that this issue is much better confronted by explicitly selecting the appropriate inflation index to be targeted. Indeed, as already noted above, different measures of underlying inflation (as suggested by the term itself) are explicitly designed to exclude temporary disturbances and focus on persistent components of inflation. Furthermore, the practice of measuring inflation as twelve-month moving-average inflation rates is, by itself, a way of averaging out some of the wider and more transitory movements in inflation. Finally, forecasts of inflation, in practice, focus more on persistent changes in inflation and less on transient ones, since the former are, by nature, easier to predict.[19]

What level of the inflation target is appropriate? Although zero inflation would seem to be a natural focal point, all countries with inflation targets have selected positive inflation targets. The inflation targets (point targets or midpoints of the target range) vary between 1.5 percent (per year) in New Zealand; 2 percent in Canada, Sweden, and Finland (before Finland joined the EMU); and 2.5 percent in the United Kingdom and Australia (the Reserve Bank of Australia has a

target range of 2 to 3 percent for average inflation over an unspecified business cycle). The Bundesbank had a 2 percent inflation target for many years (called "unavoidable inflation," "price norm," or "medium-term price assumption"). During 1997 and 1998, it was lowered to 1.5 to 2 percent (which could perhaps be translated into a point inflation target of 1.75 percent). The Eurosystem has announced "annual increases in the HICP below 2 percent" as its definition of price stability, which has been interpreted as the ranges 0 to 2 percent or 1 to 2 percent; the Eurosystem appeared to have used a point inflation target of 1.5 percent in constructing its reference value for money growth.[20]

That the inflation target exceeds zero can be motivated by measurement bias, non-negative nominal interest rates and possible downward nominal price and wage rigidities.[21] Two percent is the borderline in Akerlof, Dickens, and Perry (1996), who study the effects of the downward rigidity of nominal wages. One percent is the borderline in Orphanides and Wieland (1998), who examine the consequences of non-negative nominal interest rates. These studies indicate that inflation targets below those borderlines risk reducing average output or increasing average unemployment.[22,23] Altogether, I believe that it may be more important to announce an explicit inflation target (a point target or a range) than whether the target (the midpoint of the range) is 1.5, 2, or 2.5 percent.

A symmetric inflation target implies that inflation below the target is considered to be equally bad as the same distance above the target (which is the case if inflation targeting is represented by a symmetric loss function like (2.1)). An asymmetric inflation target may induce an upward would, from this point of view, be better than just a range. As argued in Section 4, there should be substantial benefits from inflation expectations stabilizing at the inflation target. A point inflation target then gives a well-defined focal point for inflation expectations that enter into wage setting and other contracts. With a range of 0 to 2 percent, for instance, there is a large difference between inflation expectations stabilizing at 0 percent or 2 percent. Nevertheless, a symmetric range would, in turn, be better than an asymmetric formulation like the Eurosystem's "below 2 percent." As further discussed in Section 5, these aspects may be particularly important in order to avoid a liquidity trap with persistent deflation—a possibility that seems less remote

given recent developments in Japan. A symmetric and small positive inflation target would seem to be the best defense against a liquidity trap with persistent deflation and deflationary expectations.

Maintaining price stability[24]

An era of price stability will obviously not materialize unless central banks succeed in maintaining price stability. The central bank then needs to minimize expected future discounted losses, (2.2), consisting of a weighted sum of squared deviations of inflation from the inflation variables and squared deviations of output from the output gap, (2.1). Then, inflation and the output gap are the central bank's target variables, that is, the variables entering the central bank's loss function. The central bank's control variable, its instrument, is, in practice, a short interest rate like the federal funds rate in the United States.[25] The central bank's task is then to set its instrument so as to best minimize the intertemporal loss function. To achieve this, the central bank must have a view of the transmission mechanism of monetary policy, that is, how the instrument and the current state of the economy affect the future path of the target variables.

In this section, I will discuss the central bank's framework for policy decisions, the principles for the setting of its instrument. I will discuss three alternative decision frameworks or principles for setting the instrument, namely commitment to a simple instrument rule in subsection 3.1, forecast targeting in subsection 3.2, and monetary targeting in subsection 3.3.

Commitment to a simple instrument rule

A large part of the monetary-policy literature uses the concept of "rules" in the narrow sense of a prescribed reaction function for monetary policy. Instead, as in Svensson (1999c), I find it helpful to use the concept of monetary policy rules in a wider sense, namely as "a prescribed guide for monetary policy." This allows "instrument rules," prescribed reaction functions, as well as "targeting rules," prescribed loss functions or prescribed conditions for the target variables (or forecasts of the target variables).[26] [27]

Thus, in this subsection, I am concerned with instrument rules, that is, a rule prescribing the central bank's instrument as a particular reaction function, that is, a particular function of variables observable by the central bank. Suppose we make the unrealistic assumption that the central bank can commit, once and for all, to a particular reaction function for all future periods. Furthermore, assume that the central bank knows the transmission mechanism and the current state of the economy. Under these assumptions it is, in principle, possible to find the optimal reaction function that minimizes the central bank's intertemporal loss function, (2.2).

The optimal reaction function under commitment is a very complex construction and would normally be a function of all the relevant variables that describe the state of the economy (as well as lags of these variables).[28] This is likely to be too complex to be verifiable. For this and other reasons discussed below, a commitment to the optimal reaction function is not realistic.

Consider instead the class of simple reaction functions, meaning reaction functions with few arguments. A typical simple reaction function is the much-discussed Taylor (1993) rule,

$$i_t = \bar{r} + \pi^* + 1.5(\pi_t - \pi^*) + 0.5(y_t - y_t^*),$$

Where i_t is the federal funds rate and $\bar{r}$ is the average real interest rate.[29] Under the assumptions stated above it is, in principle, possible to find the optimal simple reaction function (under commitment), the reaction function in a particular class of simple reaction functions minimizing the intertemporal loss function. A sufficiently simple reaction function is easily verified. In principle, we can, thus, conceive of a commitment to a simple reaction function, a commitment to a simple instrument rule.

We realize that, under a commitment to a simple instrument rule, the central bank need no longer be forward looking. It need only be forward-looking once and for all, when deciding to which simple reaction function it will commit. After that, it can just set the instrument mechanically according to the simple rule.[30]

Most of the current and previous discussion of monetary-policy rules is in terms of commitment to alternative instrument rules (see, for instance, McCallum (1997) and the contributions in Bryant, Hooper and Mann and Taylor [1999b]). The research on instrument rules has contributed many important insights.[31] Nevertheless, I do not believe that a commitment to an instrument rule is either a practical or desirable way of maintaining price stability, for several reasons.

First, there are considerable practical difficulties in deciding, once and for all, which instrument rule to follow. In general, Currie and Levine (1992) have shown that the optimal simple reaction function does not only depend on the model and the loss function but also on the stochastic properties of the shocks and the initial state of the economy.[32] This is a considerable problem, because the model and the stochastic properties of the shocks are not exactly known (to say the least). Still, it may be possible to find a simple reaction function that works tolerably well in different models. This idea is promoted and examined in several papers by McCallum and recently restated in McCallum (1997). Results of Levin, Williams, and Wieland (1999) for a set of models of the U.S. economy indicate that a simple reaction function may be relatively robust in this sense. Still, in a class of reaction functions as restricted as Taylor-type reaction functions with interest-rate smoothing (where the federal funds rate depends on inflation only, the output gap and the lagged federal funds rate), there is considerable variation in the suggested magnitudes for the three coefficients, as is apparent from the papers published in Taylor (1999b).

Second, a commitment to an instrument rule does not leave any room for judgmental adjustments and extra-model information. In practice, monetary policy cannot (at least not yet) rely on models only. As further discussed in Svensson (1999h), the use of judgmental adjustments and extra-model information is both desirable in principle and unavoidable in practice. Furthermore, a commitment leaves no room for revisions of the instrument rule when new information and research results in revisions of the model. For both these reasons, a commitment to an instrument rule would be inefficient.

Third, although a commitment to a simple instrument rule seems technically feasible, such a commitment is unheard of in the history of monetary policy, most likely for obvious reasons. It would involve committing the decision-making body of the central bank to reacting in a prescribed way to prescribed information. Monetary policy could be delegated to the staff, or even to a computer, and it would be completely static and mechanical and not forward looking. Such a degradation of the decision-making process would naturally be strongly resisted by any central bank and, I believe, arguments about its inefficiency would also easily convince legislators to reject it. In practice, there is, therefore, no commitment mechanism that commits the decision-making body to reacting in a prescribed way to prescribed information. In real-world monetary policy, decision-making under considerable discretion is more or less unavoidable. As Blinder (1998, p. 49) puts it, "Rarely does society solve a time-consistency problem by rigid precommitment...Enlightened discretion is the rule".[33] Instead, at best, the commitment is provided by the objective of monetary policy.[34]

Thus, we are unlikely to ever see a commitment to a mechanical simple instrument rule for monetary policy. Because any given instrument rule is likely to be more or less inefficient in certain situations, there would be frequent incentives to deviate, often for very good reasons, due to new, unforeseen information (a crash of the stock market, a crisis in Asia, the floating of the Brazilian real, etc.) and corresponding sound judgmental adjustments. Therefore, a simple instrument rule is not incentive compatible, and, in the absence of commitment, frequent deviations would occur.[35]

Thus, although alternative instrument rules can serve as informative guidelines (as emphasized in Taylor [1993]),[36] and decisions ex post may sometimes be similar to those prescribed by the simple instrument rules, a rigid commitment to a simple instrument rule is not a realistic substitute for a forward-looking decision framework. Indeed, instead of making a forward-looking decision once and for all only, at the time of a commitment to a simple instrument rule, a central bank aiming at price stability needs to be continuously forward looking and have a regular cycle of decision making. To quote Greenspan (1994, p. 244),

> "Implicit in any monetary policy action or inaction, is an expectation of how the future will unfold, that is, a forecast. The belief that some formal set of rules for policy implementation can effectively eliminate that problem is, in my judgement, an illusion. There is no way to avoid making a forecast, explicitly or implicitly."[37]

Therefore, I now turn to a practical and realistic, and, indeed, already practiced, way of maintaining price stability, namely by way of "forecast targeting."[38]

Forecast targeting

Monetary policy affects the economy with considerable lags. Normally, current inflation and output are, to a large extent, determined by previous decisions of firms and households. Normally, current monetary policy actions can only affect the future levels of inflation and the output gap, in practice, with substantial lags and with the total effects spread out over several quarters. This makes forecasts of the target variables crucial in monetary policy.

Let us preliminarily make the assumption that the transmission mechanism is approximately linear, in the sense that the future target variables depend linearly on the current state of the economy and the instrument. Furthermore, make the preliminary assumption that any uncertainty about the transmission mechanism and the state of the economy shows up as "additive" uncertainty about future target variables, in the sense that the degree of uncertainty about future target variables only depends on the horizon but not on the current state of the economy and the instrument setting. It is then a standard result in optimal-control theory that so-called certainty equivalence applies, and that optimal policy need only focus on conditional mean forecasts of the future target variables, forecasts conditional on the central bank's current information and a particular future path for the instrument.[39] Because this means treating the forecasts as target variables, the procedure can be called forecast targeting.

This procedure involves making conditional forecasts of inflation

and the output gap, conditional on different paths of the interest rate (the central bank's instrument), using all relevant information about the current and the future state of the economy and the transmission mechanism.[40] Then, the interest rate path is chosen for which the corresponding conditional forecasts minimize the intertemporal loss function, (2.2), which, in practice, means that the inflation forecast returns to the inflation target and that the corresponding conditional output-gap forecast returns to zero, at an appropriate pace. If the inflation forecast is too high relative to the inflation target at the relevant horizon (but the output-gap forecast is acceptable), the interest rate path needs to be raised. If the conditional inflation forecast is too low, the interest rate path needs to be lowered. The chosen interest rate path is then the basis for the current interest setting.[41] In regular decision cycles, the procedure is then repeated. If no new significant information has arrived, the forecasts and the interest rate path are the same and interest rate setting follows the same interest rate path. If new significant information has arrived, the forecasts and the interest rate path are updated. This is the procedure recommended by Blinder [14] and referred to as "dynamic programming" and "proper dynamic optimization." Compared with many other intertemporal decision problems that households, firms, and investors solve one way or another (usually without the assistance of a sizeable staff of Ph.D.s in economics), this particular decision problem is, in principle, not overly complicated or difficult.[42]

Forecast targeting requires that the central bank have a view of what the policy multipliers are—that is, how interest rate adjustments affect the conditional inflation and output gap forecasts. But it does not imply that forecasts must be exclusively model based. Instead, it allows for extra-model information and judgmental adjustments, as well as very partial information about the current state of the economy. It basically allows for any information that is relevant for the inflation and output gap forecasts.

Under the above assumptions of a quadratic loss function and an essentially linear transmission mechanism, together with additive uncertainty, the certainty-equivalence result implies that the mean forecasts are the relevant target variables, regardless of the degree of

uncertainty. When the uncertainty about the transmission mechanism is "non-additive," that is, there is uncertainty about the policy multipliers, or if the transmission mechanism is characterized by significant nonlinearities, certainty-equivalence no longer applies, and the mean forecasts of the target variables are not sufficient. Instead, the "balance of risks" and, indeed, the whole probability distribution of the target variables matter. Forecast targeting can then be generalized from mean forecast targeting to distribution forecast targeting.

Distribution forecast targeting. Distribution forecast targeting consists of constructing conditional probability distributions of the target variables instead of mean forecast only. Thus, for a given interest rate path, the central bank constructs the joint conditional density function of the random path of inflation and the output gap, conditional upon all information available in period t and a given interest-rate path. Then, this conditional probability distribution is used to evaluate the loss function (2.2) with (2.1). This can either be done numerically or informally by the decision-making body of the bank. In the latter case, the decision-making body is presented with the probability distributions for a few alternative interest-rate paths and then decides which path and distribution provides the best compromise.

Distribution forecast targeting is already practiced to some extent. Inflation-targeting central banks have moved beyond mean forecast targeting by considering the "balance of risks." Furthermore, Bank of England and Sveriges Riksbank have developed methods for constructing confidence intervals for the forecasts published in their Inflation Reports (see Blix and Sellin [1998] and Britton, Fisher, and Whitley [1998]).[43] Bank of England presents fan charts for both inflation and output, and Sveriges Riksbank gives confidence intervals for its inflation forecasts.[44,45] Furthermore, scrutiny of the motivations for interest-rate changes (including the minutes from Bank of England's Monetary Policy Committee and the Riksbank's Executive Board) indicate that both banks occasionally depart from certainty-equivalence and take properties of the whole distribution into account in their decisions—for instance, when the risk is unbalanced and "downside risk" differ from "upside risk."

Transparency. The above procedure may seem to involve an excessive amount of discretion. What is there to ensure that the forecasts are unbiased and that the interest-rate decisions taken follow from proper forecast targeting?[46] This is where transparency enters in a crucial way, and where some inflation-targeting central banks (in particular Reserve Bank of New Zealand, Bank of England, and Sveriges Riksbank) have broken very new ground. Transparent inflation targeting means being explicit about the numerical inflation target (and increasingly explicit about the weight on output-gap stabilization, as discussed in Section 2.2 above). As argued in more detail in Svensson (1997a and 1999c), transparent inflation targeting can be interpreted as a "targeting rule," a commitment to do whatever it takes to minimize the loss function. Just having an explicit inflation target goes a long way toward such a commitment. But the three central banks mentioned have gone further, by regularly publishing their inflation forecasts and the reasoning and main information behind these, and by using these forecasts to motivate their policy decisions. Not only should this be the best way of motivating policy decisions, this transparency also opens up the banks' analysis and reasoning to outside scrutiny (especially when minutes from policy meetings are also published), maximizes the possibility for outsiders to spot biases and deviations, and provides the best incentive in the history of monetary policy for the central banks to do their job well.[47, 48]

Monetary targeting and the role of money

Recent interest in monetary targeting has been stimulated by the view that monetary targeting is the reason behind Bundesbank's outstanding record on inflation control and the possibility that the Eurosystem would choose monetary targeting as its monetary policy strategy. However, with regard to whether monetary targeting lies behind Bundesbank's success, as discussed in, for instance, Svensson (1999c), a number of studies of Bundesbank's monetary policy have come to the unanimous conclusion that, in the frequent conflicts between stabilizing inflation around the inflation target and stabilizing money-growth around the money-growth target, Bundesbank has consistently given priority to the inflation target and disregarded the monetary target.[49] Thus, Bundesbank has actually been a monetary

targeter in words only and an inflation targeter in deeds. Furthermore, the Eurosystem has strongly rejected monetary targeting as a suitable strategy on the grounds that the relation between prices and money may not be sufficiently stable and that the monetary aggregates with the best stability properties may not be sufficiently controllable (see Issing). On the other hand, the Eurosystem has assigned a prominent role to its money-growth indicator, the deviation of M3 growth from a reference value. Allan Meltzer has, in a series of papers with Karl Brunner and in "Monetarism: The Issues and the Outcome"(1998), for instance, consistently argued for a prominent role for money as an indicator target or instrument.[50]

Some 25 years ago, several authors concluded that intermediate-variable targeting in general (and monetary targeting in particular) is inferior in most circumstances. [51] When would monetary targeting, meaning money-growth targeting, be optimal? This requires that the transmission mechanism is recursive in a particular way. The instrument and the state of the economy must affect the target variables exclusively by first affecting money growth and then by money growth affecting the target variables.[52] Suppose inflation is the only target variable (that is, assume strict inflation targeting). Then, schematically, we need to have

$$\left.\begin{matrix}\text{instrument}\\ \text{state of the economy}\end{matrix}\right\} \Rightarrow \text{money growth} \Rightarrow \text{inflation.}$$

Money growth would then be the only determinant of inflation. If so, money-growth targeting—that is, stabilizing money around a money-growth target corresponding to the inflation target—would be equivalent to stabilizing inflation around the inflation target.[53]

Clearly, such recursiveness of the transmission mechanism, that money growth would be the sole determinant of inflation, is an extreme and unrealistic case. In the real world, and in reasonable models, there are several channels of transmission from the instrument to inflation. The transmission mechanism is too complex for intermediate variables in the above sense to exist. That is, the transmission mechanism is not recursive in the above sense.[54]

Therefore, intermediate-variable targeting in general, and monetary targeting in particular, is not a good monetary policy strategy. However, there is one exception to the general nonexistence of suitable intermediate-target variables. As discussed in Svensson (1997a and 1999c), one set of intermediate-target variables always exists—namely conditional forecasts. We can always write

$$\left.\begin{matrix}\text{instrument}\\ \text{state of the economy}\end{matrix}\right\} \Rightarrow \text{conditional forecast of target variable} \Rightarrow \text{target variable},$$

where the target variable differs from the conditional forecast by an error that is uncorrelated with the instrument and the information about the state of the economy. Formally, conditional forecasts of target variables can be seen as intermediate target variables. As Mervyn King (1994) stated early in the history of inflation targeting, inflation targeting can be interpreted as having inflation forecasts as intermediate targets.

Thus, money-growth targeting is optimal (for strict inflation targeting) only if money growth is the sole predictor of future inflation. Since money growth is not the sole predictor of inflation (nor even the main predictor at horizons relevant for monetary policy),[55] how inefficient would money-growth targeting be? Rudebusch and Svensson (1999) examine this issue with U.S. data in an empirical model of U.S. inflation, output, and money. In the model, inflation is determined by a conventional accelerationist Phillips curve, where inflation is determined by lagged inflation and the output gap. The output gap is determined by a conventional aggregate demand equation, where it is determined by the lagged output gap and the real federal funds rate. Money is determined by a conventional error-correction money-demand equation, where the change in (log) real M2 balances adjusts to the lagged deviation of (log) real balances from a conventional long-run money-demand equation. These equations all fit the data quite well.[56]

Thus, the transmission mechanism in this model is the conventional interest rate channel: inflation expectations are sticky, so the nominal federal funds rate determines the real federal funds rate, which affects

the output gap one quarter ahead which, in turn, affects inflation two quarters ahead. M2 has no direct role in the transmission mechanism and is determined separately from the money-demand function. Since money demand is demand for real money, nominal money and nominal prices are highly correlated in the long run, as in the data and any reasonable monetary model. Still, this long-run correlation is irrelevant at the horizon relevant for monetary policy.

The estimated money-demand function is well behaved and money is quite controllable. Nevertheless, the results unambiguously show that although monetary targeting can, not surprisingly, achieve the same average inflation as inflation targeting, it would be quite inefficient for the United States, in the sense of causing much higher variability of inflation and the output gap than inflation targeting (both variances roughly doubles). Furthermore, setting money-demand shocks equal to zero, and thus assuming a completely stable money demand, only marginally reduces the inefficiency of monetary targeting.

Thus, counter to conventional wisdom, the results indicate that the reason why monetary targeting is inefficient is not the instability of money demand. Instead, regardless of the stability of money demand, since money growth is not a predictor of inflation and the output gap, stabilizing money growth does not mean stabilizing inflation and the output gap. The dynamics of money demand is such that the reaction function for the federal funds rate resulting from stabilizing money growth is quite unsuitable for stabilizing inflation and the output gap, also if there are no shocks to money demand.

In contrast to the model in Rudebusch and Svensson (Working Paper 1999) described above, the so-called P^* model (see Hallman, Porter, and Small [1991] and Tödter and Reimers [1994]) assigns a direct role to monetary aggregates in determining inflation. Inflation is then not determined by the lagged output gap but by the lagged "price gap," the gap between the price level and the long-run equilibrium price level that would result with the current money stock if output were at its potential level and velocity were at its long-run equilibrium price level. The price gap is equal to the negative of the "real money gap," the difference between current real balances and long-run equilibrium

real balances. The *P** model is typically seen among proponents for monetary targeting as providing a theoretical rationale for focusing policy deliberations on the behavior of monetary aggregates.[57] Nevertheless, Svensson (1999b) shows that although the *P** model gives a prominent role to monetary aggregates in the form of the real money gap, it does not provide a rationale for money-growth targeting.

For the euro area, Gerlach and Svensson (Working paper 1999)provide a preliminary study of the relationship between inflation, output, money, and interest rates using reconstructed historical data. The *P** model is shown to have substantial empirical support. The real money gap is shown to have substantial predictive power for four-quarter inflation 4 and 8 quarters ahead, with some additional information in the output gap. Gerlach and Svensson also consider a Eurosystem-type money-growth indicator, four-quarter growth of M3 relative a Eurosystem-style reference value. They find that the money-growth indicator has little or no marginal predictive power for future inflation. Thus, they find little empirical support for the prominent role that the Eurosystem has assigned to its money-growth indicator.

In the end, a rational treatment of indicators suggests that the weights on any given indicator depend exclusively on its power in predicting future inflation and the output gap. It seems that monetary aggregates should have no special role beyond that, and that any weight on monetary aggregates should exclusively depend on their predictive performance for future inflation and the output gap. In the *P** model and (according to Gerlach and Svensson [Working paper 1999]) in the euro area, inflation seems to be affected via a strong direct real-money channel. Meltzer (March 1999) and Nelson (Working paper 1999) report an empirical direct real-money channel affecting demand, separate from the effect of a short real interest rate (although Nelson interprets this as a proxy for the effect of a long interest rate). Woodford (1999d) finds that any direct real-money effect on consumption and demand is likely to be very small. In the model in Rudebusch and Svensson (Working Paper 1999), there is no direct real-money channel to inflation and output. Even if there are strong such real-money effects on demand and/or inflation, this is not an argument for monetary targeting (or an argument for a Eurosystem-style money-growth indicator).

At most, it is an argument for including real money aggregates among the many indicators affecting the forecasts of the target variables, inflation, and the output gap.

Benefits of credibility

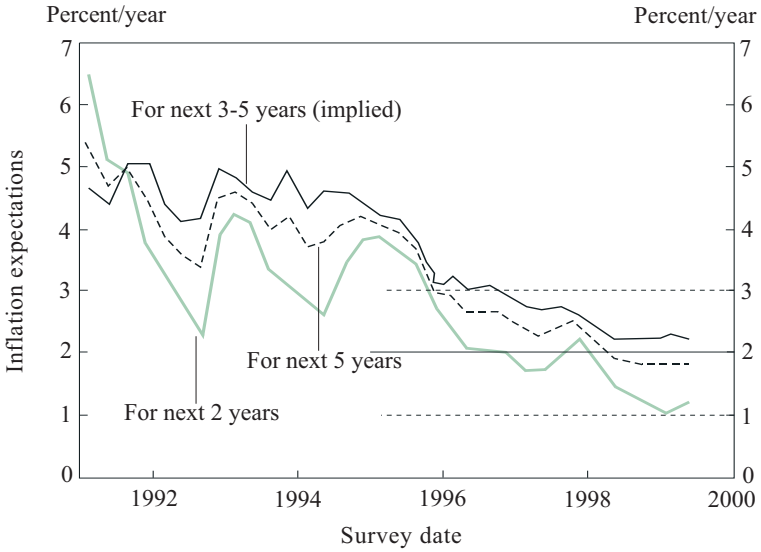
An era of low and stable inflation also creates low and stable inflation expectations, either by forward-looking observers who judge that the central banks' goals are now to maintain price stability and that the environment is unlikely to prevent them from achieving their goals, or by more backward-looking observers using history to assess future inflation outcomes. Expectations of low and stable inflation can be interpreted as good credibility for the low-inflation regime. Let me now discuss the role of credibility and the potential benefits of credibility in a monetary policy aimed at low inflation.

Defining and measuring credibility

Blinder's (1999) favorite definition of credibility involves "words matching deeds": "A central bank is credible if people believe it will do what it says." With an announced policy goal, credibility then boils down to private expectations being consistent with the goal. For a central bank with an explicit inflation target, it is then natural to define credibility as private inflation expectations coinciding with the inflation target, and to let deviations of private inflation expectations from the inflation target indicate a lack of credibility (both when inflation expectations are above and below the target). Because inflation expectations can be measured or estimated, for instance, from surveys or from nominal and real yield curves, this allows the explicit measurement of the degree of credibility. Inflation-targeting central banks regularly include measures of private inflation expectations in their inflation reports.[58]

Chart 1 shows survey data of inflation expectations for the Swedish CPI of investors on the Swedish bond market.[59] For each quarter, the thin line shows mean inflation expectations for the next two years. The semi-thick line shows the same for the next five years. The thick line shows the implied expectations for years three to five. The inflation

Chart 1
Inflation Expectations,
Sweden 1991:1-1999:2



target of 2 percent per year, with a tolerance interval of plus/minus 1 percentage point, was announced by the Riksbank in January 1993, to be effective from 1995 onward (shown as horizontal solid and dashed lines). We see that credibility was low during the first few years of the inflation-targeting regime, with expectations for years three to five far above the upper bound of the tolerance interval. From 1997, inflation expectations have been well inside the tolerance interval, and from 1998, five-year expectations and three- to five-year expectations have been close to the 2 percent inflation target, indicating that the credibility is now good.

Thus, one of the many benefits associated with an announced explicit inflation target is that the degree of credibility is easily measured. The absence of an explicit target, as in the case of the Fed, or a somewhat ambiguous definition of the target, as in the case of the Eurosystem,[60] makes the credibility less well-defined and less observable.

Benefits of credibility

Central bankers often appear to be obsessed with the notion of credibility, for which I believe there to be a good reason. Credibility, indeed, brings considerable benefits to a monetary policy aimed at low inflation. So, what are these benefits?

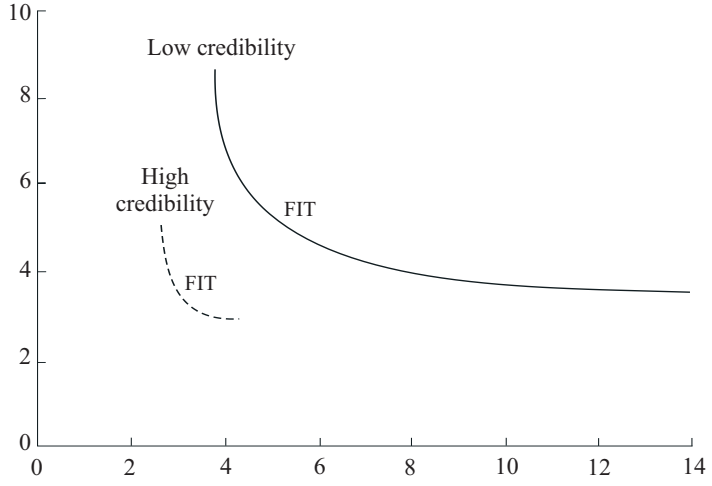
In a conventional model of inflation determination, inflation is determined by inflation expectations and costs, the latter, in turn, depending on (among other variables) the output gap or unemployment. For given inflation expectations, monetary policy then mainly affects inflation via its effects on real activity.[61]

Now, with an explicit inflation target, credibility means that inflation expectations some two years ahead and more are stable and close to the inflation target. Compared to a situation with "inflation scares" (Goodfriend [1995]) and fluctuating inflation expectations, this eliminates an important source of disturbances to inflation. Furthermore, credibility introduces considerable mean reversion of inflation toward the inflation target. Consequently, there is less need for monetary policy to affect real activity in order to keep inflation close to the target. As a result, it is easier for the central bank to fulfill the inflation target, and a more favorable trade-off between inflation variability and output gap variability arises.[62]

Furthermore, in this conventional model of the transmission mechanism, the monetary-policy instrument, a short nominal interest rate, affects real activity according to the following sequence. Because of sticky inflation expectations, the short nominal rate affects the short real interest rate rate. Expectations of future short nominal rates and future inflation affect longer real rates. These, in turn, affect real activity.[63] [64]

Now, if inflation expectations are stable around the inflation target, an important source of disturbances in the above sequence is removed. Furthermore, with stable inflation expectations, the impact of the short nominal rate on the short real rate is more direct and stable. For instance, for a shock increasing inflation, the required increase in the short nominal rate to achieve a given increase in the short real rate is

Chart 2
Variance Tradeoffs for Low and High Credibility, United States



smaller than when inflation expectations also rise. Therefore, less movement of the instrument is normally required to achieve a given change in real activity. Thus, the trade-off between output-gap variability and instrument variability improves.

Chart 2 illustrates such an improved trade-off for U.S. data. The solid curve, labeled "Low credibility," shows the trade-off between inflation variability and output-gap variability estimated for the United States in Rudebusch and Svensson ("Policy Rules for Inflation Targeting" 1999). The curve shows the efficient combinations of variances of inflation and the output gap in an empirical model of U.S. inflation and output. The northwestern end of the curve corresponds to strict inflation targeting, when there is zero weight on output gap stabilization. Points further southeast on the curve correspond to flexible inflation targeting with increased weight on output-gap stabilization.[65] The point FIT corresponds to flexible inflation targeting with the weight on output-gap stabilization equal to half that on inflation stabilization ($\lambda = 0.5$).

Behind the solid curve is an empirical Phillips curve,

$$\pi_{t+1} = \pi_t^e + \alpha_y(y_t - y_t^*) + \varepsilon_{t+1},$$

where π_t is inflation in quarter t, ε_t is an exogenous "cost-push" shock to inflation, and π_t^e can be interpreted as inflation expectations in quarter t. These inflation expectations depend on current and lagged inflation, according to

$$\pi_t^e = \sum_{\tau=0}^{3} \alpha_{\pi\tau}\pi_{t-\tau},$$

where the coefficients sum to unity, $\sum_{\tau=0}^{3} \alpha_{\pi\tau} = 1$ (the hypothesis of a unit sum cannot be rejected). When the coefficients sum to unity, there is no mean reversion in inflation (when the Phillips curve is considered in isolation). This can be interpreted as inflation expectations being exclusively determined by history, with a zero weight on any specific inflation target, and, therefore, corresponding to low credibility.

Suppose, more generally, that inflation expectations are given by a weighted average of an inflation target and history,

$$\pi_t^e = \alpha^*\pi^* + (1-\alpha^*)\sum_{\tau=0}^{3} \alpha_{\pi\tau}\pi_{t-\tau},$$

where π^* is a constant inflation target and α^* is the weight on the inflation target in the inflation expectations. Then we can interpret α^* as an index of credibility of the inflation target, with α^* equal to zero corresponding to the above case of low credibility and a positive α^* corresponding to higher credibility. A positive α^* then causes mean reversion of the inflation toward the inflation target.[66]

The dashed curve in Chart 2, labeled "High credibility," shows the trade-off resulting if the weight on the inflation target in inflation

expectations is raised from zero to a modest 0.1 ($\alpha^* = 0.1$). This modest improvement in credibility improves the trade-off substantially.[67]

Thus, stable inflation expectations makes the inflation target easier to achieve. The trade-off between inflation variability, output-gap variability and instrument variability improves. Control is improved, but the economy is increasingly on automatic pilot, so less control needs to be exercised. These circumstances make it easier for the central bank to meet is targets. Furthermore, credibility helps avoid any liquidity trap, the topic of Section 5.

Threats of deflation

For several decades, high inflation has been the main threat to monetary stability. The successful disinflation and current low inflation rate in many countries, together with the problematic situation in Japan, has brought the potential threat of deflation into focus. As *The Economist* wrote in its February 20, 1999, issue, under the heading "The New Danger":

> For many years the main economic enemy was inflation. Today, prices are rising more slowly in the G7 economies than for half a century. As Japan has learned, and Europe may soon find out, there is a new danger—falling prices may lock countries into a spiral of economic decline.

Here, it is worth emphasizing that there is a big difference between a few quarters of deflation that is expected to be only temporary (or a situation when the zero lower bound on the interest is temporarily binding), and a situation of several years with persistent deflation, deflationary expectations, zero interest rates, and ineffective monetary policy—what has been called a liquidity trap. The former situation, the occasionally binding zero bound on the short nominal interest rate, was briefly discussed in Section 2.3, with the conclusion that the appropriate inflation target is positive, although small. The latter situation, the liquidity trap, how it is avoided, and how to escape if already trapped, is the subject of this section.[68]

What is a liquidity trap?

In a liquidity trap, the economy is satiated with liquidity and the nominal interest rate is zero. By the Fisher equation, expected inflation equals the nominal interest rate minus the real interest rate. If the nominal interest rate is zero, expected inflation then equals the negative of the real interest rate. If the real interest rate is positive, we have expected deflation. In a steady state, actual deflation and expected deflation coincide. Thus, by a liquidity trap, I mean a situation with zero interest rates, persistent deflation, and persistent deflation expectations.

In a liquidity trap, monetary policy is ineffective, in the following sense. A zero nominal interest rate means that nominal bonds and money earn the same real rate of return. Therefore, money in excess of transactions balances are perfect substitutes for bonds, and the private sector is indifferent between holding bonds or excess money. Expansionary open-market operations, where the central bank purchases bonds and increases the monetary base, then have no effects on nominal and real prices and quantities. The private sector just holds the increased monetary base instead of bonds. Monetary policy is then completely ineffective. This is true, at least as long as there are still outstanding government bonds, and as long as expectations are deflationary and the private sector believes that the situation will persist.

In an open economy with a flexible exchange rate, the exchange rate channel of the transmission mechanism may increase the effect of monetary policy actions (see Svensson [1999f]), make the non-negativity constraint for the nominal interest rate less binding and improve the possibility of avoiding a liquidity trap.

Once in a liquidity trap, will foreign exchange interventions be more effective than open-market operations in domestic assets? To the extent that the exchange rate is determined by an interest-rate parity condition involving the interest rate differential relative to foreign interest rates, once domestic interest rates are zero, the domestic currency is expected to appreciate over time and the current exchange rate varies with the expected future exchange rate. If real-exchange-rate expectations do not change, the expected future exchange rate varies

with the expected future price level. If deflationary expectations do not change, non-sterilized foreign-exchange interventions are then unlikely to affect the current exchange rate (not to speak of sterilized foreign-exchange interventions). Considered in this way, nonsterilized foreign-exchange interventions seem unlikely to be more effective than open-market operations in domestic assets (unless they affect foreign-exchange risk premia differently). On the other hand, as further discussed below, it cannot be excluded that arbitrarily large foreign exchange interventions in an attempt to peg the exchange rate may succeed in stabilizing the exchange rate and break the expectations of further appreciation.

Private beliefs that the liquidity trap will persist are an important aspect of the liquidity trap. If expectations are reasonably consistent, expectations of a continued liquidity trap include beliefs that the nominal liabilities (the sum of the monetary base and outstanding government bonds) of the consolidated government (the fiscal authority and the central bank) must eventually fall over time. Otherwise, because of deflation, the real value of consolidated government liabilities would grow without bound and, in the end, exceed the economy's real assets, which is impossible. In technical jargon, and as explained in some detail in Appendix B, a transversality condition would be violated. Therefore, private beliefs in the continuation of a liquidity trap must, if consistent, involve beliefs that eventually, at least far into the future, the nominal monetary base and nominal government liabilities must fall, which is worth keeping in mind.

This concern about a liquidity trap may seem surprising when we recall that a zero nominal interest rate corresponds to Milton Friedman's (1969) "optimum quantity of money," the ideal state when the economy is satiated with liquidity and there is no longer any lost consumer surplus from keeping the opportunity cost of liquidity (the interest rate) above the marginal cost of increasing the supply of liquidity (zero, for all practical purposes). Why would this situation, nevertheless, be undesirable? First, since there are other distortionary taxes in the economy and a positive interest rate implies a positive so-called inflation tax on money, there is a well-known optimal-taxation argument in favor of a positive interest rate and less

deflation than the real interest rate (or even positive inflation), which would allow the reduction of more distortionary taxes. On the other hand, seigniorage is such a small part of government revenues in industrial countries that this case for positive interest rates is generally considered rather weak. Second, deflation is not price stability, and the absence of price stability is likely to increase information costs, infer with the market mechanism and resource allocation, and make long-term planning more difficult. On the other hand, there would be no need for discounting when making intertemporal price comparisons. Third, more importantly, we may doubt that there is sufficient downward flexibility in nominal prices and wages in the short and medium run to make deflation neutral (due to existing multi-year contracts, for instance). If nominal wage adjustment lags behind, higher real wages will hurt employment and production. Flexibility in nominal debt contracts may also lag behind, increasing real debts (so-called "debt deflation") and inducing bankruptcies, financial-sector weakness, and associated production disturbances, for instance, via the credit channel and the financial accelerator (see Bernanke and Gertler [1999]). Fourth, and arguably equally importantly, the ineffectiveness of monetary policy removes all possibilities of using monetary policy for stabilization purposes (although the weight of this argument clearly depends on one's view of the benefits and costs of monetary stabilization policy). For these reasons, most macro researchers and practically all monetary policy-makers have come to the conclusions that, although a steady deflation may, in theory, be completely neutral, in practice, a liquidity trap is likely to bring considerable instability and probably lower real activity (and perhaps even the downward spiral warned against by the *Economist* and modeled by Buiter and Panigirtzoglou [1999], Krugman [1999] and Tetlow and Williams [1999c]), relative to a monetary regime with a zero or moderately positive inflation target (or a flat or moderately increasing price-level target).[69]

Thus, it makes eminent sense to avoid a liquidity trap and escape from it if already trapped.

How to avoid a liquidity trap?

So, what is the best way of avoiding a liquidity trap? Since a liquidity trap involves deflation and deflation expectations equal to the real

interest rate, it is crucial to prevent inflation and inflation expectations from falling to such levels. The central bank should keep inflation and inflation expectations at safe distances from such levels, watch out for warnings of falls in inflation and inflation expectations, and react to such warnings in time. This is, of course, precisely what is done under inflation targeting.

As discussed in Section 2.3, an explicit inflation target of 2 percent, say, should provide an ample margin to the liquidity trap. Suppose transparent inflation targeting succeeds in making this target credible, so that private inflation expectations are anchored at the target. If the normal real interest rate is some 2 percent, the average nominal interest will then be around 4 percent. If the inflation target remains credible, so that inflation expectations remain around 2 percent, reducing the nominal interest rate to zero gives a real interest rate of minus 2 percent, 4 percentage points below the normal real interest rate. This should, in most cases, provide ample stimulus to the economy.

Indeed, inflation targeting, in the form of forecast targeting as discussed in Section 3.2, automatically means watching for warnings of changes in future inflation and reacting in time. Forecast targeting means using available information about the economy and the transmission mechanism to make inflation (and output gap) forecasts for the relevant policy horizon (the horizon at which the current instrument setting has a significant impact), and setting the interest rate such that the inflation forecast conditional on this interest rate is close to the inflation target at the appropriate horizon. This also means watching for warnings of both upside and downside risk for future inflation, as well as watching private inflation expectations (measured from surveys and inferred from nominal and real yield curves), shocks to the economy, etc.

Here, it is important that the inflation target is symmetric and unambiguous (and is perceived as such by the private sector), and that the central bank acts as decisively to downward risks as to upward risks. Furthermore, as discussed in Section 2.3, a point inflation target (or an emphasized midpoint of a target range) gives a desirable focal point for inflation expectations. A somewhat ambiguous and asymmetric

target, like the Eurosystem's "below 2 percent," is not to be recommended.

Contingency plans and emergency measures. The above should go a long way to prevent sustained deflation and a liquidity trap. Indeed, I believe that had the Bank of Japan pursued an inflation target as above in the 1990s (as Reserve Bank of New Zealand, Bank of Canada, Bank of England, Sveriges Riksbank, and other inflation-targeting central banks), Japan is very likely to have avoided the current deflationary tendencies and indications of a liquidity trap (although even such monetary policy would hardly have reduced the need for structural and financial reform discussed in Posen [1998], for instance).[70] Still, given the potential harm a liquidity trap may cause, and given the small but still positive risk that a series of unfortunate shocks may push even an exemplary inflation-targeting regime close to a liquidity trap, I believe it is prudent for central banks and fiscal authorities to prepare for the worst. Thus, I believe central banks and fiscal authorities should make advance contingency plans for a series of emergency measures to be undertaken at prescribed indications of an imminent liquidity trap, but only under such prescribed indications.

Such measures would aim at raising the central bank's inflation forecast and private inflation expectations toward the inflation target if these have fallen to dangerous levels. They can be ordered in a hierarchy of increasingly expansionary steps. Thus, if ordinary open-market operations (repurchase agreements and sales and purchases of Treasury bills) become ineffective because short nominal interest rates have reached zero, government bond rates are still likely to be positive. Then, interventions in longer government bonds may still have an effect on longer bond rates and be able to further stimulate the economy. If these longer bond rates fall close to zero, more unorthodox open-market interventions can still be undertaken in corporate bonds, property, and stocks. Opening a lending window for lending directly to the private sector is another unorthodox measure for lowering private borrowing rates.[71, 72]

A further measure is a coordinated fiscal and monetary expansion, a fiscal expansion financed by a corresponding monetary expansion

(that is, financed by the fiscal authority issuing government bonds that are immediately bought by the central bank). Here, it may be desirable to direct the fiscal expansion toward expenditure imperfectly substitutable for private consumption, so as to reduce compensating adjustments of private expenditure. For this purpose, spending on public infrastructure, law and order, defense, education, and medical care would seem appropriate, rather than cash transfers or tax cuts to the private sector (unless the taxes cut are very distortionary). Although, in theory, it need not matter much how this fiscal expansion is financed, a monetary expansion would, in practice, seem more likely to increase inflation expectations and not reduce private expenditure than to increase borrowing.[73]

Price-level targeting and the liquidity trap. The above discussion has argued that a credible inflation target is a good way of avoiding liquidity traps. However, as argued in Section 2, price-level targeting may have advantages beyond inflation targeting. In particular, price-level targeting may have a special advantage with regard to avoiding a liquidity trap. Under credible price-level targeting (with a constant or moderately increasing price-level target), a deflationary shock that pulls the price level below target would automatically create private inflation expectations if the price-level target is credible and the price-level is expected to return to target. This increase in inflation expectations would automatically lower the short real interest rate, even without a lowering of the short nominal interest rate. Under credible inflation targeting, in contrast, inflation expectations would remain at the inflation target and not, by themselves, lower the real interest rate. Further research seems required to assess whether this is a significant advantage over inflation targeting, though.

How to escape from a liquidity trap?

The above emergency measures should not only be suitable for avoiding a threatening liquidity trap, but also helpful in escaping from a liquidity trap. To a large extent, escaping from a liquidity trap is about restoring confidence and getting rid of private-sector deflationary expectations, as emphasized by Krugman (1998) and Posen (1998). Although any inflation expectations would be helpful in the

short run, as emphasized by Posen (1998), it is advantageous to anchor inflation expectations to a suitable inflation target, that is, getting a credible inflation target. This should help avoiding the opposite problem, getting too high and/or unstable inflation expectations and risking a change to a high, unstable, and uncertain inflation rate. If the central bank, for some reason, has no explicit inflation target, no time should be lost in announcing one. For Japan, Krugman (1998) has suggested a 4 percent inflation target for fifteen years. A more moderate target may be more credible, in the sense that it may be more desirable to keep it unchanged after having escaped from the liquidity trap. For Japan, Posen (1998) has suggested an initial inflation target of 3 percent to be reduced to 2 percent within a few specified years. Such an announced falling inflation target may be the optimal arrangement.

An announcement is not enough, though. Setting up the whole framework with published inflation forecasts, transparent inflation reports, etc. is a more serious commitment. Acting accordingly, motivating the interventions, explaining the role of the emergency measures, etc. is then a natural ingredient in building credibility for the inflation target and getting rid of deflationary expectations.

If the private expectations of deflation start changing toward those of inflation, the real interest rate falls and monetary policy starts being effective. If the expectations of deflation remain, monetary policy remains ineffective. A coordinated fiscal and monetary expansion may still start pushing the economy out of the liquidity trap.

As mentioned above, for an open economy, a liquidity trap with zero interest rates implies that the domestic currency is expected to appreciate relative to the rest of the world if the rest of the world has positive interest rates. In a steady state with domestic deflation and moderate foreign inflation, there will be a steady appreciation of the domestic currency. Could the central bank peg the exchange rate and this way escape the liquidity trap? Such pegging would involve a commitment to arbitrarily large nonsterilized foreign-exchange interventions, buying foreign exchange and selling domestic currency at the pegged rate. Again, for such pegging to succeed, market expectations of future appreciation would have to change. If they do not change, huge for-

eign-exchange interventions could be absorbed by the foreign-exchange market. The question is then, in such a game of attrition, who will blink first, the market or the central bank? Compared to the usual speculative attack on a pegged exchange rate to force a devaluation, the central bank does not risk running out of foreign exchange reserves. Instead, it just has to create more domestic currency. The fact that a commitment to a pegged exchange rate is immediately verifiable and the technical possibility to always create more domestic currency may make the commitment more credible in the short run than a commitment to an inflation target when interest rates have reached zero. It cannot be excluded that an exchange-rate peg can serve as a temporary emergency measure, an intermediate step toward fulfilling an inflation target.

As noted above, demonstrated in Appendix B, and shown rigorously and in detail in Woodford (1999d), consistency of private deflationary expectations requires beliefs that the nominal monetary base and nominal consolidated government liabilities must eventually decrease. Otherwise, the real value of these would rise to impossible levels. Thus, a credible commitment *not* to reduce the future nominal monetary base or total future government liabilities would be sufficient for deflation not to be expected indefinitely. How practical and how convincing such a commitment would be is an open issue. Expansion of the monetary base or total nominal government liabilities in the near future does not exclude contraction far into the future. Furthermore, expansion of the monetary base alone is simply substituting money for nominal bonds , as long as there are still outstanding bonds. Only when all nominal government bonds have been bought by the central bank does increasing the monetary base imply increasing total nominal liabilities. Since the monetary base is normally a relatively small proportion of the total nominal liabilities, this could take a long time. Even then, increasing total government liabilities in the present is hardly a commitment not to reduce these in the future. These issues point to an important role for fiscal policy in escaping from a liquidity trap, both with a fiscal expansion and with regard to nominal debt management.[74]

Conclusions

In conclusion, let me restate the main points raised in this discussion of how monetary policy should be conducted in an era of price stability. First, the conventional wisdom that price-level targeting is inferior to inflation targeting seems ill founded. Appropriately designed price-level targeting may very well succeed in reducing long-term price-level uncertainty, stabilizing inflation, and avoiding a liquidity trap better than inflation targeting. More research and experience is needed in order to judge whether this is generally the case and whether it is worthwhile to eventually move on from flexible inflation targeting to flexible price-level targeting. Second, flexible forecast targeting, in the form of transparent forecast targeting with a symmetric and small positive inflation target, seems more appropriate and realistic for maintaining price stability than either a commitment to a simple instrument rule (like a Taylor Rule) or monetary targeting. This is, in particular, the case for distribution forecast targeting, since it can incorporate model uncertainty and nonlinearities in a consistent way. Commitment to a simple instrument rule is both inefficient and unrealistic. Money-growth targeting is inefficient. Counter to conventional wisdom, this is not mainly due to the fact that money demand is subject to shocks. Instead, this is due to the transmission mechanism not being recursive in the sense that the monetary-policy instrument affects inflation and the output gap exclusively via money growth. Monetary aggregates, for instance the real money gap, may still be important indicators (among other indicators), with the optimal weight depending on their predictive power for future inflation and the future output gap. Third, the benefits of credibility of a monetary policy aimed at price stability include an economy increasingly on automatic pilot, less need for monetary-policy activism, an improved trade-off between inflation variability and output-gap variability, and less risk of falling into a liquidity trap. Fourth, transparent inflation targeting seems to be a good way of avoiding a liquidity trap, with the support of a contingency plan for emergency monetary-policy and fiscal-policy measures to be undertaken at prescribed indications of an imminent liquidity trap (but only under those prescribed indications). These measures are also likely to contribute to escaping from a liquidity

trap if already trapped. Fiscal policy is likely to have a special role in escaping from a liquidity trap.

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Appendix A

Inflation Variability under Inflation Targeting and Price-Level Targeting[75]

Suppose *inflation targeting* results in the AR(1) process for inflation

$$\pi_t = h\pi_{t-1} + \eta_t, \tag{A.1}$$

where $|h| < 1$ and η_t is iid with $E[\eta_t] = 0$ and $\mathrm{Var}[\eta_t] = s^2$. The unconditional variance of inflation under inflation targeting, denoted $\mathrm{Var}[\pi_t]_\pi$, fulfills

$$\mathrm{Var}[\pi_t]_\pi = \frac{s^2}{1-h^2}. \tag{A.2}$$

The price level, p_t, is then given by

$$p_t \equiv p_{t-1} + \pi_t \tag{A.3}$$

and has a unit root, so its unconditional variance is unbounded.

Suppose *price-level targeting* results in the AR(1) process for the price level

$$p_t = kp_{t-1} + \eta_t,$$

where $|k| < 1$. The unconditional variance of the price level under price-level targeting, denoted $\mathrm{Var}[p_t]_p$ is then

$$\mathrm{Var}[p_t]_p = \frac{s^2}{1-k^2}.$$

The corresponding inflation process is

$$\pi_t \equiv p_t - p_{t-1} = -(1-k)p_{t-1} + \eta_t.$$

The unconditional variance of inflation under price-level targeting,

$\mathrm{Var}[\pi_t]_p$, is

$$\text{(A.4)} \qquad Var[\pi_t]_p = (1-k)^2 Var[p_t]_p + s^2 = \frac{2s^2}{1+k}.$$

The difference between the unconditional variance of inflation under price-level targeting and inflation targeting is

$$\mathrm{Var}[\pi_t]_p - \mathrm{Var}[\pi_t]_\pi = \left(\frac{2}{1+k} - \frac{1}{1-h^2}\right)s^2 = \frac{1-2h^2-k}{(1-h^2)(1+k)}s^2.$$

Hence,

$$\text{(A.5)} \qquad \mathrm{Var}[\pi_t]_p < \mathrm{Var}[\pi_t]_\pi \text{ if and only if } k > 1-2h^2.$$

We see that if $h = k$, we have $\mathrm{Var}[\pi_t]_p < \mathrm{Var}[\pi_t]_\pi$ if and only if $h = k > \frac{1}{2}$.

Fischer ([1994], figure 2.4 and footnote 45) compares (A.2) and (A.4) with $h = 0$ and $k = 0.5$, for which case $k < 1-2h^2$ and $\mathrm{Var}[\pi_t]_p = \frac{4}{3}s^2 > \mathrm{Var}[\pi_t]_\pi = s^2$; the inflation variance is higher under price-level targeting.

Duguay (1994) examines the processes (A.1) and (A.3) for different values of h and k. Typical values used are $h = 0.5$ and 0.7 (inflation targeting such that 75 percent of the adjustment of inflation toward the target is achieved in 2 and 4 periods (years), respectively), $k = 0.7$ (price-level targeting where 75 percent of the adjustment of the price level toward the target is achieved in 4 periods (years)), and $s^2 = 1$ (when π and p are measured in percent/year and percent, respectively, that is, scaled by 100). Let me use these values and compute the unconditional variance of inflation. For these values, $k > 1-2h^2$, the variance is less under price-level targeting, and we get $\mathrm{Var}[\pi_t]_\pi = 1.33$ and 1.95, respectively, and $Var[\pi_t]_p = 1.18$. Now, the variance of inflation is lower under price-level targeting.[76]

Table A.1 summarizes some results for the processes (A.1) and

Table A.1

	Inflation targeting	Price-level targeting
p_t	$p_{t-1}+\pi_t$	$kp_{t-1}+\eta_t$
π_t	$h\pi_{t-1}+\eta_t$	$-(1-k)p_{t-1}+\eta_t$
p_T	$p_t+\sum_{\tau=t+1}^{T}\pi_\tau$	$k^{T-t}p_t+\sum_{\tau=t+1}^{T}k^{T-\tau}\eta_\tau$
π_T	$h^{T-t}\pi_t+\sum_{\tau=t+1}^{T}h^{T-\tau}\eta_\tau$	$-(1-k)p_{T-1}+\eta_T$
$\mathrm{Var}_t\, p_T$	$\left[(T-t)-2\frac{1-h^{T-t}}{1-h}h+\frac{1-h^{2(T-t)}}{1-h^2}h^2\right]\frac{s^2}{(1-h)^2}$	$(1-k^{2(T-t)})\frac{s^2}{1-k^2}$
$\mathrm{Var}_t\pi_{t+1}$	s^2	s^2
$\mathrm{Var}_t\pi_T$	$(1-h^{2(T-t)})\frac{s^2}{1-h^2}$	$\left[(1-k)^2(1-k^{2(T-t-1)})+1-k^2\right]\frac{s^2}{1-k^2}$
$\mathrm{Var}[p_t]$	∞	$\frac{s^2}{1-k^2}$
$\mathrm{Var}[\pi_t]$	$\frac{s^2}{1-h^2}$	$\frac{2s^2}{1+k}$

(A.3). As the above examples show, the relative variance of inflation under inflation targeting and price-level targeting is not obvious.

Appendix B
Monetary and Fiscal Policy in a Liquidity Trap

In order to discuss the role of monetary and fiscal policy in a liquidity trap, as a background to Section 5, I provide a simple example of a closed economy with a private sector and a government. The government consists of a fiscal authority and a central bank. The example is a simple perfect-foresight version of a model in Woodford (1999d), where a more general treatment is given.

Private budget constraint

Consider a private sector with preferences represented by a well-behaved utility function,

$$\sum_{t=1}^{\infty} \delta^t U\left(c_t m_t\right), \tag{B.1}$$

where $\delta\left(0<\delta<1\right)$ is a discount factor, $U\left(c_t, m_t\right)$ is a well-behaved period utility function, $c_t > 0$ denotes consumption in period t, $m_t \equiv M_t / P_t \geq 0$ is the end-of-period real monetary base, $M_t \geq 0$ denotes end-of-period holdings of base money, and $P_t > 0$ is the general price level in period t. The private sector is consolidated to include banks, so the private sector's net claims on the central bank consist of the monetary base. Including the real monetary base in the period utility function is a convenient way of modeling a transaction's demand for the monetary base.

The private sector faces a sequence of budget constraints,

$$P_t c_t + M_t + \frac{1}{1+i_t} B_t = P_t y_t + M_{t-1} + B_{t-1} - P_t \tau_t, \tag{B.2}$$

for $t = 1, 2, \ldots$, where $B_t \geq 0$ are nominal government one–period discount bonds bought in period t that pay one nominal unit of account in period $t+1$, $i_t \geq 0$ is the nominal (one-period) interest rate, $y_t > 0$ is out-

put (considered exogenous), and τ_t real taxes levied on the private sector. The initial holdings of money and bonds, M_0 and B_0 are given. The transversality condition is specified below.[77]

Define the government's nominal liabilities to the private sector in the beginning of period *t*,

$$A_t \equiv M_{t-1} + B_{t-1} \geq 0. \tag{B.3}$$

The sequence of private budget constraints can then be written

$$P_t c_t + \frac{i_t}{1+i_t} M_t + \frac{1}{1+i_t} A_{t+1} = P_t y_t + A_t - P_t \tau_t, \tag{B.4}$$

with the nominal transversality condition

$$\lim_{\tau \to \infty} \frac{A_{t+\tau}}{\prod_{j=0}^{\tau-1} (1+i_{t+j})} = 0, \tag{B.5}$$

where future nominal claims on the government are discounted by the nominal discount factor $1 / \prod_{j=0}^{\tau-1} (1+i_{t+j})$. The opportunity cost of holding money is obviously $i / (1+i_t)$. (I simplify by considering only equality in the budget constraint and transversality condition).

The sequence of budget constraints and the transversality condition can be expressed as an intertemporal budget constraint,

$$\sum_{t=1}^{\infty} \frac{1}{\prod_{\tau=1}^{t-1} (1+i_{t+\tau-1})} \left(P_t c_t + \frac{i_t}{1+i_t} M_t \right)$$
$$= \sum_{t=1}^{\infty} \frac{1}{\prod_{\tau=1}^{t-1} (1+i_{t+\tau-1})} (P_t y_t - P_t \tau_\tau) + A_0$$

(where I use the convention $\prod_{\tau=1}^{0} (1+i_{t+\tau-1}) \equiv 1$).

The real interest rate, r_t, is given by the Fisher equation,

$$1 + r_t \equiv \frac{1 + i_t}{\prod_{t+1}}, \tag{B.6}$$

where $\prod_{t+1} \equiv P_{t+1} / P_t$ denotes gross inflation in period $t + 1$. The sequence of private budget constraints can then be written in the real form,

$$c_t + \frac{i_t}{1 + i_t} m_t + \frac{1}{1 + r_t} a_{t+1} = y_t + a_t - \tau_t, \tag{B.7}$$

where $a_t \equiv A_t / P_t$, with the real transversality condition

$$\lim_{\tau \to \infty} \frac{a_{t+\tau}}{\prod_{j=0}^{\tau-1} \left(1 + r_{t+j}\right)} = 0 \tag{B.8}$$

This can also be expressed as an intertemporal budget constraint on real form.

Government budget constraint

The sequence of consolidated government budget constraints for period $t = 1, 2, ...$, can be written,

$$P_t g_t + M_{t-1} + B_{t-1} = M_t + \frac{1}{1 + i_t} B_t + P_t \tau_t,$$

where $g_t \left(0 \le g_t < y_t\right)$ is real government expenditure. In terms of (B.3), government nominal liabilities, the budget constraints can be written

$$P_t g_t + A_t = \frac{1}{1 + i_t} A_{t+1} + \frac{i_t}{1 + i_t} M_t + P_t \tau_t, \tag{B.9}$$

with the nominal transversality condition (B.5). (Again, I simplify

by considering the budget constraint and transversality condition with equality only). The sequence of budget constraints and the transversality condition can be written as an intertemporal budget constraint,

$$\sum_{t=1}^{\infty} \frac{1}{\prod_{\tau=1}^{t-1}\left(1+i_{t+\tau-1}\right)} P_t g_t + A_0$$
$$= \sum_{t=1}^{\infty} \frac{1}{\prod_{\tau=1}^{t-1}\left(1+i_{t+\tau-1}\right)} \left(\frac{i_t}{1+i_t} M_t + P_t \tau_t \right)$$

Equivalently, the budget constraints (B.9) can be written on real form,

(B.10) $$g_t + a_t = \frac{1}{1+r_t} a_{t+1} + \frac{i_t}{1+i_t} m_t + \tau_\tau ,$$

with the real transversality condition (B.8).

Adding the private and government budget constraints, (B.2) and (B.9), we have

(B.11) $$c_t + g_t = y_t ,$$

the goods-market equilibrium condition, for $t = 1, 2, \ldots$

The government consists of a fiscal authority and a monetary authority, the central bank. The fiscal authority's budget constraints can be written

(B.12) $$P_t g_t + B_{t-1}^g = \frac{1}{1+i_t} B_t^g + P_t \tau_t + P_t z_t ,$$

where B_t^g are nominal bonds issued by the fiscal authority in period t and z_t is real seigniorage received from the central bank.

The central bank's budget constraints can be written

$$P_t z_t + \frac{1}{1+i_t} B_t^c = M_t - M_{t-1} + B_{t-1}^c, \tag{B.13}$$

where B_t^c is nominal bonds bought by the central bank in period t. Adding the fiscal and monetary budget constraint obviously results in the consolidated budget constraint, where

$$B_t \equiv B_t^g - B_t^c \tag{B.14}$$

is the net nominal governments bonds issued.

Let us examine the central bank's budget constraints in more detail. Introduce the central bank's net nominal assets at the beginning of period t,

$$A_t^c \equiv B_{t-1}^c - M_{t-1}.$$

Then, the central bank's budget constraint can be written

$$P_t z_t + \frac{1}{1+i_t} A_{t+1}^c = A_t^c + \frac{i_t}{1+i_t} M_t.$$

Assume now that the central bank each period delivers seigniorage to the fiscal authority, such that its net nominal assets are always zero, $A_t^c \equiv 0$. Then, we can write the central bank's balance sheet at the beginning of period t, assets equal to liabilities, as

$$B_t^c = M_t, \tag{B.15}$$

and from the budget constraint follows that nominal and real seigniorage are given by

$$P_t z_t = \frac{i_t}{1+i_t} M_t,$$

$$z_t = \frac{i_t}{1+i_t} m_t. \tag{B.16}$$

Thus, (B.3) and (B.9), together with the transversality condition (B.5), describe the essential elements of the government budget constraint and monetary policy operations. We can think of M_t, the monetary base, as the instrument (control variable) of the central bank, and two of the three variables g_t, τ_t and B_t as the instruments of the fiscal authority, leaving the remaining variable to be determined by the consolidated budget constraint.[78]

In more detail, we can think of the central bank as setting M_t, thereby determining according to (B.15) and $P_t z_t$ according to (B.16), and the fiscal authority as receiving seigniorage and setting two of the three variables, g_t, τ_t and B_t^g, leaving the remaining variable to be determined by the fiscal authority's budget constraint, (B.12). The net issue of government bonds is then given by (B.14).

Let us define an *equilibrium* as a sequence $\{y_t, c_t, g_t, \tau_t, M_{t-1}, B_{t-1}, P_t, i_t\}_{t=1}^{\infty}$, such that (i) $\{c_t M_t B_t\}_{t=1}^{\infty}$ maximizes the private sector's utility function (B.1), subject to the sequence of private budget constraints (B.2), the transversality condition (B.5), and given $\{y_t, \tau_t, P_t, i_t\}_{t=1}^{\infty}$, B_0 and M_0 and (ii) $\{y_t, c_t, g_t\}_{t=1}^{\infty}$, fulfills the goods-market equilibrium (B.11). Under (i) and (ii), the sequence of government budget constraints (B.12) is also fulfilled.

Zero interest rate

Let us now consider an equilibrium when $i_t \equiv 0$. Then, by the Fisher equation, (B.6), we have

(B.17) $$\prod_{t+1} = \frac{1}{1 + r_t},$$

and by (B.16), seigniorage is zero $z_t \equiv 0$. The nominal government budget constraint, (B.9), can be written

$$A_{t+1} = A_t + P_t(g_t - \tau_t),$$

with the transversality condition

(B.18) $$\lim_{\tau\to\infty} A_{t+\tau} = 0.$$

Equivalently, it can be written

$$\frac{1}{1+r_t} a_{t+1} = a_t + g_t - \tau_t$$

with the transversality condition (B.8). Since now

$$a_t = \frac{A_t}{P_t} = \frac{M_{t-1} + B_{t-1}}{P_t} = \frac{m_{t-1} + b_{t-1}}{\prod_t} = \left(1 + r_{t-1}\right)\left(m_{t-1} + b_{t-1}\right),$$

where $b_t \equiv B_t / P_t$ and I have used (B.17), we can also write the government budget constraint as

$$m_t + b_t = \left(1 + r_{t-1}\right)\left(m_{t-1} + b_{t-1}\right) + g_t - \tau_t.$$

Liquidity trap

Note that the first-order conditions for *ct* and *mt*, by (B.1) and (B.2), can be written

$$\frac{U_m\left(c_m, m_t\right)}{U_c\left(c_t, m_t\right)} = \frac{i_t}{1+i_t}.$$

Solve this for m_t, to get the money demand equation,

$$m_t = f\left(c_t, i_t\right)$$

for $i_t \geq 0$, where $f\left(c_t, i_t\right)$ is increasing in c_t and decreasing in i_t.

In particular, suppose there is a satiation level for real balances for $i_t = 0$, and define $\overline{m}_t$ as this satiation level, when c_t fulfills the equilibrium condition (B.11),

$$\overline{m}_t \equiv f\left(y_t - g_t, 0\right).$$

(Note that, if $c_t = y_t - g_t$ increases over time, so will $\overline{m}_t$.)

Define a *liquidity trap* as an equilibrium when the economy is satiated with real balances, that is, when $i_t \equiv 0$ and m_t fulfills

$$m_t \geq \overline{m}_t$$

(this requires $a_{t+1} / \left(1 + r_t\right) \geq \overline{m}_t$.

When $i_t = 0$, the real return on holding money equals the real interest rate, since

$$\frac{M_t / P_{t+1}}{M_t / P_t} = \frac{1}{\prod_{t+1}} = 1 + r_t.$$

Hence, when the transactions demand for real balance, $\overline{m}_t$, has been satiated, the private sector is indifferent between holding money and bonds. Since both assets pay the same real return (seigniorage, the opportunity cost of holding money is zero), the government's budget constraint is independent of the distribution of nominal liabilities between bonds and money. That is, in a liquidity trap, any level of real balances and bonds are an equilibrium, as long as they fulfill

$$\overline{m}_t \leq m_t \leq \frac{1}{1 + r_t} a_{t+1}, \quad b_t = \frac{1}{1 + r_t} a_{t+1} - m_t \geq 0,$$

or

$$P_t \overline{m}_t \leq M_t \leq A_{t+1}, \quad B_t = A_{t+1} - M_t \geq 0.$$

This means that monetary policy is ineffective. First, nominal interest rates cannot be lowered further. Second, expansionary monetary policy, in the sense of increasing the real monetary base, is ineffective for escaping from the liquidity trap, at least as long as $m_t < a_{t+1}$. Intuitively, since the economy is satiated with liquidity, increasing liquidity

further has no effects. Open-market operations to increase real balances, *mt*, simply reduce the real value of outstanding government bonds by the same amount, without any change in equilibrium.

Holding real balances constant means reducing M_t by the rate $r_t / (1 + r_t)$.[79] Expansionary monetary policy, in the sense of reducing M_t at a lower rate, holding M_t constant, or increasing M_t, has no effect, as long as the open market operations reduce outstanding bonds to the same extent.

Note, however, that $M_t \leq A_{t+1}$ and the transversality condition (B.18) imply that, in a liquidity trap, we must have

(B.19) $$\lim_{\tau \to \infty} M_{t+\tau} = 0.$$

This transversality condition is obviously violated, if M_t is held constant or increased indefinitely over time. Intuitively, with a falling price level and sustained deflation, the real monetary base and the real value of government nominal balances would then grow indefinitely, which would violate the intertemporal budget constraint. Thus, holding M_t constant or increasing it indefinitely is not consistent with a liquidity trap.

Indeed, even if the nominal monetary base were contracting so as to fulfill (B.19), it would be enough to violate the intertemporal budget constraint if the nominal amount of government bonds were held constant or increasing, so as to make total government nominal liabilities violate the transversality condition (B.18). As clarified by Woodford (1999d), regardless of the path of real balances, any fiscal policy holding nominal assets A_{t+1} constant or increasing will violate the transversality condition in a liquidity trap, and, hence, be inconsistent with the liquidity trap.

Thus, although a credible commitment to an indefinitely constant or increasing monetary base is incompatible with a liquidity trap, a credible commitment to an indefinitely constant or increasing level of government liabilities is equally incompatible with a liquidity trap. Hence,

either fiscal or monetary policy can, in principle, get the economy out of the liquidity trap.

Note also, that a contractionary monetary policy, in the sense of reducing real balances below $\overline{m}_t$, will, in a model with flexible prices and monetary neutrality, result in $i_t > 0$ and get the economy out of the liquidity trap. However, in a model with sticky prices, sticky inflation, and sticky inflation expectations, this increase in the interest rate may increase the real interest rate, reduce output and consumption, that is, reduce $y_t - g_t$ and lower $\overline{m}_t$, which depending on the dynamics of the economy, may lead to a worse situation.[80]

Endnotes

[1] Sections 2 and 3 cover material that has previously been discussed in more detail in Svensson (1999h).

[2] This section covers material previously discussed in Svensson (1999h, section 2).

[3] At the Jackson Hole Symposium 1984, Hall argued for price-level targeting. Several recent papers compare inflation targeting and price-level targeting, some of which are collected in Bank of Canada (1994); see also Dugay. Some papers compare inflation and price-level targeting by simulating the effect of postulated reaction functions. Other papers compare the properties of postulated simple stochastic processes for inflation and the price level (see Fischer [1994]).

[4] An interesting issue is the extent to which the degree of nominal rigidity depends on whether there is inflation or price-level targeting.

[5] With a Lucas-type Phillips curve, the more favorable trade-off under price-level targeting requires at least moderate output persistence. With a forward-looking Calvo-type Phillips curve, preliminary results in Vestin (1999) indicate that the more favorable trade-off always occurs under price-level targeting, also without such persistence.

[6] See, for instance, McCallum and Nelson (1999) and Williams (1997).

[7] Moreover, Wolman (1998b) finds that a reaction function responding to price-level deviations from a price-level target (rather than inflation deviation from an inflation target) has good properties for low inflation rates.

[8] As noted by Cecchetti (1997), since $\pi_t - \pi^* \equiv p_t - \left(p_{t-1} + \pi^*\right) \equiv p_t - p_t^*$ (where $\pi_t \equiv p_{t-1}$ denotes inflation, pt denotes the log of the price level, inflation, and $p_t^* \equiv p_{t-1} + \pi^*$), inflation targeting with a constant inflation target π^* is equivalent to price-level targeting with a state-contingent price level target p_t^*. Furthermore, since $p_t - \hat{p}_t \equiv \left(p_t - p_{t-1}\right) - \left(\hat{p}_t - p_{t-1}\right) \equiv \pi_t - \hat{\pi}_\tau$ (where $\hat{p}_t$ is a deterministic price level target, for instance, a price level path given by $\hat{p}_t = \hat{p}_{t-1} + \pi^*$, and $\hat{\pi}_t \equiv \hat{p}_t - p_{t-1}$), price-level targeting is equivalent to inflation targeting with a state-contingent inflation target $\hat{\pi}_t$.

Mervyn King's paper in this volume, (1999), considers an interesting compromise between inflation targeting and price-level targeting that aims at bringing the price level back to the price-level target at a horizon H. Simple algebra shows that this is equivalent to having a state-contingent inflation target, $\bar{\pi}_t$, that is, an average of the constant inflation target under inflation target and the state-contingent inflation target under price-level targeting, $\bar{\pi}_t \equiv (1-\theta)\pi^* + \theta\hat{\pi}_t$, where $\theta \equiv 1/(H+1)$. It is also equivalent to having a price-level target, $\bar{p}_t$, that is an average of the corresponding price level targets, $\bar{p}_t \equiv (1-\theta)p_t^* + \theta\hat{p}_t$, a case examined in Batini and Yates (1999). King shows that a relatively long horizon H, reduces long-term price-level uncertainty without much effect on short-run behavior. Batini and Yates show the same result for a relatively small weight θ (corresponding to their $1-\eta$).

[9] Rotemberg and Woodford (1997), Woodford (1999b) and Erceg, Henderson, and Levin (1999) show how a quadratic loss function like (2.1) can be derived as a second-order Taylor approximation of the welfare of a representative consumer.

[10] As inflation-targeting central banks, like other central banks, also seem to smooth instruments, the loss function (2.1) may also include the term $\mu\left(i_t - i_{t-1}\right)^2$ with $\mu > 0$. Sack and Wieland (1999) provide a survey of recent work and evidence on interest-rate smoothing. Woodford (1999c) shows that, under the case of discretion (see the discussion in Section 3.1), some weight on interest-rate smoothing is advantageous because it induces some of the inertia in interest-rate setting that is optimal but otherwise only results under commitment.

[11] For instance, Fischer (1996), King (1996), Taylor (1996) and Svensson (1996) in Federal Reserve Bank of Kansas City (*Achieving Price Stability* 1996) all discuss inflation targeting with reference to a loss function of the form (2.1) with $\lambda > 0$.

[12] This discussion takes it for granted that there exists a genuine trade-off between inflation variability and output-gap variability. This trade-off is disputed in Goodfriend and King (1997), Ireland (1993), and Rotemberg and Woodford (1997). See Clarida, Gali, and Gertler (1998b) and Erceg, Henderson and Levin (1999) for further discussion of this controversy.

[13] See Sveriges Riksbank (Inflation Report, September 1997, box on p. 26), as well as Heikensten and Vredin (1998).

[14] "...actual inflation will on occasions depart from its target as a result of shocks and disturbances. Attempts to keep inflation at the inflation target in these circumstances may cause undesirable volatility in output."

[15] See Bank of England (Minutes of the Monetary Policy committee meeting 1998), para. 40: "... [I]n any given circumstances, a variety of different interest rate paths could, in principle, achieve the inflation target. What factors were relevant to the preferred profile of rates?... There was a broad consensus that the Committee should, in principle, be concerned about deviations of the level of output from capacity."

Incidentally, this shows that just specifying a long horizon, T, for the inflation target without concern about real variability, $L_t = \left(\pi_{t+T} - \pi^*\right)^2/2$, where π_{t+T} is either four-quarter inflation in period $t+T$ or a longer moving average of inflation, is not sufficient, since there may be multiple paths for the economy minimizing that loss function.

[16] The loss function (2.1) highlights an asymmetry between inflation and output under inflation targeting. There is both a level goal and a stability goal for inflation, and the level goal, that is, the inflation target, is subject to choice. For output, there is only a stability goal and no level goal. Or, to put it differently, the level goal is not subject to choice; it is given by potential output. Therefore, I believe it appropriate to label minimizing (2.1) as "(flexible) inflation targeting" rather than "inflation-and-output-gap targeting," especially since the label is already used for the monetary policy regimes in New Zealand, Canada, U.K., Sweden, and Australia.

[17] The Reserve Bank's target was previously defined in terms of a somewhat complex underlying inflation rate. In the Policy Target Agreement of December 1997, there was a change to the more transparent CPIX.

[18] See Issing (1998), Meltzer (1998), and von Hagen (1995).

[19] If there was evidence that money growth is the best predictor of a reasonable index of underlying inflation, proponents of monetary targeting would have a case. I am aware of no such evidence. See Section 3.3 for further discussion of monetary targeting.

[20] See Svensson (1999c) for a detailed discussion of alternative interpretations of the Eurosystem's definition of price stability.

[21] On the other hand, the argument that inflation increases capital-market distortions, examined in Feldstein (1997 and 1999), would, under the assumption of unchanged nominal taxation of capital, motivate a zero or even a negative inflation target.

[22] For reasons explained in Gordon (1996), I believe that Akerlof, Dickens, and Perry (1996), reach too pessimistic a conclusion. On the other hand, their data are from the United States and Canada, and downward nominal wage rigidity may be more relevant in Europe. Holden (1997) model mechanisms that may increase such rigidity in Europe. The conclusions of Orphanides and Wieland (1998) are sensitive to assumptions about the size of shocks and the average real interest rate; the latter is taken to be 1 percent for the United States. If the average real rate is higher in Europe, and the shocks not much larger than in the United States, nonnegative interest rates may be of less consequence in Europe. Wolman (1998b and 1998a) provides a rigorous examination of the consequences of non-negative interest rates in a more explicit model, and finds relatively small effects.

[23] Examining the effect of inflation on the U.S. labor market, Groshen and Schweitzer (1998) find that "grease" and "sand" effects roughly cancel for low inflation rates, and that there is no justification for inflation targets above 2.5 percent.

[24] Some of the material in this section is discussed more extensively in Svensson (1999h, Section 3).

[25] In a more detailed treatment, we can consider the (non-borrowed) monetary base as the true instrument (over which the central bank has complete control), and the short interest rate as a so-called *operating target* (over which it has almost complete control), but this degree of detail is not required here.

[26] Target(ing) rules are discussed by Rogoff (1985), Walsh (1998), Svensson (1997a and 1999c), Cecchetti (1997), Clarida, Gali and Gertler (1998b), and Rudebusch and Svensson (1999).

[27] Furthermore, (as in Rogoff, Walsh, Svensson (1997a), Cecchetti, Clarida, Gali, and Gertler [1998b] and Rudebusch and Svensson ("Policy Rules for Inflation Targeting") "targeting" here refers to loss functions and "target variables" refer to variables in the loss function. Thus "targeting variable Yt" means minimizing a loss function that is increasing in the deviation between the variable and a target level. In contrast, in some of the literature, "targeting variable Yt" refers to a reaction function where the instrument responds to the same deviation. As discussed in Svensson (1999c, Section 2.4), these two meanings of "targeting variable Yt" are not equivalent. "Responding to variable Yt" seems to be a more appropriate description of the latter situation.

[28] In a linear model with predetermined and forward-looking variables, the optimal reaction function under commitment is a linear function of the predetermined variables and the Lagrange multipliers of the forward-looking variables. These multipliers can be

expressed as a distributed lag of previous predetermined variables.

[29] Wicksell (1998) and Henderson and McKibbin (1993) have suggested other simple reaction functions with the interest rate as the instrument. Meltzer (1987) and McCallum (1998) have suggested simple reaction functions with the monetary base as the instrument.

[30] As discussed in Svensson (1999h), a commitment to a simple instrument rule can be interpreted as an "interest-rate targeting" rule, where the central bank instead of (2.1) and (2.2) has a new static loss function given by $L_t = \left(i_t - i_t^*\right)^2 / 2$ where i_t^* is the interest rate prescribed by the simple instrument rule.

[31] These insights include that stability of inflation requires the long-run response of the short interest rate to increase more than one-to-one with inflation (see Taylor 1999a), that interest-rate smoothing may be optimal (see Rotemberg and Woodford [1997] and Woodford [1999c]), that it is better that the instrument responds to the determinants of the target variables than to the target variables themselves (for instance, even if inflation is the only target variable (the only variable in the loss function), it is generally better to respond to both current inflation and the output gap, since both these are determinants of future inflation; see for instance, Svensson (1997a and 1999a), and that the response coefficients in the optimal reaction function depend on the weights in the loss function on different target variables in sometimes non-intuitive and complex ways (see, for instance, Svensson 1997a).

[32] Even if the model is linear and the loss function is quadratic, certainty-equivalence does not apply to the optimal simple instrument rule.

[33] As stated by King (1999) in this volume, "Mechanical policy rules are not credible... No rule could be written down that describes how policy would be set in all possible outcomes. Some discretion is inevitable. But that discretion must be constrained by a clear objective to which policy is directed..."

[34] There is an additional philosophical objection to once-and-for-all commitment: How come that the once-and-for-all commitment can be made in some particular period, $t = 0$, say? Why was it not already done before, so that nothing remains to be committed to in period 0? Why is period 0 special?

[35] In his commentary, Michael Woodford (1999a), suggests a very sophisticated kind of commitment, a continuous recommitment in a "timeless perspective" to a simple instrument rule (although the particular example given, strictly speaking, involves target variables (inflation and the output gap) rather than the instrument (the short interest rate) and therefore, arguably, seems to involve a targeting rule rather than an instrument rule). The continuous recommitment means that the instrument rule is subject to reevaluation each decision cycle, such that the instrument rule is revised if new information about the model and the transmission mechanism warrants this. The timeless perspective involves a commitment by the central bank to minimize the unconditional expectation of the loss function (equivalently, a commitment to the simple instrument rule "to which it would have wished to commit itself to at a date far in the past, contingent upon the random events that have occurred in the meantime").

This sophisticated commitment solves the problem "why is period 0 special?" It also allows for revision of the instrument rule in the light of new information about the model.

I cannot see that it allows for judgmental adjustment and extra-model information other than in very restricted ways, counter to what Mike claims. Furthermore, it does not solve the problem that any simple instrument rule is inherently inefficient by only using part of the relevant information, so there would still be incentives to deviate from the instrument rule. Finally, the implementation would require the central bank to issue a regular "Instrument-Rule Report" rather than the Inflation Reports currently issued by inflation-targeting central banks. This Instrument-Rule Report would detail and motivate the new revision of the instrument rule and commit the central bank to this until further notice. It would certainly be fascinating to see such a regime materialize in some country, if only to compare its performance to already existing forecast targeting.

[36] See, for instance, the contributions in Taylor (1999b) and, with regard to the performance of a Taylor rule for the Eurosystem, Gerlach and Schnabel (1998), Peersman and Smets (1998), and Taylor (1999c).

[37] I found this appropriate quote in Budd (1998).

[38] See Budd (1998) for an illuminating and detailed discussion of the advantages of explicitly considering forecasts rather than formulating reaction functions from observed variables to the instrument.

[39] For proof of the certainty-equivalence theorem for optimal-control theory, see Chow (1975) for models with predetermined variables only and Currie and Levin (1993) for models with both predetermined and forward-looking variables.

[40] Constructing conditional forecasts in a backward-looking model (that is, a model without forward-looking variables) is straightforward. Constructing such forecasts in a forward-looking model raises some specific difficulties, which are explained and resolved in the appendix of the working-paper version of Svensson (1999c). The conditional forecasts for an arbitrary interest-rate path derived there assume that the interest-rate paths are "credible", that is, anticipated and allowed to influence the forward-looking variables. Leeper and Zha (1999) present an alternative way of constructing forecasts for arbitrary interest-rate paths, by assuming that these interest-rate paths result from unanticipated deviations from a normal reaction function.

[41] The procedure results in an implicit reaction function, where the instrument is an implicit function of all information that goes into constructing the forecasts. To the extent that the current inflation and output gap are important determinants of the conditional forecasts, they will be important arguments of this implicit reaction function. Thus, forecast targeting is fully consistent with the instrument settings superficially appearing to follow a Taylor-type rule. Since variables other than current inflation and the output gap also affect the forecasts significantly, further scrutiny will normally reveal that the instrument also depends on those other variables.

[42] In a model with forward-looking variables, discretionary equilibria imply some "stabilization bias," that is, different reaction coefficients in the reaction function compared to the optimal reaction function under commitment. This implies some efficiency loss. This arises independently of any average inflation bias, cf. for instance Svensson (1997b) and Clarida, Gali and Gertler (1998b). As noted in Svensson (1999c, footnote 43), the extent to which inflation targeting can remedy stabilization bias remains an open question. In his commentary, Michael Woodford (1999a) argues that inflation-forecast targeting, by corresponding to decision making under discretion, implies such a stabiliza-

tion bias. However, the magnitude of the efficiency lost is likely to depend on the degree of "forward-lookingness" of the model; the model used by Mike is extremely forward-looking, but with substantial backward-looking elements in addition to the forward-looking ones, the stabilization bias and the efficiency loss is likely to be less. Furthermore, the emphasis on continuity, predictability and transparency in inflation targeting (in line with the above statement "If no new significant information has arrived, the forecasts and the interest rate path are the same, and interest rate setting follows the same interest rate path") may be interpreted as central banks internalizing the costs of deviation without good reasons from previous forecasts, perhaps indirectly via a concern about reputation, as modeled in Faust and Svensson (1999), thus approaching the commitment equilibrium. The potential for inflation-forecast targeting to achieve the optimal commitment equilibrium is further examined in Svensson and Woodford (1999).

[43] Banco Central do Brasil, the first central bank in a developing country to introduce inflation targeting, also presents confidence intervals for its inflation forecasts (Banco Central do Brasil 1999).

[44] Bank of England's fan charts for inflation and output should probably be interpreted as marginal distributions. However, since the distributions for inflation and the output gap are unlikely to be independent, distribution forecast targeting requires the joint distribution to be conveyed. This may require some further innovation in display, beyond the already beautiful fan charts.

[45] As discussed in Wallis (1999), Bank of England's fan charts present prediction intervals that differ from normal confidence intervals (central prediction intervals). Sveriges Riksbank, however, intervals, see Blix and Sellin (1998). Both banks, in practice, emphasize the mode as their point forecast, whereas it seems to me that it would be more natural and consistent with the theory to present the mean (or, in distribution forecast targeting, at least the median).

[46] As Vickers (1999) discusses, what ensures that the procedure is "painting by numbers" (where the fan chart is painted after the numbers have been constructed by proper assumptions and forecasting) and not "numbers by painting" (where the assumptions are constructed after the desired fan chart has been painted so as to rationalize the desired forecast)?

[47] Bernanke and Mishkin (1997) have appropriately called this "constrained discretion."

[48] Faust and Svensson (1999), building on the classic paper by Cukierman and Meltzer (1986), provide a formal argument why increased transparency increases the credibility costs to a central bank from deviating from announced goals and, in this way, provides an implicit mechanism for commitment to those goals.

[49] This literature includes Neumann (1997), von Hagen (1995), Bernanke and Mihov (1997), Clarida and Gertler (1997), Clarida, Gali and Gertler (1998a; note a crucial typo: the coefficient for money supply in Table 1 should be 0.07 instead of 0.7), Laubach and Posen (1997), and Bernanke, Laubach, Mishkin and Posen (1998).

[50] Brunner and Meltzer (1969) provide a "robust control" argument for monetary targeting. They argue that monetary targeting would be the least harmful to the economy for any model of the transmission mechanism and, hence, is advisable, given sufficient uncertainty about the true model. They express this as a min-max criterion, some thirty

years before such a robust-control approach to optimal-control theory was reintroduced to economics by Hansen and Sargent (1998).

[51] See Bryant (1980), Friedman (1975), Kalchbrenner and Tinsley (1975) and Kareken, Muench and Wallace (1973).

[52] Note that I refer to broad money here, M1-M3, say. Broad money is an endogenous variable, imperfectly controlled by the central bank and distinct from the monetary policy instrument (a short interest rate or non-borrowed reserves, for instance) used to control broad money.

[53] Actually, if money growth was the only determinant of future inflation, it would be the only determinant of the inflation forecast. Then, inflation-forecast targeting would automatically imply monetary targeting.

[54] Although, money growth and inflation are highly correlated in the long run, they are not sufficiently correlated at the horizons relevant to monetary policy.

[55] See Estrella and Mishkin (1997).

[56] Especially since the period after 1990 with considerable volatility of M2 velocity is excluded from the sample, so as to bias the result in favor of monetary targeting.

[57] The *P** model is used to discuss Bundesbank monetary targeting in Jahnke and Reimers (1995), Neumann (1997), Tödter and Reimers (1994), and von Hagen (1995). This may give the impression that the *P** model provides some rationale for money-growth targeting, especially since this model seems to be part of the Bundesbank's view of the transmission mechanism of monetary policy, see Jahnke and Reimers (1995).

[58] Similarly, for a fixed exchange rate regime, a natural indicator of lack of credibility is the difference between expected future exchange rates and the announced central parity; see, for instance, Svensson (1991).

[59] The survey is undertaken each quarter by Aragon Securities Fondkomission, Stockholm.[51] See Bryan (1980)t, Friedman (1975), Kalchbrenner and Tinsley (1975) and Kareken, Muench and Wallace (1973).

[60] See Svensson (1999e) for a discussion of alternative interpretations of the Eurosystem's inflation target.

[61] In an open economy, as discussed in some detail in Svensson (1999f), costs are also affected by the exchange rate, and monetary policy also affects inflation via its effect on the exchange rate. The exchange rate then feeds into the CPI via imported final goods, but also into costs via imported intermediate inputs.

[62] In an open economy, inflation expectations affect expectations of the future nominal exchange rate, which affects the current nominal exchange rate and, with sticky prices, the current real exchange rate. Stable inflation expectations then reduce disturbances to the real exchange rate.

[63] See Clarida, Gali, and Gertler (1998b) for a survey of recent work on the transmission mechanism along these lines. See also Taylor (1995).

[64] In an open economy, the real interest rate differential to foreign interest rates also

affects the real exchange rate which, in turn, both affects real activity and costs.

[65] The loss function is $L_t = \left[(\pi_t - \pi^*)^2 + \lambda (y_t - y_t^*)^2 + .2 (i_t - i_{t-1})^2 \right] / (1 + \lambda + .2)$, thus allowing for some weight on interest-rate smoothing. The weight λ varies from zero (corresponding to strict inflation targeting) to infinity (corresponding to strict output-gap targeting).

[66] Kuttner and Posen (1999) report some evidence of increased mean-reversion, that is, reduced persistence, of inflation after inflation targeting was introduced in New Zealand, Canada, and the U.K.

[67] This is the case even without any modification of the empirical aggregate-demand function. Modifying the inflation expectations in the aggregate-demand function to incorporate improved credibility in the form of a positive weight on the inflation target would further improve the trade-off between inflation and output-gap variability. This is because the improved trade-off between interest-rate and output-gap variability would then give rise to a more favorable trade-off between inflation and output-gap variability for any given weight on interest-rate smoothing in the loss function.

[68] Recent work on deflation, liquidity traps and/or Japan, include Buiter and Panigirtzoglou (1999), BIS [Bank for International Settlement, section IV), Krugman (1998 and 1999), Meltzer (1998 and Working Paper 1999), Posen (1998), Tetlow and Williams, Wolman (1998b and 1998a), and Woodford (1999d).

[69] Wolman (1998a and 1998b) models both the benefits of liquidity and the costs of the zero bound on nominal interest rates.[64] In an open economy, the real interest rate differential to foreign interest rates also affects the real exchange rate which, in turn, both affects real activity and costs.

[70] It may be interesting to compare with the recent experience in Sweden. Swedish 12-month CPI inflation fell to deflation of almost 0.5 percent in the third and fourth quarter of 1998 and came back to zero only in the second quarter of 1999. Underlying inflation (excluding interest rate costs and indirect taxes), on which the Riksbank has put increasing weight over the years, was running at around 1 percent, the lower bound of the plus/minus 1 percentage point tolerance interval around the 2 percent inflation target. Neither the Riksbank nor the general public seems to have been worried about this situation developing into a liquidity trap. The Riksbank has emphasized that the CPI has undershot the target because of a series of temporary shocks. Inflation expectations three to five years ahead have been anchored on the inflation target, see chart 4.1. The Riksbank's inflation forecasts (for underlying inflation two years ahead) have been close to the target, and the Riksbank has not felt compelled to lower the short interest rate below the current 2.9 percent, thus with an ample margin to the zero bound.

[71] See Lebow (1993) for an early discussion of such unorthodox monetary-policy actions.

[72] When there are legal restrictions on what assets the central bank can hold, these measures may require legislated escape clauses.

[73] When modern central-bank legislation, for sound reasons of central-bank independence, include prohibitions on fiscal-authority borrowing in the central bank, such fiscal and monetary coordination may require either legislated escape clauses or that the central bank takes the initiative to the cooperation.

[74] Buiter and and Panigirtzoglou (1999) point to the most unorthodox way of escaping from a liquidity trap. By setting up a system to tax money, so-called Gesell money, a negative interest rate on money can be implemented to avoid the zero interest rate bound and allow a lowering of the real interest rate. The administrative difficulties seem overwhelming, though.

[75] This follows the appendix of the working paper version Svensson (1999g).

[76] My notation differs from Duguay's. My h is his β, and my k is his $1-\alpha$. Duguay does not report the unconditional standard deviation of one-period inflation; instead he reports the conditional standard deviation of the price level and the average inflation rate, $\sqrt{\mathrm{Var}_t\, p_T}$ and $\sqrt{Var_t\, \frac{p_T - p_t}{T-t}} = \frac{\sqrt{\mathrm{Var}_t\, p_T}}{T-t}$, for different time horizons $T-t$.

[77] Real bonds can be introduced but are not essential for the argument.

[78] Woodford (1999d) discusses how we can alternatively consider the nominal interest rate as the central bank's instrument.

[79] Note that $m_{t+1} = m_t$ implies $M_{t+1} / M_t = \prod_{t+1} = 1/(1+r_t) = 1 - r_t/(1+r_t)$.

[80] See Buiter and Panigirtzoglou, Krugman (1999) and Tetlow and Williams (1999c) for sticky-price models of liquidity traps.

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