The credibility of monetary policy from a New Keynesian perspective

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Private agents' expectations of future monetary policy decisions play a key role in the transmission of monetary policy via their influence on long-term interest rates, asset prices and the exchange rate. That is why the credibility of monetary policy, defined as the degree of confidence of private agents in the central bank's determination and ability to conduct the monetary policy and achieve the objectives that it has announced, is a key concern for central banks.

The New Keynesian model, whose use has become widespread over the past years both in academic circles and within central banks, appears a particularly relevant theoretical framework for studying the credibility of monetary policy because it explicitly takes account of private agents' expectations while remaining very easy to use.

This article presents the three main credibility problems that monetary policy may face, as well as their solutions, in the framework of this model. Two of these problems, termed the "inflation bias" and the "stabilisation bias" in the literature, are associated with the notion of time-inconsistency whereby the central bank may have an incentive under certain circumstances not to implement a monetary policy announced beforehand. The third problem is that of the "self-fulfilling expectations" that may arise if the monetary policy followed is unable to uniquely anchor private agents' expectations.

This article is based on a general approach, illustrated by the experience of a number of central banks. Emphasis is placed on the importance of the management of private agents' expectations by the central bank in the conduct of its monetary policy, notably with the aim of optimally influencing long-term interest rates. The arguments put forward stress the need for an independent and transparent monetary policy aiming to ensure price stability over the medium to long term. They also support a gradualist approach to monetary policy, possibly accompanied by adequate communication on the expected future path for the short-term interest rate and responding, where necessary, to private agents' expectations in an appropriate manner, by attempting for example to "disconnect" current variables from these expectations.

Except under exceptional circumstances, all developed countries' central banks currently use the short-term nominal interest rate as the monetary policy instrument. The main monetary policy transmission channels nevertheless involve long-term interest rates, asset prices and the exchange rate, which depend on private agents' expectations about the future path of the short-term nominal interest rate. The effectiveness of monetary policy therefore largely rests on the ability of the central bank to influence, or even "manage" these expectations (Woodford, 2003a, 2005a; Bernanke, 2004b), i.e. on the credibility of monetary policy, defined as the degree of confidence of private agents in the central bank's determination and ability to conduct the monetary policy and achieve the objectives it has announced.

This article presents the different credibility problems that monetary policy may face, as well as their solutions, in the theoretical framework of the New Keynesian model, whose use has become widespread over the past years both in academic circles and within central banks. While this New Keynesian perspective does not do justice to all facets of monetary policy credibility, it nevertheless enables us to deal with some of its essential aspects in a structured way. After a brief presentation of the New Keynesian model in Part 1, three credibility problems for monetary policy will thus be discussed in turn. The first two, i.e. the inflation bias and stabilisation bias, examined in Parts 2 and 3 respectively, are associated with the notion of time-inconsistency (Kydland and Prescott, 1977), whereby the central bank may have an incentive under certain circumstances not to implement a monetary policy announced beforehand. The third credibility problem for monetary policy, examined in Part 4, is associated with the notion of self-fulfilling expectations, which may arise when the monetary policy followed does not enable the central bank to uniquely anchor private agents' expectations.

1| The canonical New Keynesian model

The New Keynesian model belongs to a new generation of macroeconomic models, known as dynamic stochastic general equilibrium models, which aim to characterise, in a stylised manner, the evolution over time of an economy as a whole subject to different random shocks (such as an oil shock for example). These models with microeconomic foundations have two main advantages over previous models for assessing economic policies in general and monetary policy in particular: they make it possible to simulate the effect of a given policy while taking account of the changes in private agents' behaviour that it entails[1] and to appraise this effect on the basis of a social welfare criterion rather than an ad-hoc criterion.

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1   *In other words, these models address, to a certain extent, the Lucas critique according to which the effect of a given economic policy cannot be inferred from the mere examination of correlations in historical data.*

For the sake of clarity, we present here the simplest form of the New Keynesian model, known as the canonical form (Clarida, Galí and Gertler, 1999; Woodford, 2003a). Nonetheless, all the arguments developed in this paper remain valid in different ways and to differing degrees in more complex versions of the same model, which are empirically more relevant, and more generally in most dynamic stochastic general equilibrium models. This canonical version, whose equations are presented in Box 1, features three types of agent: households, firms and a central bank.

Household consumption behaviour is described by the IS equation (1), which links the current output gap positively to the expected future output gap (wealth effect) and negatively to the difference between the ex ante real short-term interest rate and the natural rate of interest (intertemporal substitution effect, which is the basis for the stabilising role of monetary policy). By iterating this equation, the current output gap can be expressed as a decreasing function of the sum of current and expected future short-term interest rates, which can be considered a proxy for the long-term interest rate.

The price-setting behaviour of firms is described by the Phillips curve (2), which links the current inflation rate positively to the expected future inflation rate, the current output gap and a cost-push shock. The expected future inflation rate features in this equation because of a price-rigidity assumption, which moreover is necessary for monetary policy to have a real effect: firms that can change their prices at a given date do so according to their expectations of future inflation since they may not be able to change them again before some time. This curve does not feature

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Box 1

Equations of the canonical New Keynesian model

IS equation: $x_t = E_t\{x_{t+1}\} - \sigma(i_t - E_t\{\pi_{t+1}\} - r_t^n)$ (1)

Phillips curve: $\pi_t = \beta\, E_t\{\pi_{t+1}\} + \kappa x_t + u_t$ (2)

Monetary policy rule: $i_t = f(E_t\{\pi_{t+j}\}, E_t\{x_{t+j}\}, x_t, \pi_t, x_{t-j}, \pi_{t-j}, i_{t-j}, r_{t-k}^n, u_{t-k}, j \geq 1,\ k \geq 0)$ (3)

Social loss function: $L_t = E_t\{\Sigma_{k \geq 0}[(\pi_{t+k})^2 + \lambda(x_{t+k} - x^*)^2]\}$ (4)

Endogenous variables: x (output gap), π (inflation rate) and i (short-term nominal interest rate).

Exogenous shocks: r^n (natural rate of interest, of mean $1/\beta - 1 > 0$, hereafter "demand shock"), u (zero-mean cost-push shock, hereafter "supply shock").

Parameters: $\sigma > 0$, $0 < \beta < 1$, $\kappa > 0$, $\lambda > 0$, $x^* \geq 0$, $V_r \geq 0$ and $V_u \geq 0$ (variances of r^n and u).

Operator: E (rational expectations).

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the short-term nominal interest rate, as monetary policy affects prices only indirectly, via the output gap.

Lastly, the behaviour of the central bank, i.e. monetary policy, is described by a rule of type (3) that links the current short-term nominal interest rate to past, current and/or expected future endogenous variables and to past and/or current exogenous shocks. This rule can be specified exogenously, or endogenously derived from the monetary policy objective. This objective may be, for example, to minimise the social loss function (4), which is itself negatively linked to the households' utility function. This social loss function shows an inflation stabilisation objective (with a target set to zero by convention) because, under the price-rigidity assumption considered, changes in the general price level imply changes in relative prices resulting in a sub-optimal allocation of resources, as well as an output-gap stabilisation objective. It should be noted that these two objectives are compatible in the case of demand shocks but not in the case of supply shocks.

2| Inflation bias

The first credibility problem arises when the central bank seeks to stabilise output above its potential level ($x^* > 0$) with the aim of correcting structural inefficiencies in the economy. In the canonical New Keynesian model, these structural inefficiencies (responsible for the strictly positive sign of x^*) may be due to the presence of monopolistic competition in the goods and services market and the existence of a value added tax. Indeed, these two factors are sources of distortions in that they lower the level of output to below the optimal level that would be reached in the situation of pure and perfect competition.

In order to highlight this credibility problem, let us assume for simplicity that there are no exogenous shocks ($V_r = V_u = 0$). In this case, the optimal monetary policy[2] consists in constantly maintaining the inflation rate and the output gap at zero. Yet, this policy is not credible because, if private agents expected a zero future inflation rate ($E_t\{\pi_{t+1}\} = 0$, reducing the Phillips curve to $\pi_t = \kappa x_t$), then the central bank would have an incentive to choose a current inflation rate and a current output gap higher than zero, in order to reach a better trade-off between an inflation rate close to 0 and an output gap close to $x^* > 0$.

This incentive for the central bank to deviate from its inflation target results in an "inflation bias" (Barro and Gordon, 1983), since the only credible monetary policy then consists in maintaining the inflation rate

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2   *The optimal monetary policy is defined as the monetary policy that minimises the social loss function from Woodford's (1999) timeless perspective.*

Table 1 Woodford's (2003a, chap. 7) calibration					
β	κ	λ	x*	V_r	V_u
0.99	0.10	0.05	0.20	0.00	0.00

well above zero and the output gap just above zero. Under Woodford's (2003a, chap. 7) calibration of the canonical New Keynesian model (see Table 1), this bias is of a significant magnitude since it reduces social welfare by as much as a permanent increase of 9.4 percentage points in the inflation rate.[3]

This inflation bias has been considered to be partly responsible for the "great inflation" that the United States experienced in the 1970s and, by extension, for the severe recession caused by the Fed's disinflation policy at the turn of the 1980s. The solution adopted by developed countries to overcome this inflation bias was to delegate monetary policy, i.e. to assign to the central bank the objective of minimising a loss function that differs from the social loss function and is such that the corresponding monetary policy is close to, or ideally coincides with the socially optimal monetary policy. The best known example of such a delegation is that of Rogoff's (1985) "conservative central banker" whose only goal is to keep inflation stable; another example consists in assigning to the central bank, in addition to an inflation stabilisation objective, an objective of stabilising output at its potential level.[4] These monetary policy delegation schemes have been made credible by the guarantee of central bank independence. The monetary policy transparency that has accompanied them must be considered both a counterpart of central bank independence and a means of improving monetary policy credibility by facilitating its assessment.

3| Stabilisation bias

The second credibility problem arises when exogenous shocks occur, even when the central bank seeks to stabilise output at its potential level (x* = 0), due to the forward-looking nature of the model. For simplicity, let us assume that there are non-autocorrelated supply shocks (V_u > 0) and no demand shocks (V_r = 0). In this case, the optimal monetary policy consists in responding to the supply shock u_t not only at date t, but also at date t + 1 in order to influence private agents' expectations at date t for date t + 1 (indeed, by bringing $E_t\{\pi_{t+1}\}$ closer to $-u_t/\beta$, the central bank brings the Phillips curve closer to the equation $\pi_t = \kappa\, x_t$ and can therefore

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3 *The details of the computations can be found in Woodford (2003a, chap. 7).*
4 *These two delegation schemes correspond to the social loss function (4) with λ = 0 and x* = 0 respectively. The first delegation scheme allows the implementation of the optimal monetary policy only if there are no supply shocks (V_u = 0).*

choose π_t and x_t close to 0). Yet, this policy is not credible because at date $t+1$ the central bank has no longer any incentive to respond to a shock that has ceased to affect the economy.

This credibility problem may be presented alternatively as follows. As a simple iteration of the IS equation shows, the central bank affects the inflation rate and the output gap through the sum of current and expected future short-term interest rates, a proxy for the long-term interest rate. The optimal monetary policy consists in spreading the burden of the adjustment to supply shocks over time, that is to say, in response to an inflationary supply shock, in raising the short-term nominal interest rate and only gradually bringing it back to its initial value, even if the shock has ceased to affect the economy, in order to have a significant initial impact on the long-term nominal interest rate. In contrast, the only credible monetary policy consists, in response to an inflationary shock, in raising the short-term nominal interest rate only during this shock, but in a more aggressive manner than the optimal monetary policy in order to have an initial impact of a comparable magnitude on the long-term interest rate and thus on the inflation rate and the output gap.

This credibility problem severely limits the central bank's ability to influence private agents' expectations of future monetary policy in order to facilitate the stabilisation of the inflation rate and the output gap at the current date and thus gives rise to a "stabilisation bias" (Clarida, Galí and Gertler, 1999; Woodford, 2003a, chap. 7). Under Woodford's (1999) calibration of the canonical New Keynesian model (see Table 2), this bias is admittedly of a small magnitude compared to the inflation bias but it is nevertheless non-negligible, since it reduces social welfare by as much as a permanent increase of 0.43 percentage point in the inflation rate.[5]

In order to overcome this bias, the academic literature has proposed a number of monetary policy delegation schemes consisting for instance in introducing into the loss function assigned to the central bank a price level stabilisation objective, a monetary growth stabilisation objective, a nominal output growth stabilisation objective, an output gap change stabilisation objective or an inflation forecast change stabilisation objective. All these delegation schemes aim to make monetary policy "inertial", like the optimal monetary policy described above, in the sense that monetary

Table 2 Woodford's (1999) calibration

β	κ	λ	x*	v_r	v_u
0.99	0.10	0.05	0.00	0.00	0.01

5 *The details of these computations can be found in Loisel (2005).*

policy responds without undue aggressiveness but in a lasting manner to a one-off supply shock, or in other words they aim to make the current value of the short-term nominal interest rate depend positively on its past value (Woodford, 2003a, chap. 7).

The rationale for such delegation schemes can however be questioned on the grounds that reputational concerns alone could be enough to dissuade the central bank from deviating from the optimal monetary policy when seeking to minimise the social loss function. Loisel (2005) thus defines the reputation of the central bank as its credibility – in the eyes of private agents – to implement the optimal monetary policy and makes this reputation depend on past and current monetary policy, thus modelling the argument of Bernanke, Reinhart and Sack (2004, p.9). In this framework, under Woodford's (1999) calibration, the central bank is dissuaded in all circumstances from deviating from the optimal monetary policy provided that the loss of reputation due to a deviation from the optimal monetary policy lasts between 2 and 12 years (according to the assumption used concerning the statistical distribution of the supply shocks).

If reputational considerations actually make the optimal monetary policy credible in the eyes of private agents, then the implementation of this policy only requires the central bank to communicate about its future monetary policy, i.e. about the short-term nominal interest rate path that it would plan to follow in the – unlikely – absence of shocks occurring in the meantime. Indeed, any deviation from the announced path, not justified by the occurrence of a shock, would result in a loss of reputation.

This communication may take various implicit or explicit forms. The first form consists in explaining the monetary policy strategy and justifying current monetary policy decisions within the framework of this strategy to private agents in general and financial markets in particular. Insofar as they perceive the strategy to be permanent and the decisions to be consistent with the strategy, markets can thus infer expectations about the future course of monetary policy from their expectations about the future economic situation. Similarly, by simply examining the past behaviour of the central bank, markets can assess the systematic response of monetary policy to the economic situation (i.e. the monetary policy rule) and thus infer expectations about the future course of monetary policy.

As we mentioned above, the optimal monetary policy rule (that which makes it possible to overcome the stabilisation bias) is inertial, that is to say that it avoids changes in the short-term nominal interest rate that are too abrupt. This policy resembles the gradualist approach adopted by many central banks, which consists in changing policy rates by small steps in the same direction (Woodford, 2003b) (see Chart 1). This gradualism increases the predictability of the future course of the short-term nominal interest

Chart 1 ECB and Fed policy interest rates

(% per year)

ECB refinancing rate
Fed funds target rate
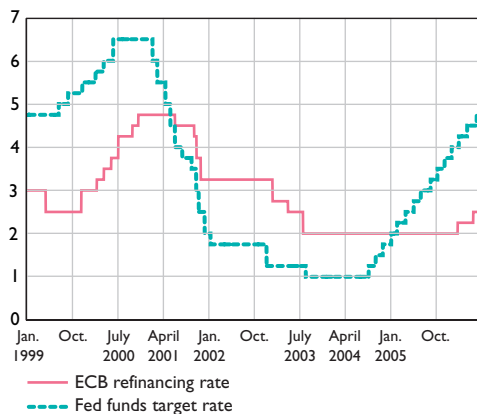
Sources: ECB, Fed.

rate and therefore the central bank's ability to influence the long-term nominal interest rate, thus providing a powerful lever on long-term rates with relatively modest volatility in short-term rates (Bernanke, 2004a).

The second form of communication consists in systematically producing macroeconomic projections on the basis of a monetary policy rule (rather than on the basis of a constant short-term nominal interest rate or the future path of the short-term nominal interest rate expected by the markets) and make public this rule or the corresponding path of the short-term nominal interest rate conditional on the economic scenario considered (Woodford, 2005a). This approach was adopted by the central banks of Canada, New-Zealand and the Czech Republic.[6]

The third form of communication consists in making occasional public announcements about the future path of the short-term nominal interest rate conditional on the scenario considered. Two central banks have recently used this form of communication in a context where the short-term nominal interest rate was close or equal to its zero bound, implying that monetary policy could be further eased (i.e. the long-term nominal interest rate could be further lowered) only by a reduction in expected future short-term nominal interest rates.

On the one hand, the Fed announced, in its statements released at the end of the Federal Open Market Committee (FOMC) meetings of August to December 2003, that policy accommodation could be maintained for a "considerable period" in order to stimulate the economy through a decrease

6 *The rules used by these central banks in their macroeconomic projections are nevertheless not inertial and therefore would not enable them to overcome the stabilisation bias in the canonical New Keynesian model.*

Chart 2 Fed communication and nominal interest rates

(% per year)
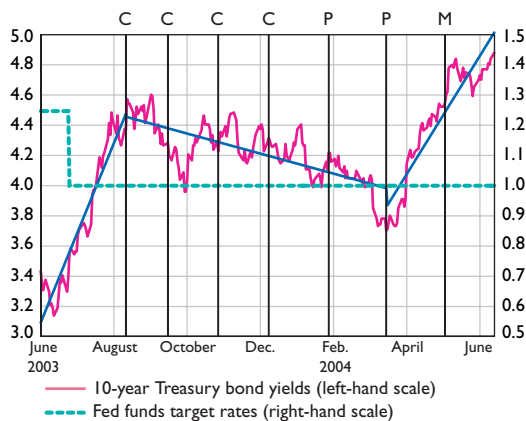
C : "the Committee believes that policy accommodation can be maintained for a considerable period".
P : "the Committee believes that it can be patient in removing its policy accommodation".
M : "the Committee believes that policy accommodation can be removed at a pace that is likely to be measured".

Source: Fed.

in the long-term nominal interest rate (Bernanke, 2004b; Woodford, 2005a). This series of announcements enabled it to interrupt and even partly reverse the rise of over 100 basis points in the long-term nominal interest rate observed between the end of June and the start of August 2003 (see Chart 2), which thwarted its efforts to prevent deflation.[7]

On the other hand, the Bank of Japan announced in April 1999 that it would keep the short-term nominal interest rate at zero until deflationary concerns were dispelled, here again with the aim of stimulating the economy by a decrease in the long-term nominal interest rate (Bernanke, 2004b). The empirical study of Bernanke, Reinhart and Sack (2004) shows that, for both the Bank of Japan and the Fed, the announcement seems to have had the desired effect (Bernanke, 2004b).

The canonical New Keynesian model, which we used above to study the consequences of the stabilisation bias and the ways to overcome it when the inflation rate is close to its target, may also be used to study them in a deflationary situation such as that recently experienced by Japan (Eggertsson and Woodford, 2003; Woodford, 2005a). To this aim, let us assume $x^* = 0$ and $V_u = 0$ for simplicity, and consider a negative demand shock sufficiently large to make the natural rate of interest strictly negative

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7   *The minutes of the August 2003 FOMC meeting attributed this remarkable rise to a number of factors, among which the fact that the markets might have been surprised by the absence of a press release, at the conclusion of the June 2003 FOMC meeting, specifying the possible unconventional policy actions considered to avoid deflation, following the speech of Bernanke (2002) mentioning the possibility for the Fed to target medium-term nominal interest rates, while ensuring in particular that they do not exceed a given explicit ceiling.*

$(r_t^n < 0)$ and having a constant probability (strictly between 0 and 1) to unwind at each date t. The positivity constraint for the short-term nominal interest rate ($i_t \geq 0$) makes it impossible to meet the inflation and output gap targets, and the monetary policy consisting in keeping the short-term nominal interest rate at zero only during the time of the shock does not prevent strong deflation and recession during this time. The optimal monetary policy then consists in credibly committing, if possible, to keep the short-term nominal interest rate at zero for longer than the time of the shock, in order to lower the long-term nominal interest rate and thus to minimise the deflation and the recession during the time of the shock. The potential lack of credibility of this policy stems from its time-inconsistency. Indeed, while it is optimal ex ante, while the shock lasts, this policy is not optimal ex post, when the shock is over, as it is inflationary. The Bank of Japan recently explicitly acknowledged this dilemma (Fukui, 2003) and resolved it by publicly committing on 10 October 2003 to maintaining the short-term nominal interest rate at zero at least until the inflation rate was positive for several months.

Besides, Eggertsson and Woodford (2003) note that, in a deflationary context of this nature, the credible adoption of a price level (rather than an inflation rate) stabilisation objective allows the optimal monetary policy to be implemented. In the case of the Bank of Japan, whose statutes assign to monetary policy the goal of maintaining price stability without specifying this goal,[8] the adoption of a price level stabilisation objective may be temporary, justified by the exceptional circumstances, and decided upon by the central bank itself, without requiring the formal framework of an institutional delegation of monetary policy. The credibility of such an objective, and consequently the effectiveness of the corresponding monetary policy, should however no more be taken for granted in this deflationary context than when the inflation rate is close to its target, due to the time-inconsistency reasons mentioned above, as this price level stabilisation objective requires the offsetting of past deviations of the inflation rate from its target by current deviations of the opposite sign.

The arguments developed so far concerning the stabilisation bias rest on the assumption of rational expectations on the part of private agents. Woodford (2005b) however shows that, in the canonical New Keynesian model, the stabilisation bias is greater under the alternative, less restrictive assumption of near-rational expectations. In other words, the optimal monetary policy is more inertial than under the rational expectations assumption.

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8   *This is also the case for the European Central Bank and the Fed.*

4| Self-fulfilling expectations

The third credibility problem arises, independently of the first two, when the monetary policy followed is unable to uniquely anchor private agents' expectations. Private agents' expectations are then self-fulfilling in the sense that they determine the direction of the economy, which compromises the central bank's ability to optimally stabilise the economy.

In general, the existence of self-fulfilling expectations has been considered in academic literature to be a possible explanation for many economic phenomena ranging from "rational bubbles" on foreign exchange and stock markets (the expectation of a higher future value for the price or rate leading to a rise in its spot value) to exchange rate crises (the expectation of a devaluation leading to a rise in the interest rate and thus providing an incentive to devalue) and, for the subject at hand, to certain macroeconomic developments.

In the latter case, self-fulfilling expectations can be classified as either "convergent" or "divergent". Convergent self-fulfilling expectations give rise to socially undesirable fluctuations of endogenous variables around their steady state values (irrespective of whether exogenous shocks occur), in particular fluctuations of the inflation rate around its target. Divergent self-fulfilling expectations, for their part, tend to move endogenous variables away from their steady state values, for example they may push the inflation rate to high levels – or on the contrary to low levels, driving the economy into a liquidity trap where monetary policy loses its effectiveness, as the short-term nominal interest rate reaches its zero percent lower bound.

A very simple example of convergent self-fulfilling expectations is given by Bernanke and Woodford (1997) in a framework very close to the canonical New Keynesian model:[9] if the central bank's rule is to raise the short-term nominal interest rate in the event of a rise in the long-term nominal interest rate (rightly or wrongly interpreted as an "inflation scare"), then expectations of an increase in the short-term nominal interest rate by the markets will result in a rise in the long-term nominal interest rate and consequently in a rise in the short-term nominal interest rate that will validate these expectations.

Naturally, some rises in the medium- or long-term nominal interest rate actually reflect "inflation scares", i.e. a lack of credibility of the medium- or long-term inflation target, and not convergent self-fulfilling expectations.

9 Bernanke and Woodford (1997) base their analysis on the canonical New Keynesian model slightly modified by the assumption that the price changes made at a given date come into effect only at the following date, so that the Phillips curve features respectively $E_{t-1}\{\pi_{t+i}\}$ and $E_{t-1}\{x_t\}$ rather than $E_t\{\pi_{t+i}\}$ and x_t.

Chart 3 Two-year nominal interest rates

(% per year)
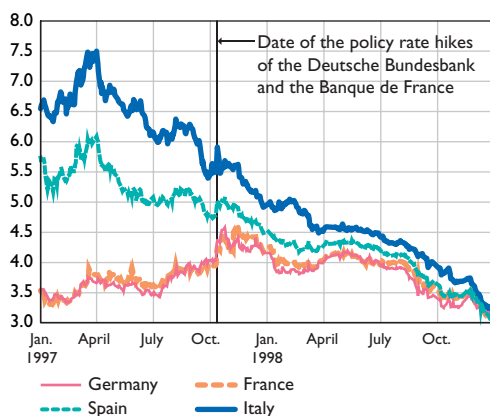
Source: Bloomberg.

This is notably the case for the rise in medium-term (two-year and five-year) nominal interest rates observed in Germany and France in summer 1997, as the markets were expecting national nominal interest rates within the future euro area to converge towards the average rate rather than the lowest rate. Indeed, as stated by Trichet (2005), the hike in the short-term nominal interest rate implemented in October 1997 by the Deutsche Bundesbank and the Banque de France and the communication of these central banks in the following months did not lead to medium-term nominal interest rates in both countries rising or remaining at their previous levels (which would have been observed in the case of convergent self-fulfilling expectations), but to their decline (see Chart 3).

In the framework of the canonical New Keynesian model, let us consider a monetary policy rule that positively links the deviation of the short-term nominal interest rate from the natural rate of interest to the deviation of the expected inflation rate from its target (Rule A in Box 2). In order to prevent convergent self-fulfilling expectations, this rule must satisfy the "Taylor principle" (Woodford, 2003a, chap. 4), i.e. be such that the ex ante real short-term interest rate increases in response to a rise in inflation expectations ($\alpha > 1$). Indeed, this rise in the ex ante real short-term interest rate results in a fall in the current output gap that offsets the impact, described by the Phillips curve, of the rise in inflation expectations on current inflation, and this stabilisation of inflation at each date invalidates the initial rise in inflation expectations.

Clarida, Galí and Gertler (2000) and Lubik and Schorfheide (2004) thus estimated, on the basis of the canonical New Keynesian model, that the

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Box 2

Monetary policy rules [10]

Rule A : $i_t = r_t^n + \alpha\, E_t\{\pi_{t+1}\}$

Rule B : $i_t = r_t^n + E_t\{\pi_{t+1}\} + (E_t\{x_{t+1}\} - x_t)\,/\sigma + \pi_t$

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monetary policy rule followed by the Fed has prevented convergent self-fulfilling expectations as of 1979, when Paul Volcker became Chairman, and viewed this result as an explanation of the marked decline in macroeconomic volatility in the United States as of this date.

While it eliminates convergent self-fulfilling expectations, Rule A with $\alpha > 1$ nevertheless allows for divergent self-fulfilling expectations. Indeed, when divergent self-fulfilling expectations are in place, a too small a rise in the ex ante real short-term interest rate (following a rise in inflation expectations) may stimulate activity, thus validating the initial rise in inflation expectations. To understand this, it suffices to observe from the IS equation and Rule A with $\alpha > 1$ that a rise in inflation expectations ($E_t\{\pi_{t+1}\}$ ↑) leads to, via the increase in the ex ante real short-term interest rate ($i_t - E_t\{\pi_{t+1}\}$ ↑), a rise in the expected change in the output gap ($E_t\{x_{t+1}\} - x_t$ ↑) that in turn implies either a decrease in the current output gap (x_t ↓), or an increase in the current output gap (x_t ↑) accompanied by a more pronounced increase in the future expected output gap ($E_t\{x_{t+1}\}$ ↑↑). In the latter case, where private agents expect a divergent output gap, the rise in the output gap therefore validates the initial rise in inflation expectations (divergent self-fulfilling expectations).

Such divergent self-fulfilling expectations, when on the upside, may appear more relevant than convergent self-fulfilling expectations for explaining the "great inflation" experienced by the United States in the 1970s. When on the downside, they may explain why an economy such as Japan's in the 1990s gradually slid into the liquidity trap (Benhabib, Schmitt-Grohé and Uribe, 2001) despite monetary policy easing, i.e. despite a decrease in the ex ante real short-term interest rate: once in place, these expectations are difficult to reverse.

Two kinds of monetary policy rule of type (3) (see Box 1) can be used to prevent to a large extent both convergent and divergent self-fulfilling expectations. The first kind of rule eliminates convergent self-fulfilling expectations and makes the short-term nominal interest rate respond aggressively to certain endogenous variables so as to reduce the possibility

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10 When $V_u = 0$, these two rules are compatible with an inflation rate and an output gap constantly equal to zero (optimal situation), but only Rule B ensures that this will actually be the case: indeed, as Rule A does not eliminate divergent self-fulfilling expectations, it is compatible with other inflation rate and output gap paths.

of divergent self-fulfilling expectations. This is the case, for example, of Rule A with a high α coefficient.[11] Such a rule implies a sharp rise in the ex ante real short-term interest rate in response to a rise in inflation expectations and consequently eliminates the possibility of slightly divergent self-fulfilling expectations (those associated with a moderate rise in the expected future output gap), thus allowing only strongly divergent self-fulfilling expectations. The aggressive nature of this first kind of rule may nevertheless undermine the credibility and therefore the effectiveness of these rules for a number of reasons: in particular it may transfer to the economy, by amplifying them, measurement errors of endogenous variables by the central bank and, depending on whether the divergent self-fulfilling expectations are of a downward or upward nature, bring the short-term nominal interest rate dangerously close to its zero percent lower bound or compromise financial stability.[12]

The second kind of rule, designed and studied by Loisel (2006), avoids these inconveniences thanks to its non-aggressive nature. These rules aim to "disconnect" current variables from private agents' expectations. An example of such rules is provided by Rule B in Box 2, which makes the difference between the short-term nominal interest rate and the natural rate of interest positively depend on three factors: the current inflation rate, the expected future inflation rate and the expected future change in the output gap. This rule eliminates all convergent and divergent self-fulfilling expectations by isolating current inflation from private agents' expectations. Indeed, inserting this rule into the IS equation exactly offsets the impact of variables $E_t \{\pi_{t+1}\}$, $E_t \{x_{t+1}\}$ and x_t (irrespective of their values) on current inflation π_t, which is thus uniquely determined ($\pi_t = 0$). This reasoning, applied at the following date, shows that the same is true for future expected inflation ($E_t \{\pi_{t+1}\} = 0$), and therefore, via the Phillips curve, for the current output gap ($x_t = 0$). As mentioned above, this rule is moreover non-aggressive in that, contrary to the coefficients of the first kind of rule, its coefficients (equal to 1 and $1/\sigma$) are not large.

The ability of Rule B to eliminate all convergent and divergent self-fulfilling expectations has been proved above only in the benchmark case where the central bank has a perfect knowledge of the structure of the model and the value of its parameters, in particular of the parameter σ that features in the IS equation and on which one of the coefficients of this rule depends. Loisel (2006) shows however that, in the more realistic case where the central bank has an imperfect knowledge of the structure of the model and the value of its parameters, this second kind of rule still eliminates convergent and slightly divergent self-fulfilling expectations by using the structural equations as a fulcrum to exert leverage on

11 More precisely, this coefficient must be both much greater than 1 and much lower than $1+2(1+\beta)/(\kappa\sigma)$, because a necessary and sufficient condition for Rule A to eliminate convergent self-fulfilling expectations is $1 < \alpha < 1+2(1+\beta)/(\kappa\sigma)$ (Woodford, 2003a, chap. 4).
12 The canonical New Keynesian model takes account of the first two drawbacks (but not the third) by showing their negative impact on social welfare.

private agents' expectations. Lastly, it is also shown that in the canonical New Keynesian model like in most dynamic stochastic general equilibrium models, this second kind of rule is necessarily forward-looking, i.e. these rules necessarily make the short-term nominal interest rate conditional on private agents' expectations (with the aim of "disconnecting" current variables from these expectations).

The arguments put forward up to this point concerning the possibility of self-fulfilling expectations rest on the assumption of rational expectations on the part of private agents. This assumption, which is at first useful as a benchmark, may then be abandoned in favour of the more realistic assumption of private agents learning the structure of the model and the value of its parameters. The corresponding literature[13] has shown, notably in the framework of the canonical New Keynesian model, that convergent and divergent self-fulfilling expectations remain possible under this assumption with the commonly considered monetary policy rules.

In the canonical New Keynesian model like in most dynamic stochastic general equilibrium models, the central bank may face a number of credibility problems in the conduct of its monetary policy. In addition to the well-known inflation bias problem, there are the problems of the stabilisation bias and self-fulfilling expectations, which may undermine the determination and the ability of the central bank to influence the long-term nominal interest rate in an optimal manner and more generally to manage private agents' expectations. These credibility problems may be overcome by a monetary policy that is: always independent, transparent and intended to ensure price stability over the medium to long term; sometimes inertial or (equivalently) gradual, possibly accompanied by adequate communication on the expected future path for the short-term nominal interest rate and responding, where necessary, to private agents' expectations in an appropriate manner.

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13 *The references are given in Loisel (2006).*

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