TAYLOR RULES*

*Fernando Martins***

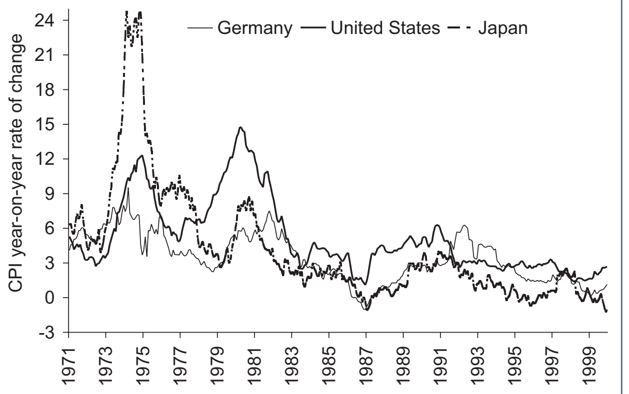
1. INTRODUCTION

Building on Taylor's seminal article (1993), a wide set of literature has tried to identify the monetary policy features prevailing in the course of the past two decades, during which the monetary authorities proved to be rather efficient in reducing inflation (chart 1). In this literature, the conventional approach consists in estimating a reaction function for a monetary authority (the Federal Reserve, in most cases) in which a nominal benchmark interest rate is adjusted in response to inflation (actual or expected) and output deviations from their equilibrium levels. These reaction functions, usually called Taylor rules, are consistent with a set of principles proposed in the literature for the optimal monetary policy rules.

Given the prominent role played by Taylor rules in the recent debate on monetary policy, this article presents a summary of the empirical literature on the subject, briefly focusing on the possible advantages, as well as on the operational difficulties and limitations associated with the use of this kind of analysis instrument. In section 2, the Taylor rule is analysed within the scope of the literature on monetary policy and some empirical results are presented. The main operational issues and the limitations associated with the use of the rule are discussed in section 3. Finally, section 4 concludes, arguing that notwithstanding the identified limitations, Taylor rules may provide a useful element of analysis in the debate on monetary policy.

Chart 1

INFLATION RATE IN GERMANY, UNITED STATES AND JAPAN 1971-1999



Source: Datastream.

2. TAYLOR RULES: THEORETICAL FRAMEWORK AND EMPIRICAL APPLICATIONS

2.1 Theoretical framework

The sharp increase in inflation rates, recorded in several industrial countries during the 1970s — the so-called "High Inflation" period — has directly or indirectly given rise to a large part of the investigation in the field of monetary economy. The pioneer works of Kydland and Prescott (1977) and Barro and Gordon (1983) have shown that, if the monetary authorities have incentives to expand output (reduce unemployment) above (below) its equilibrium level, the discretionary policy

* Economic Research Department.

** The views expressed in this paper are those of the author and not necessarily those of the Banco de Portugal. The author is grateful for the comments of Marta Abreu, Carlos Robalo Marques, Pedro Teles, José A. Ferreira and Maximiano Pinheiro, which have significantly contributed to improve this paper. The author is fully responsible for any errors.

will have a bias towards an excessive inflation (the so-called "inflation bias")(1). In this sense, these authors argue in favour of a reform of monetary institutions, as a mean of preventing inflation from reaching again the values recorded in the 1970s. These reforms would include, inter alia, the setting-up, by legislative means, of an independent central bank, responsible for the control of the monetary policy instruments, and with the explicit objective of maintaining price stability.

During the past few years, increasing attention has been paid to the way monetary policy is conducted and, in particular, to the role played by monetary policy rules. Several reasons seem to be behind this trend, namely the fact that since the late 1980s a wide set of literature has pointed to the significant influence of monetary policy on the performance of economic activity in the short run. In most of these works, the temporary price rigidity is the basic friction, which explains the non-neutrality of monetary policy. The literature tries to identify simple monetary policy rules, capable of reducing the probability of emergence of inflationary shocks similar to those occurred in the 1970s. Among these rules, those trying to model the way the monetary authority changes the monetary policy instrument (usually, a short term interest rate) have played a prominent role. These rules are now called "Taylor rules", after John Taylor's paper published in 1993. The original formulation of the Taylor rule was the following:

$$i_{TAYLOR} = r^* + \pi_t + \gamma(\pi_t - \pi^*) + \varphi x_t \qquad (1)$$

or, in an equivalent way, with $\beta = 1 + \gamma$ e $\theta = r^* + (1 - \beta)\pi^*$:

$$i_{TAYLOR} = \theta + \beta\pi_t + \varphi x_t \qquad (1a)$$

where i_{TAYLOR} is the target interest rate proposed by the rule, π_t the average inflation rate in the past four quarters (measured by the GDP deflator), π^* the target for the inflation rate, x_t the output gap (defined as the deviation of output from potential output, as a percentage of potential output) and r^* the equilibrium real interest rate. All variables are defined in levels. It should be noted that if $\beta > 1$ and $\varphi > 0$, the real interest rate is adjusted in order to stabilise inflation and output; if $\beta < 1$, part of the inflation is accommodated. In this case, the nominal interest rate change is not sufficient to give rise to a real interest rate change in the same direction. The same applies to φ, which must be non-negative in order to obtain a stabilising rule. This kind of analysis is somewhat contrasting, for instance, with that of the so-called limited participation models (see Box).

The main contribution of Taylor's work was the distinction between normative and positive elements. At the normative level, approximate (and sometimes exact) formulations of the Taylor rule are optimal for a monetary authority with a quadratic loss function in inflation and output deviations from their respective targets, in a context of general equilibrium models with price rigidity [see, for example, Ball (1997)](2). In particular, the rule stipulates that, in response to an inflation rate increase, the nominal interest rate is sufficiently adjusted in order to raise the real interest rate(3). At the positive level, Taylor demonstrated that with

(1) Christiano and Gust (1999) argue that Barro and Gordon's theories may have lost some of their influence in recent years because evidence did not confirm them. In the United States, and in the absence of any institutional reform, from the early 1980s onwards there was a sustained fall in inflation, three years before the unemployment rate started to decrease from historically high levels. Between 1980 and 1983, the US inflation rate decreased from 13.5 to 3.2 per cent, whereas in the same period the unemployment rate increased from 7.2 to 9.7 per cent — the highest level recorded in the second half of the century. A similar phenomenon took place in Europe and in other countries, i.e. inflation seems to have started to abate when incentives to its emergence were bigger.

(2) In most models, an optimal monetary policy rule is defined as one that minimises the weighted sum of output and inflation variances, the weights being determined by policy-makers' preferences. An efficient rule is one that, given the weights, becomes optimal, or one that places the economy in the boundary defined by output and inflation variances.

(3) Clarida, Galí and Gertler (1999) build on a monetary authority objective function targeted at minimising output (x_t) and inflation (π_t) gaps vis-à-vis their equilibrium values, which is subject to two restrictions: an equation which establishes an inverse relation between the output gap (x_t) and the real interest rate (IS curve); and another equation which establishes a positive relation between inflation and the output gap (Phillips curve). The solution for this problem leads to the following optimality condition:

$$x_t = -(\lambda / \alpha)\pi_t$$

where λ and α translate the gain in terms of inflation per output unit (a parameter of the Phillips curve) and the weight of the output gap on the target function, respectively. Whenever inflation stands above the target $(\pi_t > 0)$, the output gap must narrow (the interest rate increases), the reverse occurring when the inflation rate is lower than the target defined.

certain values for the parameters (the values defined by Taylor were β=1.5, φ=0.5, π*=2 and r*=2[4]), the rule provides a reasonable description of the US Federal Reserve monetary policy from 1987 to 1992 (the beginning of this period coincides with the entrance into office of the Federal Reserve Chairman, Alan Greenspan).

2.2 Taylor rule and monetary policy gradualism

The kind of formulation originally proposed by Taylor does not consider the gradualist approach, which seems to characterise the action of monetary authorities in many situations (the so-called "interest rate smoothing"). This problem may be solved by means of a partial adjustment of the interest rate (i_t) vis-à-vis the target defined by the rule (i_{TAYLOR}):

$$i_t = \rho i_{t-1} + (1-\rho) i_{TAYLOR} \qquad (2)$$

With ρ defining the degree of monetary policy gradualism ($0 < \rho < 1$). Combining (1a) and (2) we obtain:

$$i_t = (1-\rho)\theta + (1-\rho)\beta\pi_t + (1-\rho)\varphi x_t + \rho i_{t-1} \qquad (3)$$

The values estimated for the adjustment coefficient (ρ) range generally between 0.6 and 0.8 for quarterly data, and are close to 0.9 for monthly data[5].

In several models, there is an implicit trade-off between the interest rates volatility, on the one hand, and inflation / output volatility, on the other. In other words, there is the possibility of stabilising output and inflation according to policy rules, which despite being very aggressive, induce significant interest rate fluctuations. To overcome this problem, the monetary authority loss function may be increased by including an interest rate stabilisation term:

$$L_t = \left(\pi_t - \pi^*\right)^2 + \lambda x_t^2 + \nu(i_t - i_{t-1}), \text{ com } \lambda > 0 \text{ e } \nu > 0$$

Sack and Wieland (1999) argue that the existence of gradualism in monetary policy is useful when the economic agents have a forward-looking behaviour, when there are measurement errors associated with certain fundamental variables, or when some relevant structural parameters are not known. In models with forward-looking expectations[6], rules of type (2) may be more appropriate in the stabilisation of inflation and output than those without partial adjustment. With a sufficiently gradualist policy, agents expect a small initial interest rate movement to be followed by additional movements in the same direction, which increases the monetary policy impact on output and inflation, avoiding large interest rate changes. On the other hand, models usually assume that policy-makers consider economic variables without any type of measurement errors. In practice, economic data tend to be revised on several occasions after their first release. Thus, a rule of type (2) may moderate the interest rate response to the first release of data, when these are still subject to revisions. Finally, due to uncertainty regarding the fundamental parameters of the economic structure underlying the transmission mechanism, authorities chose to act more cautiously, making gradual interest rate adjustments.

The literature gives other explanations for the preference of monetary authorities for the adoption of a gradualist policy, such as the concern in avoiding adverse reactions from financial markets to frequent and opposite changes in official interest rates, or for reasons concerning the monetary authority reputation [see Goodhart (1995)].

2.3 Taylor rules and the forward-looking nature of monetary policy

Formulations (1) and (2) consider only current inflation, not taking into account the forward-looking nature of monetary policy. Taking this into consideration, Clarida, Galí and Gertler [CGG, (1998)] examine the US monetary policy since 1960, on the basis of a forward-looking version of the Taylor rule:

(4) Several studies have subsequently shown that a modified version of the original Taylor rule with a higher φ coefficient would have better stabilising properties, while continuing to give a good description of the recent behaviour of monetary policy [see for instance Taylor (1999a)].

(5) It is possible to demonstrate that in a model described by equation (3) the average transmission lag to the interest rate of a unit variation in the inflation rate equals $\rho/(1-\rho)$. In this context, a value of 0.8 for ρ for quarterly data corresponds to a value of 0.5 in the case of annual data.

(6) As opposed to expectations based only on the extrapolation of past behaviour.

Table 1

ESTIMATED VALUES FOR THE FED REACTION FUNCTION

GMM estimation; standard deviations in parenthesis

	β	φ	ρ
Pre-Volcker	0.8	0.44	0.75
1960:1 – 1979:2.......	(0.09)	(0.04)	(0.04)
Volcker-Greenspan...	1.8	0.12	0.66
1979:3 – 1996:4.......	(0.19)	(0.13)	(0.04)

Source: Clarida, Galí e Gertler (1998).

$$i_t = \theta + \beta E_t \pi_{t+1} + \varphi x_t \qquad (1b)$$

As in the original rule (1), the magnitude of parameters β and φ characterises the monetary policy stance, and it is still desirable that $\beta > 1$ and $\varphi > 0$. This version has the advantage of considering the Taylor rule as a particular case. Indeed, if both the current inflation and the output gap are sufficient to explain future inflation, then the two formulations are equivalent.

CGG concluded that the Taylor rule, with the formulation suggested, characterises adequately the US monetary policy from 1979 to 1996 (the period in which the Chairmen of the Federal Reserve were successively Paul Volcker and Alan Greenspan). During the preceding period (1960-79), coefficient β is lower than 1 (table 1), suggesting that monetary policy accommodated somehow the increases in expected inflation. For the Volcker-Greenspan period, this value is significantly higher than 1. Given that in this period, the coefficient φ is not significantly different from zero, the output gap influenced the Federal Reserve reaction function only as an inflation rate predictor.

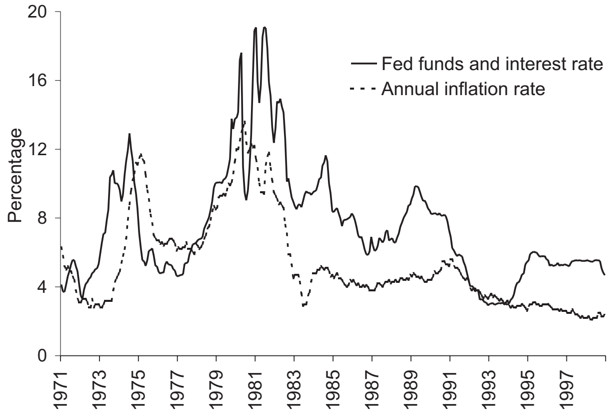
The change in the Federal Reserve monetary policy stance from 1979 onwards is shown in chart 2. This chart shows that from mid-1979 onwards there was a shift in the interest rate behaviour. Until 1979, the ex post real interest rate was negative or nil on several occasions. As from 1979, the real interest rate became positive.

Chart 2

UNITED STATES

Inflation rate and interest rate

1971-1998



Source: Datastream.

Table 2

MONETARY POLICY RULES FOR THE FEDERAL RESERVE

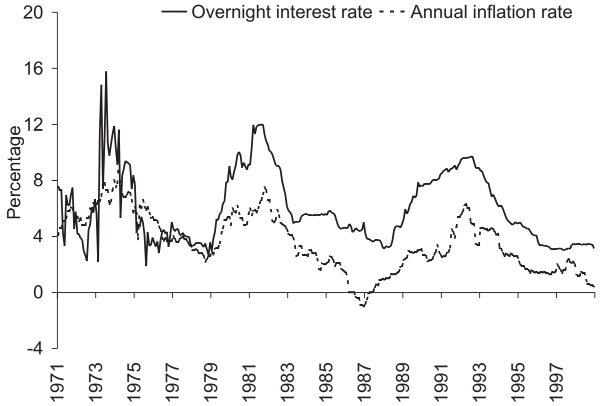
Estimation by the ordinary least quare method; *t* statistics in parenthesis

	Constant	β	φ
1960:1 – 1979:4	2.05	0.81	0.25
	(6.34)	(12.9)	(4.93)
1987:1 – 1997:3	1.17	1.53	0.77
	(2.35)	(9.71)	(8.22)
1954:1 – 1997:3	1.72	1.10	0.33
	(5.15)	(15.1)	(3.16)

Source: Taylor (1999b).

Identical results are obtained in Taylor's work (1999b). Several episodes of the US monetary policy history are analysed in this paper, leading to the conclusion that the type of rule which characterises the Federal Reserve policy in the so-called "Greenspan era" is quite different from the one of the preceding periods. This shift is associated with an equally significant reduction of both output and inflation volatility in the United States. Table 2 presents a numeric example of the magnitude of

Chart 3
GERMANY
Inflation rate and interest rate
1971-1998



Source: Datastream.

Table 3

ESTIMATED VALUES FOR THE BUNDESBANK (1979:3-1993:12) AND FOR THE BANK OF JAPAN (1979:4-1994:12) REACTION FUNCTION

GMM estimation; pattern deviations in parenthesis

	β	φ	ρ
Deutsche Bundesbank . . .	1.31	0.25	0.91
	(0.09)	(0.04)	(0.01)
Bank of Japan.	2.04	0.08	0.93
	(0.19)	(0.03)	(0.01)

Source: CGG (1997).

this reversal in the performance of monetary policy.

It is interesting to verify that two other central banks, the Bundesbank and the Bank of Japan (chart 3), have behaved similarly after 1979. CGG (1997) estimate the rule with the same specification and obtain results, which are similar to those for the Federal Reserve in the Volcker-Greenspan period (table 3). This behaviour was mirrored in a worldwide disinflation process as from the 1980s.

2.4 Information problems in the real time application of Taylor rule

Orphanides (1999) analyses a type of limitation associated with the utilisation of Taylor rules to characterise from an historical point of view the monetary policy stance. Orphanides argues that the validity of the conclusions obtained in the works mentioned in the last section is seriously threatened, as these are based on unrealistic assumptions regarding the set of data available to the monetary authorities at the decision-making moment. In particular, rules admit that authorities have reliable information on the contemporary values of inflation and output gap when they decide on level of interest rates. However, in particular the output gap[(7)] is measured with a considerable margin of error, being frequently subject to significant revisions.

The problem may be analytically described as follows. Being e_t the measurement error of the true inflation rate (π^a) and f_t the measurement error of the true output gap (x^a):

$$\pi_t^a = \pi_t + e_t \quad (4)$$

$$x_t^a = x_t + f_t \quad (5)$$

Substituting (4) and (5) in (1), Taylor rule is obtained according to inflation and output gap true values and to the measurement errors:

$$i_{TAYLOR} = r^* + \pi_t^a + \gamma\left(\pi_t^a - \pi^*\right) + \varphi x_t^a - \left[(1+\gamma)e_t + \varphi f_t\right] \quad (1c)$$

Equation (1c) reveals the true nature of the problem. The setting of the interest rate level on the basis of the inflation rate or the output gap may, under certain circumstances, lead to undesirable effects, because authorities do not know the true values of these two variables. Therefore, an historical analysis of the monetary policy stance should be conducted on the basis of the information available at the decision-making moment.

Orphanides examines the US economic performance from 1965 to 1993 in the light of a Taylor rule, but with real time data. The final series and

(7) The measurement of the output poses, in general, two types of problems: one concerns the measurement of output itself and the other involves the potential output calculation method.

the real time series for the inflation rate show differences that in the first half of the 1970s are frequently higher than one percentage point. Nevertheless, when compared with the output gap differences, the measurement error for the inflation rate may be considered low. Indeed, the real time output gap series is systematically below the final series in all the sampling period. This holds particularly true during the 1970s, when the difference between the two series reached around ten percentage points. The most interesting conclusion of Orphanides work is perhaps that the original formulation of the Taylor rule describes quite well the Federal Reserve behaviour, not only in the past years but also during the 1970s — the so-called "High Inflation" period — when real time information is used. Therefore, the 1970s inflation acceleration may have been the result of an excessively lax monetary policy, which by contrast with the conclusions of Taylor works, followed closely a Taylor rule based on very unreliable data.

3. TAYLOR'S RULES: OPERATIONAL ASPECTS

From an operational point of view, the Taylor rule envolves some aspects, which should be taken into account. One of them concerns the choice of the values to be used for parameters β and φ. Table 4 shows the values suggested by different models for the US economy. It is evident that, although the prameters are not qualitatively very different, the results drawn from each model can be rather different in terms of magnitude. On the other hand, as derived from equation (1), the Taylor rule recommends an objective for the nominal interest rate, which depends on three variables (real equilibrium interest rate, target value for the inflation rate and the output gap) which are derived from a set of assumptions. The usefulness of Taylor rules for information purposes depends therefore on their robustness to small variations in the hypotheses assumed for these variables.

3.1 Real equilibrium interest rate

One of these elements is the real equilibrium interest rate or "real neutral interest rate", i.e. the interest rate which is consistent with a scenario where the inflation equals the target value defined by monetary authorities, and the output matches potential output. The interest rate recommended by the rule is rather sensitive to real equilibrium interest rate estimates: in the absence of monetary policy gradualism, real equilibrium interest rate changes have a one-for-one effect on the interest rate proposed by the rule. As it is not directly observed, the real equilibrium interest rate must be estimated. In accordance with the "golden rule" for the accumulation of capital, the marginal product of capital (which, in equilibrium is equal to the real interest rate) must be higher than the output growth rate (a condition for dynamic efficiency). For example, in the case of the euro area, current estimates of the potential output suggest that the real long-term equilibrium interest rate must have a floor close to 2-2.5 per cent. In Taylor's original paper, the real equilibrium interest rate admitted for the United States is constant and equal to 2.0 per cent, whereas according to the CGG model (1997), the figures admitted are 3.5, 3.8 and 3.3 per cent for the United States, Germany and Japan respectively. Usually, the estimates result from the difference between two averages, i.e. from a nominal interest rate controllable by the monetary authority and the inflation rate, with both averages being calculated for a relatively wide sample. Evidence shows that the results can vary significantly according to the sample period; in certain cases this period can cover different monetary policy regimes.

In the case of the euro area the real equilibrium interest rate may have declined with the advent of the monetary union. Gerlach and Schnabel (1999) suggest that the reduction of the real equilibrium interest rate was greater in the countries whose currencies depreciated against the Deutsche mark

Table 4

VALUES FOR PARAMENTERS β AND φ IN ACCORDANCE WITH VARIOUS MODELS

	Inflation deviation (β)	Output gap (φ)
Taylor (1993)	1.50	0.50
Taylor (1999a)	1.50	1.00
Ball (1997)	1.50	1.00
Christiano (1999)	3.00	0.50
Clarida, Galí e Gertler (1998) ..	1.80	0.12
Rotemberg e Woodford (1998) .	1.20	0.06

over recent years. However, the figure presented by these authors for the real equilibrium interest rate in the euro area (3.5 per cent) seems excessive, given that it covers a rather long period (1982-97) and weighs large and small countries similarly[8]. Based on the evidence compiled, the current level of the real equilibrium interest rate seems to stand at around 3.0 per cent — a figure close to the estimates obtained with a reaction function for the Bundesbank for the past two decades and to the average of the G7 real interest rates in the past five years.

It should be noted that the level of the real equilibrium interest rate is endogenous to the credibility of the monetary authority. For example, the more credible the European Central Bank (ECB) is in the pursuance of the objective of price stability, the lower the risk premium associated with inflation rate variability and the lower the real equilibrium interest rate.

3.2 Target value for the inflation rate

The most common Taylor rules incorporate an inflation target to be achieved in the medium term, which is constant over the whole sample period. However, the inflation targets have rarely been maintained over the time horizon of the analysis: the current inflation target is not necessarily the same as it was 10 or 20 years ago, depending, for instance, on the preferences of the monetary authorities over time, as well as on the monetary policy regime pursued. For example, the primary objective of the Eurosystem's monetary policy strategy is to maintain price stability, which is defined as an increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2 per cent per annum. In addition, it should be noted that the original Taylor rule uses as inflation measure the percentage change in the GDP deflator between year-on-year quarters, whereas CGG (1997) use the Consumer Price Index (CPI). Thus, an analysis should be made of the robustness of the recommendations made by the rule as regards alternative inflation measures. Kozicki (1999) analyses the robustness of the Taylor rule by means of four alternative inflation measures — CPI, trend CPI, GDP deflator and expected inflation — concluding that the recommendations suggested by the rule are modestly robust across the various measures.

3.3 Output gap

The inclusion of the output gap in the rule poses several problems. Given that it is not an observable variable, the output gap must be estimated, with significant disparities being frequently observed across different estimates, depending on the estimation method that is used. For example, the European Commission forecasts disclosed last April showed estimates for the euro area output gap in 2000 of -0.2 per cent when the HP filter is used and -1.2 per cent when the production function approad is applied. On the other hand, it should also be noted that the concept of potential output itself, and hence of the output gap, is not consensual, for there are different notions in the literature.

For the purpose of formulating the monetary policy, the knowledge of the output gap estimates for the more close periods is particularly important. However, estimates for the contemporaneous output gap are uncertain, either because recent output figures are still preliminary or because most estimation techniques, namely univariate methods such as the HP filter, pose some problems at the end of the sample. Smets (1998) concludes that, within the scope of the Taylor rules, uncertainty in the output gap measurement reduces the responsiveness of the output gap estimate (coefficient φ) in comparison with that of the inflation rate deviation. In a way, this can explain the reason why the estimate for the coefficient associated with the output gap in the Taylor rule is normally lower than what is considered optimal in literature in general.

(8) The calculation of the real equilibrium interest rate for the euro area on the basis of the average of the real interest rates prevailing, for example, during the past two decades, is likely to show an upward bias. In fact, over this period, one could notice a disinflation process in the euro area, which may have caused real interest rates to stand above their equilibrium level. Against this background, it seems more appropriate to use the previous interest rates recorded in Germany - a country characterised by a high level of macroeconomic stability in recent years.

4. CONCLUSIONS

Evidence shows that Taylor rules reasonably describe the behaviour of the main monetary authorities, namely the US Federal Reserve and the Bundesbank, in the past two decades — a period in which the monetary policy performance is generally considered as having been rather successful in reducing inflation. In this respect, it seems reasonable to argue that, even under different economic circumstances, such as those currently prevailing in the euro area, the Taylor rule can be a useful reference to the debate on monetary policy.

The operational aspects and the limitations presented in this article must be considered in the analysis of the indications suggested by the Taylor rule. The latter should not be followed mechanically, but as an additional element to be taken into account. In this context it should be noted that, in addition to the limitations of a conceptual and methodological nature associated with the utilisation of the rule, there are situations in which monetary policy decisions are influenced by events not directly related to inflation or the output gap. A good example of this were the three successive cuts in the target for the Federal funds rate undertook in the second quarter of 1998, in the aftermath of the international financial crisis. The following extract from the minutes of the Federal Open Market Committee meeting held on 29 September 1998 is quite clear in this respect:

"(…) all the members endorsed a proposal calling for a slight easing in reserve markets to produce a decline of ¼ percentage point in the federal funds rate to an average of about 5¼ per cent.(…) such action was desirable to cushion the likely adverse consequences of the global financial turmoil that had weakened foreign economies and of the tighter conditions in financial markets in the United States that had resulted in part from that turmoil. (…)"

REFERENCES

Ball, L. (1997) "Efficient rules for monetary policy", National Bureau of Economic Research, *Working Paper* 5952.

Banque de France (1999) "Taux de taylor et taux de marché de la zone euro", *Bulletin de la Banque de France*, no. 61, January.

Barro, R. and Gordon, D. (1983) "Rules, discretion and reputation in a model of monetary policy", *Journal of Monetary Economics*, no. 12.

Bernanke, B. and Blinder, A. (1992), "The federal funds rate and the channels of monetary transmission", *The American Economic Review*, September.

Bernanke, B. and Mihov, I. (1996) "What does the Bundesbank target?", National Bureau of Economic Research, *Working Paper* 5764.

Buiter, W. (1981) "The superiority of contingent rules over fixed rules in models with rational expectations", *Economic Journal*, Volume 91.

Christiano, L. (1991) "Modeling the liquidity effect of a money shock", Federal Reserve of Minneapolis, *Quarterly Review*, Winter.

Christiano, L. and Gust, C. (1999) "Taylor rules in a limited participation model", *mimeo*.

Clarida, R. and Gertler, M. (1996) "How the Bundesbank conducts monetary policy", National Bureau of Economic Research, *Working Paper* 5581.

Clarida, R., Galí, J. and Gertler, M. (1997) "Monetary policy rules in practice: some international evidence", Centre for Economic Policy Research, *Discussion Paper* 1750.

Clarida, R. and Gertler, M. (1998) "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory", National Bureau of Economic Research, *Working Paper* 6442.

Clarida, R., Galí, J. and Gertler, M. (1999) "The science of monetary policy: a new keynesian perspective", Centre for Economic Policy Research, *Discussion Paper* 2139.

Deutsche Bundesbank (1999) "Taylor interest rate and Monetary Conditions Index", *Monthly Report*, April.

Fuhrer, J. and Moore, G. (1995) "Monetary policy trade-offs and the correlation between nominal interest rates and real output", *American Economic Review*, no. 85, March.

Gerlach, S. and Schnabel, G. (1999) "The Taylor rule and average interest rates in EMU-11 area: a note", Bank for International Settlements, *mimeo*.

Goodhart, C. (1995) "Why do the monetary authorities smooth interest rates?", European Monetary Policy, edited by Stefan Collignon, Association for the Monetary Union of Europe.

Judd, J. and Rudebusch, G. (1998) "Taylor's rule and the Fed: 1970-1997", Federal Reserve Bank of San Francisco, *Economic Review*, no. 3.

Kozicki, S. (1999) “How useful are Taylor rules for monetary policy?”, Federal Reserve Bank of Kansas City, *Economic review*, Volume 84, no. 2.

Kydland, F. and Prescott, E. (1977) “Rules rather than discretion: the inconsistency of optimal plans”, *Journal of Political Economy*, no. 85.

McCallum, B. (1988) “Robustness properties of a rule for monetary policy”, Carnegie-Rochester *Conference Series on Public Policy*, Volume 29.

Murchison, S. and Siklos, P. (1997) “Central bank reaction functions in OECD economies: are they informative about the conduct of monetary policy?”, *mimeo*.

Orphanides, A. (1999) “The Quest for Prosperity Without Inflation”, *Working Paper*, Federal Reserve Board.

Peersman, G. and Smets, F. (1998) “The Taylor rule: a useful monetary policy guide for the ECB?”, paper presented in the conference of the Bank of Italy on “Monetary policy of the ESCB: strategic and implementation issues”, held on 6 and 7 July 1998.

Rotemberg, J. and Woodford, M. (1998) “Interest-rate rules in an estimated sticky price model”, *mimeo*.

Sack, B. and Wieland, V. (1999) “Interest-rate smoothing and optimal monetary policy: a review of recent empirical evidence”, European Central Bank, *mimeo*.

Smets, F. (1998) “Output gap uncertainty: does it matter for the Taylor rule?”, Bank for International Settlements, *Working Papers*, no. 60, November.

Taylor, J.B. (1993) “Discretion versus policy rules in practice”, Carnegie-Rochester *Conference Series on Public Policy*, no. 39.

Taylor, J.B. (1999a) “The robustness and efficiency of monetary policy rules as guidelines for interest rate setting by the European Central Bank”, *Journal of Monetary Economics*, Volume 43, no. 3, June.

Taylor, J.B. (1999b) “A Historical Analysis of Monetary Policy Rules”, Monetary Policy Rules, edited by J.B. Taylor. National Bureau of Economic Research.

Box – TAYLOR RULES WITHIN THE SCOPE OF LIMITED PARTICIPATION MODELS

Most of the works published in this field assess monetary policy rules within the framework of IS-LM models, with rational expectations and rigid prices. As an alternative to the conventional approach, Christiano and Gust (1999) study Taylor rules performance within the scope of the so-called limited participation models [see Christiano (1999)]. The limited participation models are different from those usually utilised in two key aspects. On the one hand, it is a credit market friction that implies the non-neutrality of monetary policy. On the other hand, the transmission of inflation expectations to output is different from the one admitted in traditional models. A self-sustained rise in inflation expectations has a depressive effect on the economic activity, while it has an expansionary effect on conventional models.

Following the IS/LM tradition, in conventional models an increase in expected inflation reduces the real interest rate, stimulating the components of aggregate demand which are sensitive to the interest rate. Considering that both the expected inflation and the output gap increase, a restrictive monetary policy is appropriate, preventing inflation expectations from becoming self-sustained. Therefore, sufficiently high φ *and* β *avoid the emergence of equilibria in which inflation expectations are self-sustaining. On the contrary, in the limited participation models a higher expected inflation leads to a replacement of financial assets with physical assets, giving rise to cash shortage in the financial sector and an upward pressure on interest rates. With a small* β*, the monetary authority supplies sufficient liquidity to moderate interest rate increases, leading to the inflation rise anticipated by agents. Thus, in line with the conventional literature, a high* β *reduces the probability of inflation expectations being self-sustaining. On the other hand, it has to be taken into consideration that interest rate increases, due to expectations of a higher inflation, have a recessive effect on the economy. Therefore, with a sufficiently high* φ *coefficient, the narrowing of the output gap may offset the direct effect of inflation increases on the interest rate, the inflation expectations becoming self-sustained. Christiano and Gust thus claim that the possibility of existing equilibria with self-sustained inflation expectations is eliminated when the interest rate reacts aggressively to inflation and does not (or virtually does not) react to the output gap.*