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ข้อคิดเห็นที่ปรากฏอยู่ในเอกสารวิจัยนี้เป็นความเห็นส่วนตัวของผู้เขียนโดยเฉพาะ  
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# The Theory of Monetary Policy: A Review

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## Abstract

This paper reviews the main developments in the theory of monetary policy that have taken place since the early decades of the 20<sup>th</sup> century. The starting point of the review is the quantity theory of money as a basis for monetary policy conduct under the Gold Standard. The collapse of the Gold Standard and empirical evidence, which cast doubts on the validity of the quantity theory of money, brought about a strand of literature on monetary conduct. The focal points were the analysis on time-inconsistency problems, i.e. rule against discretion, and alternative approaches to impose constraints on monetary policy conduct to achieve the optimal results. The paper accounts for series of theoretical developments under different frameworks- from the early type of model under static framework with flexible prices to the most recent dynamic framework with sticky prices in the New Keynesian fashion. A conclusion could be drawn in favour of a monetary policy conduct under rule.

*Keywords:* Monetary Policy, Time Inconsistency, New Keynesian

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## 1. Introduction

This paper reviews the main developments in the theory of monetary policy that have taken place since the early decades of the 20<sup>th</sup> century. It shows that a feature of this modern approach is that monetary policy is seen as a process rather than a series of historically unique and almost independent interventions by the monetary authority. The starting point of the review is the quantity theory of money as a basis for monetary policy conduct under the Gold Standard. The collapse of the Gold Standard and empirical evidence, which cast doubts on the validity of the quantity theory of money, brought about a strand of literature on monetary conduct. The focal points were the analysis on time-inconsistency problems and alternative approaches to impose constraints on monetary policy conduct to achieve the optimal results. The paper accounts for theoretical developments under different frameworks- from the early type of model under static framework with flexible prices to the most recent dynamic framework with sticky prices in the New Keynesian fashion.

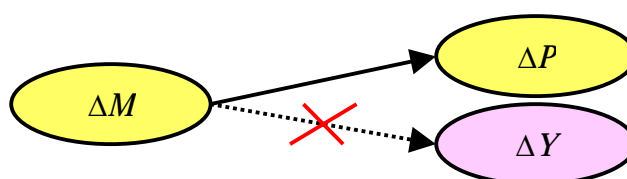
## 2. Early Theoretical Developments

For many years the analysis of monetary policy was conducted within the framework provided by the quantity theory of money, which, in its simplest and most familiar form, uses the identity

$$MV = PY \quad (1)$$

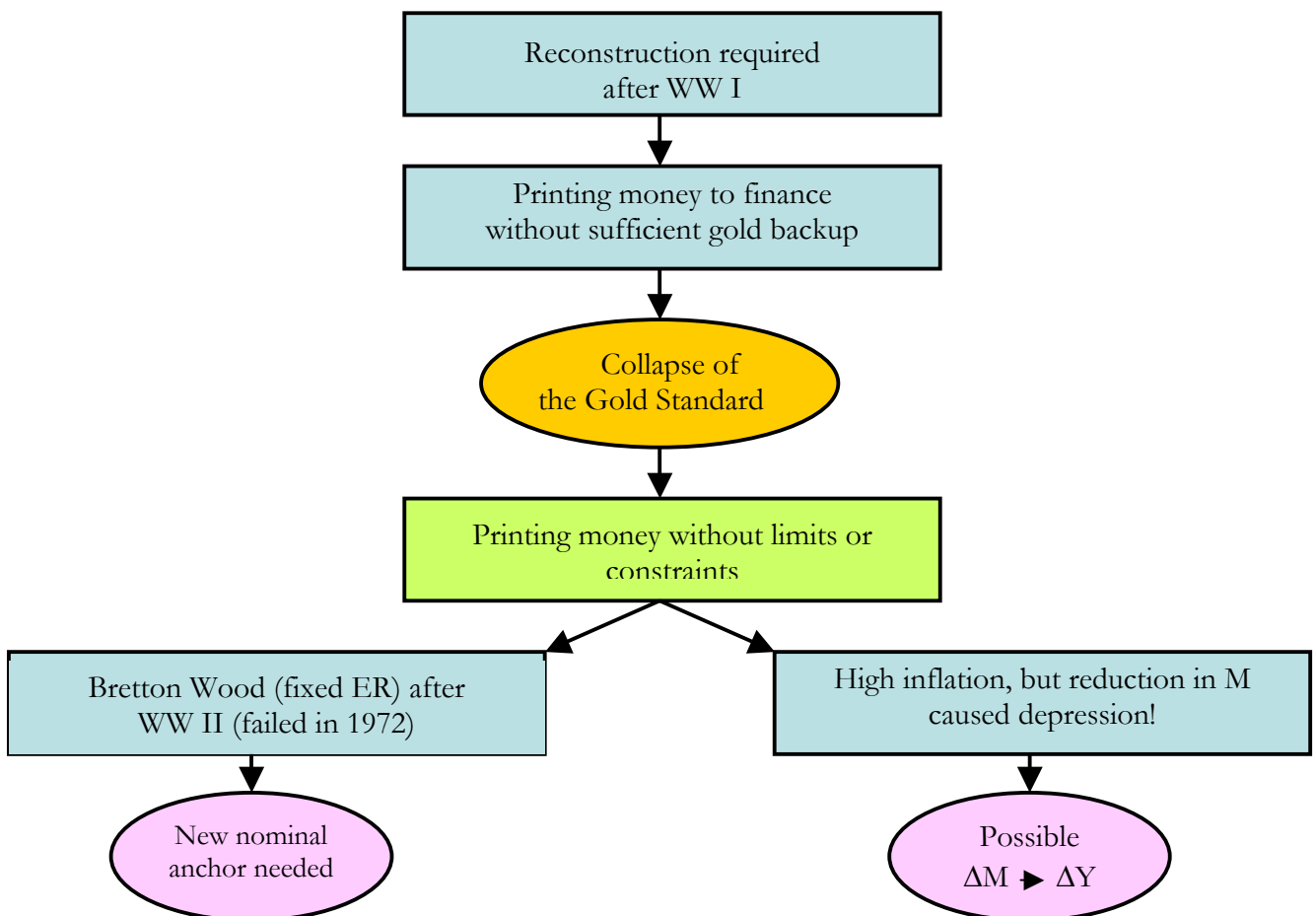
Where  $M$  is the nominal quantity of money;  $V$  is velocity;  $P$  is the price level; and  $Y$  is the level of aggregate output.

The standard view during the time was that  $V$  was virtually constant and that movements in nominal income could therefore be determined by manipulation of  $M$ . Furthermore, since the variables which influenced  $Y$  were real variables, such as technological growth and population growth, and were largely independent of movements in  $M$ , changes in  $M$  primarily influenced the price level. Steadiness in the quantity of money, it was felt, would produce steadiness in prices and inflation.



It was felt that in a world of fiat currency this steadiness in  $M$  would, at least in the longer run, be forced by adherence to the Gold Standard - an arrangement by which the Central Bank of a country agreed to pay the holder of one of its paper notes a certain amount of gold. The Central Bank's ability to create currency was limited by its holdings of gold reserves to back this commitment.

The destruction of the first World War prompted the need to print money in financing reconstruction and development. Thus, it inevitably led to money printing without sufficient backup of the gold supply, hence the collapse of the Gold Standard. Excessive money supply induced high inflation. However, attempts to deflate via reduction in money supply brought about high unemployment. The new constraint on monetary policy conduct or new nominal anchor was required in the years following the collapse of the Gold Standard and failed attempts to restore it. At the same time, interaction between changes in money supply and real output, which could not be accounted for by the quantity theory of money, provoked series of theoretical developments.



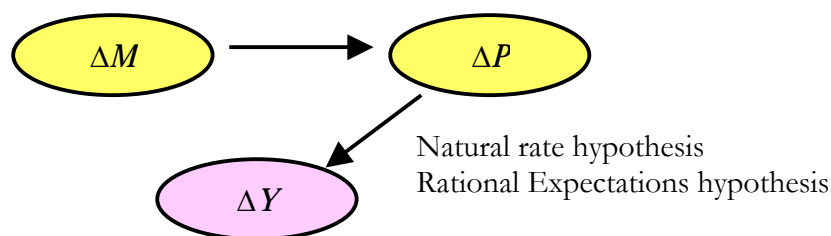
Since the publication of Keynes *General Theory* in 1936 the components of a richer framework for the analysis of monetary policy were developed. Chronologically the first of these was Friedman's (1956) 'Restatement of the Quantity Theory of Money' as a theory of the demand for money. From this perspective the proportion of one's nominal income - the inverse of velocity - that agents wish to hold in the form of money was seen as a choice variable which, in Friedman's view at least, was a stable function of a limited number of variables, notably the nominal rate of interest. The series of empirical findings which, initially, (see Laidler (1985)) suggested that the demand for money was indeed a reasonably stable function of a few variables, encouraged a greater analysis of monetary policy which had rather fallen into neglect in the Keynesian era.

The second and most influential theoretical development was Friedman's (1968) statement of the natural rate hypothesis. This provided a sounder theoretical basis for the view that changes in monetary policy not only affected prices and inflation, but also had temporary but possibly severe effects on real output and employment. According to this view, a surge in monetary growth, for example, was likely to cause a temporary and unsustainable surge in output. The mechanism at work was this: in a world of imperfect information, where people were not instantly well-informed about prices and demand conditions in all other markets, suppliers would at least partly interpret a surge in demand for their product as specific to them. They would take advantage of what they saw as a favourable relative demand and price by producing more. Since all suppliers - or at least the typical supplier - would respond in this way, a surge in money growth - provided it was unexpected - would initially cause a surge in aggregate output. In the end, as suppliers realised their mistake, output would fall back to its initial level and the surge in monetary growth would be felt solely as a surge in prices. The Quantity of Money result, or Classical dichotomy, would be re-established but only as a 'long-term' phenomenon.

The importance of the natural rate hypothesis for the purposes of monetary policy is twofold: it established a mechanism through which pure monetary policy could affect real variables such as output and employment; and in doing so it suggested a possible route through which governments might artificially stimulate the economy for their own electoral advantage.

The third theoretical advance was the Rational Expectations Hypothesis put forward initially by Muth (1960, 1961) but now most associated with Lucas (1972, 1975). This suggested that if agents were rational they would exploit their information set fully when forming expectations and that where lagged information could be considered

costless, only unpredictable movements in monetary policy ( or anything else) could have the effect Friedman suggested. The most theoretically elegant expositions of this ‘rational expectations- imperfect information’ model of the business cycle are to be found in Lucas (1972), and Barro (1976).



The idea that rational agents are forward looking and will exploit whatever information is available to them when forming expectations is used in the fourth theoretical development pertaining to monetary policy analysis. This is the idea that governments can be analysed in much the same way as firms or consumers, i.e. as having an objective which they attempt to maximise given the tools at their disposal. In most applications this idea has been expressed by assuming that governments or central banks have a loss function which it attempts to minimise. The arguments of this loss function are usually taken to be some measure of inflation and of output. The government or central bank is then assumed to minimise this loss function subject to the natural rate hypothesis and rational expectations hypothesis.

In the remainder of this chapter I shall review other important and more recent developments in the literature on monetary policy within a framework, which incorporates these central ideas in as simple a way as possible. The economy is assumed to obey the natural rate hypothesis in that aggregate output is modelled as equal to its natural rate plus some positive function of the difference between actual and expected inflation. It is assumed that the natural rate has a mean value of  $y^*$  but, in any period, is equal to  $y^* + \varepsilon$  where  $\varepsilon$  is a supply disturbance with a constant variance and is assumed to be independently distributed around its mean of zero. Formally, we assume

$$y = y^* + b(\pi - \pi^e) + \varepsilon \quad (2)$$

where  $y$  is aggregate output;  $\pi$  is actual inflation;  $\pi^e$  is expected inflation; and  $b$  is a positive constant.

It is assumed that expectations in the private sectors are formed – and nominal wage contracts agreed - prior to observation of the current supply shock. Furthermore, it

is assumed that expectations so formed are rational (RE) in the sense that they fully exploit any relevant information available at the time they are formed.

The monetary authority, whether it is the government or the central bank, has the objective of minimising a loss function. It is conventional to assume that the arguments of this loss function are the departures of inflation and output from their respected desired values. In the case of inflation the desired or target level is assumed to be zero. In the case of output it is assumed, initially at least, that because of tax and other distortions, the natural level of output is considered too small, and so the government's target level of output is  $ky^*$  where  $k > 1$ , and the desired level of  $y$  is above  $y^*$ . This feature of the core model is crucial to a lot of what follows.

A standard loss function is the following

$$L = a\pi^2 + (y - ky^*)^2 \quad (3)$$

where  $a$  is the weight attached to inflation stability relative to that of output.

The monetary authority is assumed to set monetary policy after it has observed the current supply shock,  $\varepsilon$ . It therefore has superior information to the private sector, and can, in effect, react to any supply disturbance before the private sector can revise wage contracts. Its actions therefore will affect prices, and so inflation can diverge from the level that the private sector was expecting. In some models a shock to velocity is assumed to occur after policy has been set but prior to the determination of actual inflation and output. But, as Walsh (1998) claims, this assumption makes little difference to the analysis and we shall assume here that the monetary authority, through its control of the quantity of money, has total control of inflation.

### **3. Static framework with flexible prices**

#### **3.1 Inflationary bias in discretionary monetary policy**

The best-known issue in monetary policy which equations (2) - (3) allow us to discuss is the problem of the inflationary bias that occurs under conventional discretionary monetary policy, i.e. a policy framework where the authority sets policy as it sees fit at any time, unconstrained by any constitutional or other limits. This analysis was developed by Barro and Gordon (1983a) who built on ideas presented in a highly influential paper by Kydland and Prescott (1977) whose general idea was:

‘... optimal control theory is an appropriate planning device for situations in which current outcomes and the movement of the system’s state depend only upon current and past policy decisions and upon the current state. But we argue, this is unlikely to be the case for dynamic economic systems. Current decisions of economic agents depend in part upon their expectations of future policy actions. Only if these expectations were invariant to the future policy plan selected would optimal control theory be appropriate. Changes in the social objective function reflected in, say, a change of administration do have an immediate effect upon agents’ expectations of future policies and affect their current decisions.’ (Kydland and Prescott (1977), pp. 474)

To see this important issue using the framework developed above, we assume the monetary authority aims to minimise its loss function by appropriate selection of  $\pi$ . Straightforward differentiation of equation (3) given (2) yields an optimising condition and rational expectations (RE) it follows that

$$\pi^e = \frac{b(k-1)y^*}{a} \quad (4)$$

which, in turn, implies that the inflation rate under this regime will be

$$\pi = (k-1)\frac{b}{a}y^* - \frac{b\varepsilon}{a+b^2} \quad (5)$$

Output will, after substituting equations (4) and (5) into (2), be given by

$$y = y^* + \frac{a\varepsilon}{a+b^2} \quad (6)$$

It is clear from this simple analysis that unless  $a \rightarrow \infty$  the average inflation rate will be positive (given that  $k > 1$ ) whilst the average level of output will be  $y^*$ . This result is clearly suboptimal since the same average level of output,  $y^*$ , is achievable with a lower inflation rate, in fact with an inflation rate of zero. The reason for this is that since  $k > 1$  the monetary authority - unless it gives total dominance to the aim of keeping inflation zero - has an incentive in any period to set policy that generates a positive inflation rate on average.

This apparent suboptimality of conventional discretionary policy led to the consideration of what rule should govern the conduct of monetary policy.

In what follows we assume a rule of the form<sup>1</sup>

$$\pi = \alpha + \beta\varepsilon \quad (7)$$

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<sup>1</sup> See King (1997)

If the authorities follow such a rule then clearly the inflation rate, on average, will be  $\alpha$ . And if the rule is credible then it follows that private sector agents' expectations of inflation at the time wage contracts are agreed upon will also be  $\alpha$ . Of course, this implies that private sector agents are confident that the authorities are not intending to set monetary policy to achieve a level of output above (or below) the natural rate since this would inevitably mean an inflation rate different from the one they were expecting. Hence it implies that in equation (3) the authorities are setting  $k = 1$  and attempting to minimise the loss function

$$L = a(\alpha + \beta\varepsilon)^2 + (b\beta\varepsilon + \varepsilon)^2$$

by appropriate selection of  $\alpha$  and  $\beta$ .

Minimising this loss function with respect to  $\alpha$  gives

$$\alpha = -\beta\varepsilon$$

Since the rule itself is derived prior to the realisation of  $\varepsilon$  it follows that the authorities must set  $\alpha = 0$ . Given this value of  $\alpha$ , minimisation of the loss function with respect to  $\beta$  gives

$$\beta = \frac{-b}{a + b^2}$$

So, under this rule, inflation and output will be

$$\pi = \frac{-b}{a + b^2} \varepsilon \quad (8)$$

$$y = y^* + \frac{a}{a + b^2} \varepsilon \quad (9)$$

Since inflation averages zero whilst output on average equals its natural level, this state-contingent monetary rule is superior to pure discretion. In what follows we take these values of  $\pi$  and  $y$  to be the optimal values of inflation and output.

However, as Barro and Gordon (1983a) argue, such a state contingent rule may not be feasible: the temptation to renege on the commitment is ever-present since, with inflationary expectations equal to zero, the marginal costs of inflation at a zero inflation rate are less than the marginal benefits. Given expectations of inflation at zero, the monetary authority's optimum rule (of the form shown in equation (7)) would be one which minimises

$$L = a\pi^2 + (y^* + b(\pi - 0) - ky^* + \varepsilon)^2 \quad (10)$$

by appropriate selection of  $\alpha$  and  $\beta$ . This minimisation produces the inflation rate

$$\pi = \frac{b(k-1)}{a+b^2} y^* - \frac{b}{a+b^2} \varepsilon \quad (11)$$

which is of course positive on average if  $k > 1$ . Under RE the private sector will foresee this result, there will be a loss of credibility and the eventual outcome will be equivalent to that achieved under discretion.

### 3.2 Methods of alleviating inflationary bias

The recognition that a world consistent with the natural rate hypothesis, rational expectations, and a monetary authority with a plausibly specified loss function was likely to be a world of persistent inflation led to a number of suggestions about how to alleviate inflationary bias.

One particularly influential idea associated with Rogoff (1985) is that inflationary bias can be alleviated through the appointment of a conservative central bank. By ‘conservative’ Rogoff means a central bank which attaches an especially heavy weight to inflation stabilisation in its loss function. Within the framework developed above, let the conservative central bank’s loss function be represented by

$$L = (a+d)\pi^2 + (y - ky^*)^2$$

where  $d$  is a positive constant implying greater weight on inflation. Using the same optimisation technique as before we can derive that such a central bank with full discretion will generate the following inflation rate and level of output.

$$\pi = \frac{b(k-1)}{a+d} y^* - \frac{b}{a+d+b^2} \varepsilon$$

$$y = y^* + \frac{a+d}{a+d+b^2} \varepsilon$$

The conservative central bank produces lower inflationary bias, but also a lower response in inflation and a higher response in output to supply shocks. Hence the loss in inflationary bias may to some extent be offset by an increase in ‘stabilisation bias’.

A related idea is that of an inflation contract which emerges from the principal-agent approach developed in Walsh (1995). In this, the government appoints a central bank (with the same preferences as the government) and influences its incentives by assigning a state-contingent wage contract. Walsh claims that, if the contract is designed correctly, inflationary bias can be eliminated.

To see how, let the central bank’s utility be given by

$$U = T - L$$

where  $T$  is the central bank's pay and  $L$  its loss function.

Maximizing this utility function with respect to the inflation rate gives

$$\begin{aligned} \frac{\partial U}{\partial \pi} &= \frac{\partial T}{\partial \pi} - \frac{\partial L}{\partial \pi} \\ &= \frac{\partial T}{2\partial \pi} - [a\pi + b(1-k)y^* + b^2(\pi - \pi^e) + b\varepsilon] = 0 \end{aligned}$$

From this and under rational expectations  $E_t \frac{\partial T}{\partial \pi} = \frac{\partial T}{\partial \pi}$

and after some algebraic manipulation,

$$\pi = \frac{\frac{\partial T}{\partial \pi} - E_t \frac{\partial T}{\partial \pi}}{2(a+b^2)} + \frac{E_t \frac{\partial T}{\partial \pi}}{2a} - \frac{b(1-k)y^*}{a+b^2} - \frac{b^3(1-k)y^*}{a(a+b^2)} - \frac{b}{a+b^2} \varepsilon \quad (10)$$

The last expression in this equation is the optimal rule for inflation given in equation (8). It follows that a pay-contract which implies that all the other terms on the right hand side of this expression sum to zero will generate the optimal inflation rate. And it is relatively straightforward, after recognising that under rational expectations

$$E_t \frac{\partial T}{\partial \pi} = \frac{\partial T}{\partial \pi},$$

to derive this pay contract as implying that

$$E_t \frac{\partial T}{\partial \pi} = 2b(1-k)y^*$$

and so the optimal pay contract has the form

$$T = T_0 + 2b(1-k)y^* \pi \quad (11)$$

Although this regime appears promising as a solution to the inflationary bias problem, the effectiveness and the possibility of implementation are dubious and the performance-related remuneration contract may not affect the incentive of the central banker as much as postulated since the opportunity cost of being a central banker is already very high in terms of pay elsewhere. Furthermore, according to Svensson (1997), a practical complication arises under this regime. The pay contract must presumably be expressed in monetary terms whilst the loss function is expressed in utility units. There arises the need to translate monetary costs into utility, hence incorporating the central banker's marginal utility of money.

Svensson (1997) has proposed a third solution to inflationary bias - inflation targeting - and regards it as equivalent to that of Walsh's inflation contract, i.e. it is a second-best solution when commitment to a rule is not feasible, which eradicates inflationary bias without unnecessarily destabilizing output. He considers Rogoff's conservative central banker as the third-best since it creates excessive output variability.

This approach adopts a principal-agent framework in which society (the principal) delegates monetary policy to an agent (the central bank). Society assigns a loss function, and the central bank is given independence to minimise this loss function, and is accountable for minimising it. In other words, the central bank is given operational but not goal independence. An explicit inflation target,  $\pi^b$ , is assigned to the central bank, which may differ from that of the socially desired rate (zero in this case). An output target,  $y^b$ , is implicit and, under inflation targeting, is not usually assigned to be the natural level on the grounds that this may be a politically unpopular level or that there are difficulties in verifying what the natural rate actually is.

To compare Svensson's model with those outlined earlier I shall present a modified one-period model without persistence in output and employment rather than the dynamic model Svensson himself presents. As explained in his article, a more realistic framework, where there is persistence in employment and output together with lagged effects of monetary policy, predicts that the degree of inflationary bias becomes state-contingent and discretionary policy leads to inflationary bias which is even more severe than in the static case. This latter result is essentially because, with persistence, an increase in current employment also increases future employment.

Let the assigned loss and aggregate supply functions be, respectively

$$L^b = a(\pi - \pi^b)^2 + (y - y^b)^2$$

$$y = y^* + b(\pi - \pi^e) + \varepsilon$$

Minimising this assigned loss function with respect to inflation we can derive

$$\pi = \frac{-b}{a} y^* + \frac{b}{a} y^b + \pi^b - \frac{b}{a+b^2} \varepsilon \quad (12)$$

Again, the last term on the right-hand side of equation (12) is the optimal level of inflation given in equation (8). Hence the optimal inflation target should be set so that the other terms on the right-hand side of equation (12) sum to zero, that is,

$$\pi^b = \frac{b}{a} (y^* - y^b)$$

In this case, actual inflation and output will be at their respective optimal levels

$$\pi = \frac{-b}{a+b^2} \varepsilon$$

$$y = y^* + \frac{a}{a+b^2} \varepsilon$$

Svensson goes on to show that if  $y^b = ky^*$  his optimal inflation targeting regime is equivalent to an optimal inflation contract. Under this condition the central bank's loss function becomes

$$\begin{aligned} L^b &= a(\pi - \pi^b)^2 + (y - y^b)^2 \\ &= L + a(\pi^b)^2 - 2b(1-k)y^* \pi \end{aligned}$$

which is identical to Walsh's expression for  $-U$  if Walsh's  $T_0 = -a(\pi^b)^2$ .

The following table compared and contrasted aforementioned theoretical developments under static framework with flexible prices.

	Rule	Discretion	Conservative CB	Inflation contract	Inflation targeting
Loss function	With $y^*$ as target to gain credibility	With $ky^*$ as target	With $ky^*$ as target and higher weight on inflation	With $ky^*$ as target	With new tgt: $(\pi^b, y^b)$
AS	standard	standard	standard	standard	standard
Policy Maker	government	government	CB	CB with pay from gov	CB with tgt assigned
Specific feature	Stick to pre-announced rule	Optimise period by period	Optimise period by period	Max utility (=pay - loss fn)	$\pi^b = b(y^* - y^b)/a$
Average Inflation	0	$\pi = b(k-1)y^*/a$	$\pi = b(k-1)y^*/(a+\delta)$	0 If contract set properly	can be 0 if the condition above satisfied
Drawbacks	Temptation	Inflationary bias	Stabilisation bias	Difficult to implement	

#### 4. Dynamic framework with flexible prices: Reputation models of monetary policy

The general model used above has clearly provided an intellectually stimulating framework for analysing monetary policy and in particular the problem of inflationary bias. Some economists, however, have suggested that the problem of inflationary bias may be exaggerated. For example, Goodhart and Huang (1995) argue that when there are lags involved in the conduct of monetary policy, some wage contracts may not be binding by the time the manipulation of monetary instrument takes effects on the actual economy. Only those wage contracts which are still binding will be affected.

A more general point is that in practice the monetary authority is unlikely to be as myopic as the static models presented above assume. With a time span in office greater than one-period, it will have continuous interaction with private agents, and the temptation to cheat to have a one-period gain will be tempered by any resultant inflationary bias in subsequent periods. Two important strands have emerged in the literature which considers monetary policy in a dynamic setting: models which emphasise the reputation of the policy maker; and models which employ a timeless perspective (See Woodford (1999) for details).

Among the earlier reputational models, Barro and Gordon (1983b) developed a dynamic model based on their earlier static model in which reputational forces can substitute for formal rules: the loss of reputation motivates policy makers to abide by the rule. In this model, the loss function is specified as quadratic in inflation and linear in output for mathematical simplicity, and total costs over the whole horizon are considered. Let the loss function be

$$z_t = \frac{a}{2} \pi_t^2 - b_t (\pi_t - \pi_t^e)$$

where  $b_t > 0$  and is stochastic with an expected value of  $b$ . The first term represents the cost of inflation, the latter term is the benefit from an inflationary shock. At date  $t$ , the present value of costs is:

$$Z_t = E_t \left[ z_t + \frac{1}{1+r_t} z_{t+1} + \frac{1}{(1+r_t)(1+r_{t+1})} z_{t+2} + \dots \right]$$

where  $r_t$  is discount rate applied between periods  $t$  and  $t+1$  and where it is assumed that the discount factor,  $q_t = 1/(1+r_t)$ , and  $b_t$  are unknown at date  $t$ .

Within this framework the optimal rule would yield  $\pi_t^* = \pi_t^e = 0$ , and the costs in period would be  $z_t^* = 0$ . However, if the authority takes zero inflationary expectations as given then it will minimize  $z_t$ , by setting inflation equal to  $\pi_t^c = b/a$  and the 'costs' of this cheating will be  $(-b^2/2a)$  or, rather, the temptation to cheat is  $E_t(z_t^* + \frac{b^2}{2a}) = \frac{b^2}{2a}$ .

Finally, a non-cooperative game between the policy maker and rational private agents - in which the government takes  $\pi^e$  as given and minimises  $Z_t$  with respect to  $\pi_t$  - will result in the discretionary outcome  $\pi_t^d = b/a = \pi^e$ . The cost each period will then be  $z_t^d = b^2/2a$  which is greater than zero.

We assume that, acknowledging the temptation to cheat by the policymaker, private agents form their expectations according to the following scheme:

- Agents expect the rule to be followed and hence  $\pi_t^e = 0$  if  $\pi_{t-1} = \pi_{t-1}^e$
- Agents expect discretion and hence  $\pi_t^e = \pi_t^d$  if  $\pi_{t-1} \neq \pi_{t-1}^e$

So if the authority cheats during period  $t$ ,  $\pi_{t+1}^e = b/a$  and the authority minimises  $z_{t+1}$  by setting  $\pi_{t+1} = b/a$ . In period  $t+2$ , because expectations were confirmed in the previous period  $\pi_{t+2}^e = 0$ . The punishment from violating the optimal rule during period  $t$  is the discretionary solution during period  $t+1$  but credibility is restored in period  $t+2$ . There is only one period's worth of punishment for each 'crime'.

The temptation for the authority to cheat during period  $t$ , assuming that  $\pi_t^e = 0$ , is the gain in period  $t$ ,  $b^2/2a$ , minus the discounted value of the costs in period  $t+1$ ,  $b^2/(2a(1+r_t))$ , which is equal to  $b^2 r_t / (2a(1+r_t))$ . Since this will always be positive it is clear that in this model too it is irrational to expect an inflation rate of zero and hence an equilibrium inflation rate of zero is inconsistent with rationality. Equilibrium will exist only if the cost to the authority of cheating,  $E_t(\frac{z_{t+1}^c - z_{t+1}^*}{1+r_t})$ , is at least as great as the temptation,  $E_t(z_t^* - z_t^d)$ , and this will only occur at a non-zero inflation rate. The problem of inflationary bias exists then in this reputational model too.

The main criticism made of this model (see, for example, Canzoneri (1985)) is its assumption that private agents can readily determine whether cheating has occurred. In reality, inflation can be caused by factors other than the actions of the monetary authority.

Another type of reputational model has been developed by Backus and Driffill (1985) and Ball (1995). This assumes a world in which there is imperfect information

and, as a result, there are uncertainties about whether the monetary authority is ‘wet’ (placing greater concern on output) or ‘dry’ (regarding inflation as particularly important). In the Backus and Driffill model, the ‘wet’ central bank may mimic the ‘dry’, otherwise its identity is revealed and expectations of inflation are as high as they would be under discretion. The model was developed in a finitely repeated game fashion – where in the last period the type will be revealed. Prior to the last period, the wet central bank may well choose zero inflation with positive possibility in order to gain credibility and randomise its strategy. For a dry central bank it is beneficial to set a positive inflation target because in the first period, while its credibility is still in doubt, its pursuit of zero inflation might generate an undesirable recession. Therefore, it is possible to have a pooling equilibrium where both types announce a positive inflation rate. However, if the public places high probability on the central bank being of the dry type, it may be more worthwhile for the dry type to have inflation very close to zero and the resulting equilibrium is a separating one.

## **5. Dynamic framework with sticky prices: New-Keynesian monetary policy**

The most recent developments in the theory of monetary policy have taken place within a New-Keynesian framework which contains some of the elements described above but whose distinctive characteristic is that there is an element of stickiness in prices. Within such a setting it is possible to show that ‘in the presence of a trade-off between output and inflation, society will generally gain from having a central bank that can (credibly) commit to a state-contingent plan, even in the absence of a classic inflationary bias, i.e. even if the central bank has no desire to push output above its natural level. That result overturns an implication of the classic Barro-Gordon analysis, where the gains from commitment arise only if the central bank sets a target for output that does not correspond to its natural level.’ (Gali (2001) pp.3). This result occurs because, where prices are sticky, current price setting depends upon expectations of the future: a credible commitment to fight inflation in the future can improve the current output/inflation trade-off faced by a central bank. Specifically, it can reduce the effective cost in terms of current output loss that is required to lower current inflation.

I derive this important result using the framework provided by Clarida et al. (1999). First I represent the sticky price New-Keynesian model of inflation in standard form<sup>2</sup>

$$\pi_t = \lambda y_t^g + \beta E_t \pi_{t+1} + u_t \quad (13)$$

where  $y_t^g$  is ‘the output gap’ – equivalent to  $y - y^*$  in the static model;  $u_t$  is an error term, often assumed to be a first-order autoregressive error, the first-order parameter denoted by  $\rho$ ;  $\lambda$  and  $\beta$  are positive parameters with  $\beta$ , the discount factor, less than one. The derivation of (13) was based on price-setting model by Calvo (1983). The gist of the model was profit maximisation by setting prices as mark-ups over marginal costs subject to limited probability of re-setting prices in each period. Once able to reset prices, firms need to form expectations on what will happen to prices in the following periods, hence the term:  $E_t \pi_{t+1}$ . Marginal costs are assumed to be directly related to output gap owing to a linear form of production function with a single input, which is labour. Therefore, marginal costs, i.e. wages are closely related to labour supply, which in turns determines the level of output, hence the term  $y_t^g$ .

Aggregate demand is represented by the so-called dynamic IS curve

$$y_t^g = -\frac{1}{\sigma} [r_t - E_t \pi_{t+1} - rr] + E_t y_{t+1}^g + g_t$$

where  $r$  is the nominal interest rate;  $rr$  represents the rate of time preference;  $g$  is government expenditure; and  $\sigma$  is a positive parameter. The intuition behind IS relation, was household optimisation by maximising discounted stream of utility (consumption and labour supply) subjected to budget constraints (consumption expenditure and wages). Interest rate (policy instrument) is incorporated into the calculation of the present value of spending and wages.

The government is assumed to act to minimise the loss function by maximising

$$-\frac{1}{2} E_t \left[ \sum_{i=0}^{\infty} \beta^i [a y_{t+i}^{g2} + \pi_{t+i}^2] \right]$$

where  $a$  now indicates the weight attached to output in the loss function. Note that in this loss function there is no presumption that the central bank is aiming to achieve a higher level of output than the natural level.

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<sup>2</sup> Strictly, this equation is in deviation-from-equilibrium form. Here, it is simplest to assume that the economy’s equilibrium inflation rate is zero.

The following table briefly compared earlier framework under flexible prices assumption with the current one under sticky prices.

<b>Similarities</b> between <i>flexible price</i> and <i>sticky price</i> frameworks		
1. Private sector forms expectations rationally		
2. Inflation target = 0		
3. <b>Rule</b> authority's decision affects private expectations of future inflation <b>Discretion</b> : authority conducts money policy period by period, taking private expectations as given		
<b>Differences</b> between <i>flexible price</i> and <i>sticky price</i> frameworks		
	<b>Flexible price</b>	<b>Sticky price</b>
<b>AS</b>	$y = y^* + b(\pi - \pi^e) + \varepsilon$	$\pi_t = \beta E_t \pi_{t+1} + \lambda y_t + u_t$
<b>Loss fn</b>	$L = (y - ky^*)^2 + a\pi^2$	$-\frac{1}{2} E_t \left[ \sum_{i=0}^{\infty} \beta^i [ay_{t+i}^{g2} + \pi_{t+i}^2] \right]$
<b>AD</b>	Not mentioned	$y_t^g = -\frac{1}{\sigma} [r_t - E_t \pi_{t+1} - rr] + E_t y_{t+1}^g + g_t$
<b>Policy conduct</b>	authority can manipulate $\pi$ <b>directly</b>	authority uses interest rate as an <b>instrument</b> to manipulate $\pi$ and $y$ through AD

In each period, optimal conditions of output and inflation are found from minimisation of the loss function subject to the aggregate supply. From the aggregate demand function, interest rate, consistent with optimal conditions of output and inflation, is chosen. Once interest rate is changed, output is affected through aggregate demand function, then via aggregate supply, inflation is altered.

$$\Delta r \rightarrow \Delta y \text{ in AD} \rightarrow \Delta \pi \text{ in AS}$$

Under discretion the central bank can re-optimize each period and can be seen as choosing  $y_t^g$  and  $\pi_t$  so as to maximise

$$-\frac{1}{2} [ay_t^{g2} + \pi_t^2] - \frac{1}{2} E_t \left[ \sum_{i=1}^{\infty} \beta^i [ay_{t+i}^{g2} + \pi_{t+i}^2] \right]$$

subject to equation (13), given  $E_t[\sum_{i=1}^{\infty} \beta^i [ay_{t+i}^{g2} + \pi_{t+i}^2]]$  and  $\beta E_t \pi_{t+1} + u_t$ . It is straightforward to derive the first-order condition as

$$y_t^g = -\frac{\lambda}{a} \pi_t$$

Combining this with equation (13) allows us to write

$$y_t^g = -\lambda q u_t$$

$$\pi_t = a q u_t$$

where

$$q = \frac{1}{\lambda^2 + a(1 - \beta\rho)}$$

The optimal feedback policy for the interest rate is then derived simply by inserting the desired value of  $y_t^g$  in the dynamic IS curve to get

$$r_t = \gamma_{\pi} E_t \pi_{t+1} + \sigma g_t + rr \quad (14)$$

where

$$\gamma_{\pi} = 1 + \frac{(1 - \rho)\lambda\sigma}{\rho a}$$

A well known result of modern monetary policy analysis, in particular of so-called Taylor Rules (Taylor (1993)), which is explicit in equation (14), is that optimal monetary policy requires that if there is a rise in expected inflation, nominal interest rates should rise sufficiently to increase real interest rates, i.e.  $\gamma_{\pi} > 1$ .

Consider now a central bank which credibly commits to a rule of the form<sup>3</sup>

$$y_t^{gc} = -\omega u_t \quad (15)$$

for all  $t$ , where  $\omega > 0$  is the coefficient of the feedback rule, and where  $y_t^{gc}$  denotes the value of  $y_t^g$  conditional on commitment to the policy, and where if  $\omega = \lambda q$  we have the optimal rule under discretion. Combining this equation with the inflation equation allows us to write

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<sup>3</sup> Of course, the central bank need not commit to this particular form of a rule, there is a more general, globally optimal rule. The point here is to show that discretion can be improved upon by some form of a rule.

$$\pi_t^c = \frac{1 - \lambda\omega}{1 - \beta\rho} u_t = \frac{\lambda}{1 - \beta\rho} y_t^{sc} + \frac{1}{1 - \beta\rho} u_t$$

The central bank chooses the optimal value of the feedback parameter,  $\omega$ . For our purposes the important point is that the ability to commit to a feedback policy provides the central bank with an improved short-run output/inflation trade-off. Under discretion a reduction in  $y_t^s$  by one percent produces a fall in  $\pi_t$  of only  $\lambda$ ; this is clearly less than  $\lambda/(1-\beta\rho)$  which is the equivalent amount under commitment to rule. The extra effect under commitment is because of the impact of the policy rule on expectations: the choice of  $\omega$  affects not only the current output gap but also expectations about the course of the future output gap since  $E_t^c y_{t+i}^{sc} = -\omega u_t$ . A central bank that commits to a high value of  $\omega$  can credibly signal that it will sustain over time an aggressive response to a persistent supply shock. Since inflation depends upon the future course of excess demand, commitment to the tough policy rule leads to a magnified drop in inflation per unit of output loss. Clarida et al. go on to show that the optimal rule of the form shown in equation (15) is

$$y_t^{sc} = -\frac{\lambda}{a^c} \pi_t^c$$

where

$$a^c = a(1 - \beta\rho) < a$$

Because of this last condition, commitment to a rule implies that it is optimal for a central bank to engineer a greater contraction in output in response to inflationary pressures and it is possible to show that commitment to the policy rule raises welfare. So, Clarida et al. summarise the position as follows

‘..If price-setting depends on expectations of future economic conditions, then a central bank that can credibly commit to a rule faces an improved short-run trade-off between inflation and output. This gain from commitment arises even if the central bank does not prefer to have output above potential. ... The solution under commitment in this case perfectly resembles the solution that would obtain for a central bank with discretion that assigned to inflation a higher cost than the true social cost.’ (p. 1680)

For monetary policy theory in general and this paper in particular, the central point of this most recent analysis is this. It will be advantageous, even where there is no

temptation to achieve a level of output above its natural level, to commit to some form of rule.

## **6. Conclusions**

This paper has established the now common view that the conduct of monetary policy should be by some form of rule - a commitment to change an instrument of monetary policy in response to some indicator of the state of the economy, where both the nature and size of the response are fixed in advance. It has proven that, even in an absence of inflationary bias, the impact of commitment to rule on expectations could bring about improvement in welfare.

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