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# Dynamic Inconsistency of Monetary Policy: Rules, Reputation, and Flexibility

Adam Geršl*

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**Abstract**

The paper reviews the literature on dynamic inconsistency of monetary policy, and discusses, also in a formalized way, the different measures how to limit the incentive of policymakers to use inflation to maximize their objective function, leading to an inefficient outcome of higher than necessary inflation without any impact on real economy. The nature of the dynamic inconsistency problem is presented in a game theory framework and the paper then discusses the rules versus discretion dilemma, reputation building, flexibility versus credibility trade-off, independence of central banks, and optimal contracts for central bankers, i.e. issues in the monetary constitution that attracted a lot of attention over the last two decades. The constitutional economics perspective is applied when discussing the role of rules in monetary policy and checks and balances as a means to solve the flexibility versus credibility problem.

**Keywords:** Dynamic inconsistency; reputation building; monetary policy

**JEL Classification**: D78; E58

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## Introduction

One of the most famous approaches to study of central banks' behavior is the dynamic inconsistency research program. Since 1977, a year in which the seminal paper by Kydland and Prescott (1977) was published, a considerable work based on dynamic inconsistency of discretionary monetary policy has emerged.

In this paper, I provide an overview and discussion of the most important contributions within this research program. The aim is to identify issues that relate to the institutional design of central banking. Thus, the paper includes discussion of the rules versus discretion dilemma, reputation building, flexibility versus credibility trade-off, independence of central banks and optimal contracts for central bankers, i.e. issues that attracted a lot of attention over the last two decades. I show that individual contributions in the above mentioned areas help to understand very well the challenges for the design of optimal institutional arrangement for monetary policy, but are necessarily only partial in providing satisfactory answers. However, when combined together, they offer a consistent picture as to what features should monetary institutions have.

The paper is organized as follows: in section 2 the concept of dynamic inconsistency is explained, while in section 3 it is applied to monetary policy. Section 4 discusses the results of the dynamic inconsistency model of monetary policy. Following sections review the solutions to the inflation bias, a result of discretionary monetary policy as seen from the dynamic inconsistency perspective. Section 5 discusses the role of rules in monetary policy from the perspective of constitutional economics, a research program has been attracting a lot of attention since 1970s. Section 6 the issue of reputation building by a central bank. Section 7 extends the model by introducing stochastic features, i.e. shocks to the economy, and discusses the possibilities of state-contingent rules. Section 8 reviews the proposal of Rogoff (1985) to delegate monetary policy to an independent and conservative central banker, but adds the dimension of checks and balances in the political system and their relation to monetary policy. Section 9 shortly discusses the proposal to link central banker's remuneration to inflation performance via optimal contracts, while section 10 concludes.

## 2. Game Theory Framework of Dynamic Inconsistency: A Simple Example

The general idea of the dynamic (or time-) inconsistency is simple and, as Bofinger (2001, p. 175) points out, at a first sight it does not appear to be a particularly significant phenomenon: a strategy is time-inconsistent if it is optimal at a point of time $t_0$ but no longer optimal at a point of time $t_1$. It is clear that if the underlying circumstances have changed

(because, for example, new information has arrived), the strategy optimal at $t_0$ will not necessarily be optimal at $t_1$. However, the dynamic inconsistency becomes significant in the game theory framework if the changing circumstances are themselves reactions by other decision makers on the strategies taken (or planned to be taken) by the initial decision maker.

Blinder (1987, p. 407) gives a simple example of dynamic inconsistency in the game theory framework that is taken from university life. Imagine a professor who wishes to encourage his students to study as hard as possible but at the same time hates marking examination papers. How does his optimal strategy look like? The best thing he can do is to announce at time $t_0$ (i.e. at the beginning of his course) that there will be an examination at the end of the academic term. This provides the students with necessary incentive to learn hard. However, short before examination (at time $t_1$) the professor cancels it and gives the certificate to all students because his two aims have been reached: students have learned (hopefully hard) and acquired the knowledge, and he does not have to spend his time with marking the examination papers.

Notice that the optimal strategy for the professor is not optimal over time, i.e. it is time-inconsistent. At time $t_0$ it is optimal for the professor to set and to announce the examination, but at time $t_1$, after the students have learned the course stuff, to cancel the examination. The inconsistency would not cause any problems if the students were unaware of the professor's "objective function", especially his hate of marking examination papers, and could in no way find it out. In such a case, the professor could repeatedly announce and cancel the examination in each academic term and the students would be "fooled" again and again. Thus, the fact that he already twice cancelled the examination just before the announced date would not automatically mean that he would do it for the third time (because students indeed do not know what he is optimizing).

However, students are obviously not fools and if we regard them as a rational and optimizing partner in the just described game, assuming that they know the professor's objective function and hate learning, we can discuss their optimal strategy. The students' optimal strategy is evidently not to learn at all because they know that they will get the certificate from the professor without having to take an examination. Now, there is a kind of trap. The professor would like the students to acquire necessary knowledge but if he is not believed to give examination at the end of the course, i.e. if he has no credibility, the students will not learn. In such a situation, the professor cannot do better by carrying out the examination because he would only reduce his utility.

Let us discuss shortly a dynamic view of this simple example, i.e. a repeated game. It is possible that in the first round of the game the professor succeeds with his time-inconsistent strategy. However, if he tries to practice his strategy in next rounds, he will loose his credibility and rational students will tend to study less and less. The professor, recognizing the problem, can try to persuade the students that his intention to carry out the examination is "real" and irreversible, hoping to motivate students to study, but even if he himself actually intends to give examination, shortly before the examination date he has still the incentive and power - given his objectives and discretion - to cancel it again. Because students *know* this, they will not believe any of the "irreversible" announcements and will not study hard.

Where is the source of the problem? The objective function of the professor that is known to the students and the discretion he has caused the problem. What the professor is trying is to "get free lunch", using the famous Milton Friedman's phrase. If the objective function includes two variables bounded by a trade-off restriction, one cannot then simultaneously reach the maximum of both of them, hoping to break the trade-off relationship only by changing the strategy in the "right" time. Because there are rational agents beyond the trade-off relationship, they do not want to be fooled and they do not therefore allow the trade-off to be broken. Second source of the problem is the discretionary power the professor has. Even if

he really intended to carry out the examination, he faces rational agents knowing his objective function and his free power to cancel the examination at time $t_1$.

**3. Monetary Policy Games and Dynamic Inconsistency: Assumptions of the Basic Model**

Let us turn our attention now to the application of the dynamic inconsistency phenomenon in the monetary policy. There is a large field of work that deals with dynamic inconsistency of discretionary monetary policy, starting with seminal articles by Kydland and Prescott (1977), Barro and Gordon (1983a, 1983b), Barro (1986) or Rogoff (1985). The basic model that is common for most papers dealing with dynamic inconsistency can be described in a simple form by following equations:

| | |
|---|---|
| $y = \bar{y} + b(\pi - \pi^e), \quad b > 0$ | (1) |

The equation (1) is the well-known expectations-augmented short-run Phillips curve denoting the positive aggregate relationship between the deviation of the real output $y$ from its natural level $\bar{y}$ and unanticipated inflation, i.e. difference between actual inflation $\pi$ and expected inflation $\pi^e$ (the real variables are usually in logarithms). The natural level of output corresponds to the natural level of employment that would be obtained in the absence of monetary disturbances - in other words, following Friedman (1968), a level that is determined only by real forces like structure of the labor and commodity markets, costs of mobility etc. The parameter $b$ denotes the "sensitivity" of the output on the change in surprise inflation.[1]

The relationship (1) can result from two not necessarily competing views about how economy works. First, following Lucas (1972, 1973), unanticipated inflation affects output because individuals in the economy are not able to distinguish between aggregate nominal shocks and real relative shocks.[2] As a result, when an individual (producer) observes an increase in the price of his product, he does not know whether it reflects a change in the good's relative price or a change in the aggregate price level. However, there is a positive probability that a part of the change is an increase in the relative price of his good, the extent being determined by the variance of (past) nominal aggregate shocks.[3] An optimal response for the individual producer is therefore to increase output somewhat because the change in the relative price alters the optimal amount to produce while the change in aggregate price level not. Thus, an unexpected increase in the aggregate price level raises the overall output produced because all producers attribute a part of the price change to the change in relative prices.

A second explanation for the equation (1) comes from the existence of long-term wage contracts in conjunction with ex post determination of employment by labor demand side (Fischer 1977, Taylor 1980). Here, workers are assumed to sign nominal wage contracts prior to the setting of monetary policy. The contracted wages are based on the expected inflation. An inflation surprise reduces the real value of the contracted nominal wage, thereby inducing firms to hire more labor and produce more output.[4] This "wage contracting" approach prevails in the literature.

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[1] Some authors formulate the model in employment/unemployment – inflation terms (Barro and Gordon 1983b; Rogoff 1985; Cukierman 1992; Bofinger 2001). With a direct linkage between the employment and output through the production function the formulation in output – inflation terms is equivalent.

[2] A simple version of the Lucas model can be found in Romer (2001, pp. 266-276).

[3] The higher the variance of nominal aggregate shocks is, i.e. the more volatile the aggregate demand is, the lower is the parameter b in the equation (1) and the more inflation surprise is necessary to affect real output (see Romer 2001, pp. 276-277).

[4] A simplified version of the model is presented in Cukierman (1992, pp. 35-38). Cukierman points out that a decrease in real wages will lead to the rise in employment only if the employment is determined by the demand side, i.e. if the real wage is above the market clearing value (for example, because of strong labor union). Otherwise, the binding constraint would be the supply side of the labor market, inducing even a decrease in employment by a decline in real wages.

The second building block of the basic model is the social welfare function *L* (or society's utility function) that is formulated as a cost function, in which social costs have two components. First is the (squared) deviation of the actual real output *y* from the targeted output $y^*$, second the (again squared) deviation of the actual inflation $\pi$ from the targeted inflation $\pi^*$. The parameter *a* denotes the relative weight placed on the inflation and output goals.[5]

| | |
|---|---|
| $L = \frac{1}{2}(y - y^*)^2 + \frac{1}{2}a(\pi - \pi^*)^2, \quad y^* > \bar{y}, \quad a > 0$ | (2) |

In the basic model, the social cost function is a target function of both private sector and the policymaker (usually monetary authority, but let us call it only policymaker and suppose that this political body has all economic functions, i.e. fiscal, monetary and other policies). It is assumed that the policymaker acts as "benevolent planner", maximizing the social welfare of the private sector. Social costs rises when output and inflation deviate from their "bliss points" $y^*$ and $\pi^*$, irrespective whether the deviation is positive or negative. Because larger deviations are assumed to cause higher social costs, the deviations are squared.

The fact that outputs higher than $y^*$ are valued negatively is somewhat puzzling. Why should not individuals wish the output to be as high as possible? One possible answer comes from the linkage between output and employment: the targeted level of output corresponds to the optimal level of employment that results from an optimization calculus of individuals between leisure and work. An output that is higher than optimal would then lead to more employment than preferred, decreasing the utility of individuals and thus increasing the social costs.

The inflation target does not have to be necessarily zero;[6] however, most of the literature for simplicity assumes $\pi^*$ to be zero. Higher than social optimal inflation rate increases social costs and reduces welfare due to the real costs high inflation induces, mainly the distortion of signals prices play and resulting misalignments in investment, menu costs, distortion of tax system functioning, "shoe leather costs", redistribution effects etc. Too low inflation (or even deflation) has known negative effects on welfare as well.[7]

One of the key assumptions of the dynamic inconsistency model is that the targeted output $y^*$ is higher than the natural output $\bar{y}$. The reason for this fact is not obvious. It is usually argued that distortions in the economy make natural level of output undesirably low. Barro and Gordon (1983a, p. 103) give some examples of distortions: the income taxation (i.e. non-lump-sum taxes) or unemployment compensation may make the level of private-chosen work too low. However, as Bofinger (2001, p. 180) points out, it has to be at the same time assumed that individuals do not take account of the associate increase in the supply of public goods financed from the taxes when deciding about leisure and work. Canzoneri (1985, p. 1058) provides another argument for $y^* > \bar{y}$: because of trade unions, the labor supply curve

[5] With a being unity, the same weight is put on both targets. When a is higher than one, the inflation target is given a high priority, the opposite being true for a lower than one.

[6] For example, as Rogoff (1985) points out, the literature on "optimal rate of inflation" provides an argument for $\pi^* > 0$. If the tax system is inefficient, the government may prefer to gain revenues via seigniorage, i.e. through printing more money and hoping that real balances that are "taxed" through inflation will decline more slowly than the inflation rises (see Phelps 1973 or Romer 2001, pp. 510-514). However, there are other, more realistic arguments as well, the rigidity of nominal wages downwards and resulting problems in situations with negative shocks in certain industries or regions, or the risk of deflation being the major ones. Hence, the most inflation targeting countries target an inflation rate that is small but positive. For further discussion of setting $\pi^* > 0$ see Bernanke et al. (1999, pp. 28-30).

[7] For the discussion of costs of inflation or deflation see for example Romer (2001, pp. 519-524), Bofinger (2001, pp. 132-148) or Bernanke et al (1999, pp. 16-19).

including only the union members causes the real wage to be too high and natural employment (and hence natural output) too low in comparison with the level regarded as desirable by all (i.e. not only union insiders) workers.
The basic model is completed by assuming that both players of the game (policymaker and private sector) have perfect information about the target functions and that policymaker is able to determine the inflation rate $\pi$ directly through its monetary policy instruments, usually money growth.[8]

**4. Playing the Basic Monetary Policy Game**

The policymaker decides about $\pi$ by maximizing his target function, in this basic model the social welfare function, i.e. it minimizes the social cost function (2) under the constraint (1). Substituting (1) into (2), differentiating in terms of $\pi$ and setting the first-order condition equal to zero yields the policymaker's optimal inflation rate $\pi^{opt}$ as a function of $\pi^e$ (and, of course, other parameters):

$$\pi^{opt} = \pi^* + \frac{b}{a+b^2}(y^* - \bar{y}) + \frac{b^2}{a+b^2}(\pi^e - \pi^*) \quad (3)$$

For simplicity, let us assume the targeted inflation rate $\pi^*$ to be zero. In such a case, the equation (3) simplifies to the equation (4):

$$\pi^{opt} = \frac{b}{a+b^2}(y^* - \bar{y}) + \frac{b^2}{a+b^2}\pi^e \quad (4)$$

Thus, the inflation $\pi$ policymaker chooses depends crucially on the inflation rate $\pi^e$ expected by the other player, the private sector. Now, there are principally three possible situations, how the monetary policy game can proceed.

*Situation 1: Fooling the public.* Consider the case where the private sector expects the inflation to be zero ($\pi^*$), in other words, it expects the policymaker to choose the targeted inflation. This is, at a first sight, a plausible assumption (if policymaker announces her target, why should she not be believed that she is going to realize it?). However, because targeted output is higher than natural output, policymaker will actually choose a positive inflation rate according to the equation (4) and surprise the public. Why? Because the marginal social cost of slightly higher inflation is zero (differentiating the second term in (2) according to $\pi$ in the situation $\pi = \pi^* = 0$) and the marginal social benefit of resulting higher output is positive (the change in social costs in the first term of (2) is negative by slightly higher inflation). Thus, the policymaker can raise the social welfare by delivering a positive rate of inflation $\pi_1$ according to the equation (5).

$$\pi_1 = \frac{b}{a+b^2}(y^* - \bar{y}) \quad (5)$$

Equations (6) and (7) show the resulting output and social costs:

$$y_1 = \bar{y} + \frac{b^2}{a+b^2}(y^* - \bar{y}) \quad (6)$$

$$L_1 = \frac{1}{2}\frac{a}{a+b^2}(y^* - \bar{y})^2 \quad (7)$$

In this situation, the private sector is fooled by the policymaker, who had announced the target inflation $\pi^*$ (zero) to reduce the expected inflation. After the individuals have contracted their nominal wages according to expected zero inflation announced by the policymaker, she surprises them with positive inflation $\pi_1$, and pushes the output above its natural level.

[8] As a result, some of the authors (Cukierman 1986, 1992) use the money growth rate instead of inflation.

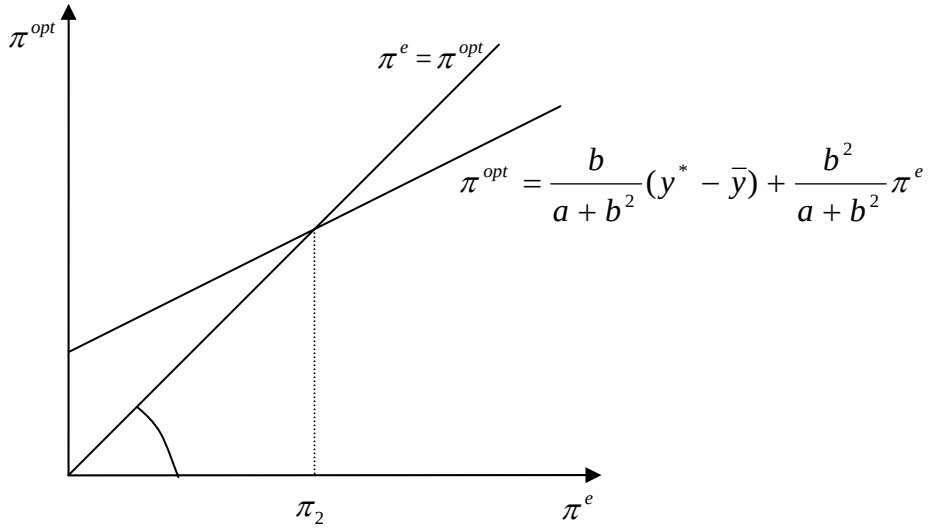
In terms of game theory framework, this situation represents a one-shot non-cooperative game where the public is not fully informed about the target function of the monetary authority. If we assume perfect information, the payoffs given by (5) - (7) must necessary remain in the policymaker's dreamland and can never happen in reality.[9]

*Situation 2: Discretionary equilibrium with rational expectations.* If the private agents are rational and perfectly informed, why should they let the policymaker surprise them? Hence, because of perfect information, the private individuals know that the policymaker will intend to exploit their expectations of inflation in order to raise output. As a result, they will expect such an inflation rate that is equal to the policymaker's optimal inflation rate, i.e. $\pi^e = \pi^{opt}$. Imposing $\pi^e = \pi^{opt}$ in (4) yields the equilibrium inflation rate $\pi_2$.

| | |
|---|---|
| $\pi_2 = \frac{b}{a}(y^* - \bar{y})$ | (8) |

Figure 1 shows the reaction functions of private sector ($\pi^e = \pi^{opt}$) and of the policymaker (equation 4). The equilibrium inflation rate is depicted as an intersection of both reaction curves:

**Figure 1: Reaction functions**




If both players are rational, the only equilibrium rate of inflation is $\pi_2$ that is both expected and realized. According to (1), the actual output $y_2$ is in this case equal to the natural output $\bar{y}$, and the actual inflation $\pi_2$ is higher than in the situation 1, as well as the social costs $L_2$:

| | |
|---|---|
| $L_2 = \frac{1}{2}\frac{a+b^2}{a}(y^* - \bar{y})^2$ | (9) |

Hence, there is an unnecessary inflation $\pi_2$ that was intended to raise the output above the natural level, but because of rational private sector, the intention was neutralized by expecting this inflation rate by the private sector. Again, in terms of game theory, this result represents a

[9] As Romer (2001, p. 482, fn. 9) points out, if the policymaker was able to fool the private sector, it could do even better by announcing that inflation will equal $\pi^* - (y^* - \bar{y})/b$ (by assumption of zero target inflation thus negative inflation rate) and then setting $\pi = \pi^*$. This yields both bliss points and causes the social costs to be zero.

Nash discretionary equilibrium characterized by an inflation bias with the output still at its natural rate (Blackburn and Christensen 1989, p. 14). It is easy to show that this Nash equilibrium is inferior and that there is another one (discussed in situation 3) leading to higher social welfare.

*Situation 3: Pre-commitment to the announced policy.*

Suppose that the policymaker can pre-commit to a policy whereby he will not create surprise inflation and the private sector believes this. The announcement of zero inflation is in this situation binding and credible and the private sector will thus expect $\pi^e$=0. Because of pre-commitment, the policymaker cannot take advantage of low inflation expectations as in the situation 1 and he must realize inflation $\pi_3$=0, being effectively bounded by the pre-commitment. According to (1), the actual output remains at its natural level, $y_3 = \bar{y}$. The equation (10) gives the social costs $L_3$:

| | |
|---|---|
| $L_3 = \frac{1}{2}(y^* - \bar{y})^2$ | (10) |

It is easy to show that $L_1 < L_3 < L_2$. From the policymaker's point of view (and because the target function of policymaker is simultaneously the target function of the private sector, from the public point of view as well), if the best solution with the lowest social costs $L_1$ is due to rational expectations unattainable, the second best solution – the pre-commitment not to inflate more than private sector expects – is preferred to the discretionary solution with highest social costs $L_2$. The situations 2 and 3 differ only in the realized inflation – by the pre-commitment policy the inflation is equal to zero, by the discretionary policy there is an inflation bias given by (8).

Some authors (for example Cukierman 1986, p. 7) have tried to represent the game structure as a prisoners' dilemma. However, there is one relevant difference between standard prisoners' dilemma matrix and the basic monetary policy game, the reason being in impossibility to derive the classical prisoners' dilemma payoff structure directly from the welfare function (2). The following Table 1 shows the outcome structure with payoffs resulting from the situations 1, 2 and 3 (the numbers represent payoffs <policymaker, private sector> in terms of costs):[10]

**Table 1: Payoffs of the monetary game**

| | | ***Private sector*** | |
|---|---|---|---|
| | | $\pi^e = 0$ | $\pi^e = \pi_2$ |
| ***Policymaker*** | $\pi = 0$ | 3, 3 | 10, 10 |
| | $\pi = \pi_2$ | 0, 0 | 6, 6 |

The dominant strategy from the point of view of the policymaker (without pre-commitment) is to inflate; its payoffs for $\pi = \pi_2$ are higher (costs are lower) regardless what inflation rate

[10] For the table, we need the payoff for the case where the public expects positive inflation $\pi_2$, but the policymaker delivers zero inflation. Let us denote resulting social costs for this situation as $L_4$ and show that $L_4 = \frac{1}{2}\frac{(a+b^2)^2}{a^2}(y^* - \bar{y})^2$. It is clear that $L_4$ is higher than the discretionary payoff $L_2$ because choice of zero inflation when public expects positive $\pi_2$ does not meet the optimizing condition (4), i.e. $L_1 < L_3 < L_2 < L_4$. For simplicity, let us substitute some arbitrary values for these disutility payoffs, for example 0<3<6<10.

the public expects. On the other hand, the dominant strategy of the private sector is to expect zero inflation, $\pi^e = 0$; its payoffs are higher regardless what the policymaker chooses, too. Hence, with both players following their dominant strategies, there is a unique equilibrium with the best payoffs <0, 0>. However, we have argued that private sector dislikes being fooled and that (without effective pre-commitment) it thus expects positive inflation rate, knowing the policymaker's dominant strategy. Then, however, the public does not follow its dominant strategy. This is a bit puzzling – why does the public dislike being fooled when only this way it can reach the best payoff?

From the just described puzzle, one has to conclude that the social welfare function *L* cannot be the target function of the private sector. What is missing in the welfare function is, in particular, the resistance to being fooled on the part of private agents. This is only a different formulation of the argument that is present in the later literature on dynamic inconsistency of monetary policy (Blackburn and Christensen 1989; Bofinger 2001). The function (2) cannot be the social welfare function of the private sector not only because it lacks the aversion against being fooled, but as well because there is a contradiction in the individual rational choice of optimal employment (or output). Barro and Gordon (1983b) argue that individuals do not take into account the positive external effects of public goods financed by taxes, which leads to the choice of (natural) employment level that is suboptimal. However, at the same time they are supposed to take into account these positive effects when formulating the welfare function. As Bofinger (2001, p. 186) points out, it is thus assumed that in their labor supply decisions individuals systematically ignore relevant information which they however take into account when formulating their social welfare function. This contradiction leads to the reinterpretation of function (2) as a target function of the policymaker (without any direct links to the private sector) in some later literature, representing the result of political pressures on the policymaker (Lohmann 1992).[11]

The argument that there is an obvious contradiction in the decision of individuals does not apply if the social preference (of all individuals) of $y^*$ over $\bar{y}$ is based on the labor union power argument (Canzoneri 1985). If the real wages are high, employment is too low because in this case the labor demand curve is binding. The individuals may prefer to work more, so that their bliss point $y^*$ is higher than natural output, but at the same time they may dislike the decline in real wages, caused by the surprise inflation.[12]

One possible way to overcome the just described problem is to add arbitrarily a component to the welfare function of private sector (thus divorcing it from the policymaker's target function) that represents the dislike to being fooled.[13] For simplicity, assume that being surprised by higher than expected inflation raises the social costs (disutility) to 10 units (because the public very much dislikes to be fooled, i.e. their real wages to be inflated away). Thus, the table will be modified in the following way:

[11] This approach is usually called "political approach" in the opposition to the "welfare approach" presented in the basic model here. The political approach has, however, a disadvantage in the impossibility of welfare comparison across monetary regimes with different levels of inflation and output (see Lohmann 1992, p. 274, ft. 3).

[12] This seems to be confirmed, at least in part, in reality – people would like to have lower unemployment but with the same level of their current real wages.

[13] Other possible way would be to formulate the dislike as a kind of constraint: public prefers higher than natural output, but it is not allowed for the output to be reached via surprise inflation – in such a case the social costs rise.

**Table 2: Adjusted payoffs of the monetary game**

| | | ***Private sector*** | |
|---|---|---|---|
| | | $\pi^e = 0$ | $\pi^e = \pi_2$ |
| ***Policymaker*** | $\pi = 0$ | 3, 3 | 10, 10 |
| | $\pi = \pi_2$ | 0, **10** | 6, 6 |

In such a payoff structure, the dominant strategy of the policymaker (i.e. to inflate) does not change. However, the strategy of the private sector depends now on the strategy chosen by the policymaker. If the policymaker is expected to choose zero inflation, for the public it is better to expect zero inflation as well. If the policymaker chooses positive inflation, for the public that does not like to be fooled it is better to expect positive inflation, too. Because, in absence of some effective pre-commitment, the dominant strategy of the policymaker is to inflate, the public will expect $\pi^e = \pi_2$ as well, and the resulting discretionary Nash equilibrium with payoffs <6, 6> in cost units will be inferior, as in the standard prisoners' dilemma.
Now, there are two questions to answer: first, if the discretionary equilibrium is inferior, how the policymaker can pre-commit to follow the low inflation policy, leading to the best outcome for the public, and second, are there some other possibilities to reduce the inflation bias as well?

**5. Rules as Credible Commitment: A Task for Constitutional Economics?**

The problem of pre-commitment is not a trivial one. Toma (2001, p. 452) argues that the commitment technology problem is an issue in constitutional economics.[14] In this section I try to apply some of the main theses from constitutional economics on the commitment problem. Before I start it is important to point out that there is a small difference between the commitment issue usually discussed in constitutional economics (sometimes in public choice theory as well, see Mueller 1996), and the commitment problem here. In the former, a little bit simplified, the problem is which rules (and how, of course) should we as members of the society impose on politicians in order to constrain their discretion and create for them incentives so that they, following their own interest, at the same time promote our common interests. In other words, policymakers are totally dependent on what individuals decide, at least in this conceptual sense (constitutional economics calls it "at the constitutional level"). In the latter, the problem is which rules should the policymaker himself choose and impose on himself, following his own interest, in order to gain credibility. The commitment can be understood as a contractual agreement between the policymaker and the private agents as well (Barro and Gordon 1983a) and the policymaker has a status of equal partner. An important difference is that in the former case, the policymaker does not want to be constrained, whereas in the latter case he does, because it is in his own interest.
Even if the policymaker knows that by pre-committing to low (zero) inflation it can lower its (and social) costs, there is still a problem of credibility. If pre-commitment is not credible, i.e. the private sector does not believe that policymaker's hands are effectively tied, we are back in the situation 2 with inferior discretionary equilibrium. The public will expect positive inflation rate and the policymaker can only fulfill these expectations (by delivering zero

[14] For questions adressed in and methods used by constitutional economics (or constitutional political economy) see for example Buchanan (1990).

inflation the social costs would be higher). Thus, the policymaker must find a way to pre-commit credibly.

The way how to pre-commit credibly to follow low (zero) inflation discussed in this section is to impose rules on the policymaker in order to constrain his discretion. As already noted above, it is in the policymaker's interest to impose rules on himself. For example, in a deterministic world of our basic model (i.e. without any shocks), the optimal ex ante rule for the policymaker is to follow zero inflation at all times. In this regard, the dynamic inconsistency model provides a new argument for rules in the traditional debate about rules versus discretion in monetary policy (Binder 1987; Bofinger 2001).

Before I discuss rules as commitment, it will be useful for our purposes to distinguish between rules as procedures and rules as constraints. The distinction is a little bit arbitrary but it can help understand the credibility issue. Rule as a procedure is designed to provide a standard solution to recurrent choice problems. By adopting such a rule one saves resources necessary to make many similar single choices. Rules as procedures are usually formulated positively, i.e. "do". Rule as a constraint does something else: it prevents the agent from pursuing his targeted function directly, imposing further condition that must be fulfilled when making choice. In comparison with procedures, rules as constraints are usually formulated negatively, i.e. "do not".[15]

### 5.1 Procedures as Binding Rules

Now, suppose that the policymaker can still directly influence inflation, but that he must do it via some monetary policy instruments (change in money supply, interest rates etc.). Let us start with rules as procedures: can procedures in monetary policy like Friedman's *k*-percent-rule of money growth (or similar arrangements, for example currency board including a rule that the monetary base must be fully covered by foreign exchange reserves), serve as commitment device? Imagine a time point before the one-shot monetary game begins. The policymaker pre-commits (via public announcement) that she will determine her monetary policy instrument according to some monetary rule leading to low (or zero) inflation. Should the public believe the policymaker?

The announcement of such monetary rules is for the public credible only if they are binding, i.e. there are some positive costs in form of sanction for the policymaker when reneging on the commitment during the game. It is in the policymaker's interest to be exposed to some direct positive costs when breaking the promise because only in this way she can gain credibility. However, the sanction must be imposed externally to the policymaker, i.e. the decision about imposing costs on her (after she has broken the promise) may not lie in his hands. There are principally two possible external sanction mechanisms; let us call them natural and institutional.[16]

The natural sanction mechanism is based on notion that there are external costs built-in "in the nature" of the situation. Thus, when breaking a rule, the agent incurs some utility loss because of subsequent impossibility to take advantage of situations that are possible only if he adheres to the rule. This concept is proposed for example by Gauthier (1986). In the monetary policy game, the natural sanction is the possible utility cost of landing in situation 2 (i.e. the disutility given by difference between $L_3$ and $L_2$). However, the question is if this natural sanction is sufficient for gaining credibility. One can argue that these costs create only one part of the

[15] The distinction is similar to the one between personal rules (procedures) and social rules (constraints) that can be found in some constitutional economics literature (see Vanberg 1994, pp. 19-20). It is worth noting that the usual discussion in monetary theory and policy about "monetary rules" (for example, the Taylor rule, see Taylor 1993) refers exclusively to rules as procedures.

[16] It is hardly imaginable to design some internal sanction mechanism: can you imagine that after you have broken some self-commitment given to yourself, you voluntarily impose some additional costs on yourself?

whole expected costs of breaking the commitment. There are as well some possible gains of reneging on the commitment, exactly given by difference between $L_2$ and $L_1$, if the policymaker succeeds in fooling the private sector. These gains reduce the expected costs of reneging on commitment, thus reducing the credibility.

The institutional sanction mechanism, as proposed for example by Buchanan (1975, p. 68), assumes that an external agency must be charged with the responsibility of enforcing agreed-on rules.[17] Having only two parties in our basic monetary policy game, the only party external to the policymaker is the public. Now, there are two possibilities. Either the public as a whole can decide about sanction, for example via replacement of the policymaker through election., or an institution (agency) can be created, staffed by members from the private sector and charged with the task to enforce the commitment the policymaker announces and to induce, when necessary, a sanction.[18] In reality, such institution is usually judiciary. The question remains if the "agency" solution is itself dynamic consistent, i.e. if the agency is credible. McCallum (1995) argues that when some agency external to the monetary authority should enforce the rules of monetary policy, there is again a built-in incentive for it not to punish the policymaker when he reneges on the commitment (punishment is costly).

Institutional sanction mechanisms are expensive and if natural sanctions do not suffice, are there any other possibilities with respect to procedure rules that could raise credibility? One way for the policymaker to gain credibility without relying on external sanction mechanisms is to signal in advance the intention to adhere to the announced rules via investing some costs before workers contract their wages. For example, the policymaker could design such rules which are not simple, i.e. which need time and resources before they can even be used (think of complicated monetary models, econometric techniques etc. that must be conducted by trained economists with special software, using all relevant information). Against the usual conviction introduced by Friedman (1960) and Taylor (1993), I argue here that in order to raise credibility of pre-commitment in the monetary policy game, the policymaker should not introduce too simple procedural rules as *k*-percent-rule of money growth or Taylor Rule because, in absence of effective external enforcing mechanism, the policymaker does not suffer any direct loss when he changes the rule.

Again, as in our simple example from university life, "there is no free lunch". Both external enforcing mechanism and investment in advance as means of gaining credibility of announced pre-commitment are costly. However, we are still in the simple basic one-shot game model. Let us leave the basic model for a while now and suppose additionally (and more realistically) that there is a time-lag between the use of the instrument and the effect on inflation (that is assumed to be direct and quantitatively predictable), so that in order to reach some level of inflation in the current period, the instrument must be changed before the period begins (i.e. before the workers contract their nominal wages). In such a situation, the policymaker does not have the possibility to fool the public more: when he announces to follow some procedure leading to low inflation and he must change the instruments before the public chooses its strategy, his dominant strategy is to follow low inflation policy. The dynamic inconsistency problem disappears, without the necessity to pay some additional costs to gain credibility.

[17] In the approach presented by Buchanan (1975), the external agency enforces rules that were agreed in a contract among agents, not rules intended to introduce and follow by one party, the policymaker. However, in my approach, we can think of the monetary policy procedure rules as of rules (1) agreed-on between the policymaker and the public, i.e. introduced by the policymaker in his own interest, but at the same time in the interest of the private sector, or (2) agreed-on among individuals and then imposed on the policymaker through political process.

[18] There are, of course, other possibilities, including some international arrangements that can serve as enforcing agencies.

### 5.2 Constraints as Binding Rules

The second kind of rules – rules as constraints – directly restricts the discretion of the policymaker. We have already discussed that it is in the policymaker's interest to constrain her discretion. In addition to monetary rules as procedures there is a possibility to introduce rules explicitly forbidding those kinds of behavior that can lead to high inflation. In our basic model, the rule would be "you cannot choose inflation higher than $\pi^*$". In the more complicated reality where inflation is reached by monetary policy instruments, imagine for example restricting such kinds of behavior as printing money directly for the state budget or using such monetary rules that would lead to high inflation (for example, restricting *k* in the *k*-percent-rule of money growth). Such rules may take form of legislative restrictions both of special legislation for monetary policy ("central bank acts") or special clauses written in the formal constitution. In this respect, the procedural rules can be regarded as constraint rules as well, under the assumption that they are written into the legislation or constitution.

If the policymaker pre-commits to follow low inflation by restricting by law those strategies leading to high inflation, the question remains if this kind of pre-commitment is credible. In this regard, the credibility will depend on two variables: first, how the rules will be enforced, i.e. what sort of sanction mechanism will be called into force when the policymaker breaks the rule, and second, how high are costs associated with formal change of the rules. To the former variable we can apply our discussion of natural and institutional sanctions of breaking the rules from the last section. If natural sanction is not sufficient, a need for an external agency arises that will impose sanctions on the policymaker.

To the latter variable, i.e. costs of legislative change, we can discuss and compare working properties of different institutional arrangements. In our basic model where the policymaker possesses the whole power to change the once approved legislation or constitution, the credibility is of course low. However, in reality, there are many alternative arrangements imaginable, for example division of legislative power between two or more elected political bodies, voting rules, procedural obstacles as necessary time-lags etc. (see Mueller 1996; Moser 2000; Padovano et al. 2003).

## 6. Repeated Monetary Game: Credible Commitment through Reputation

Blackburn and Christensen (1989) point out that in the absence of effective formal commitment technologies there are still more informal incentive schemes that motivate the policymaker not to act opportunistically. Only by enlarging the horizon of the policymaker beyond one shot-game, there is – under certain assumptions - a built-in incentive for the policymaker to follow low inflation policy. In the introduced terminology, the policymaker informally pre-commits at the beginning of the game and her pre-commitment will be under certain assumptions believed because the natural sanction of breaking the promise considerably rises in multi-period game.

Let us consider a simple multi-period model that is based on models presented in Barro and Gordon (1983a) or Bofinger (2001, pp. 187-192). The policymaker minimizes an inter-temporal loss function *L* which is obtained using (2):

$$L = \sum_{t=1}^{\infty} \frac{1}{(1+r)^{t-1}} \left[ \frac{1}{2}(y_t - y^*)^2 + \frac{1}{2} a \pi_t^2 \right], \quad y^* > \bar{y}, \quad a > 0, \quad r > 0 \qquad (11)$$

We assume for simplicity that $\pi^*=0$, *r* is the discount factor. Thus, the policymaker minimizes the present value of all future period losses. For each period there is again an output-inflation relationship given by Phillips curve (1) formulated with a time dimension:

$$y_t = \bar{y} + b(\pi_t - \pi_t^e), \quad b > 0 \qquad (12)$$

In the case of rational expectations, the future values of the variables are independent of those already realized, so that the multi-period game becomes a single-period game and both

partners will set their strategies in both periods independently (Barro and Gordon 1983b, p. 595).

However, in the game theory (Blackburn and Christensen 1989) as well as in reality, there are often interdependency between the current strategy and the results of the past. As in our simple example form university life, when taken dynamically, students may base their expectations of the professor's optimal strategy on their past experience. In the context of monetary policy, it is reasonable to assume that individuals take account of past inflation rate when forming their expectations. Such an expectations building means that the public may "punish" the policymaker for surprise inflation in one period by forming higher inflation expectations in the next period.

Let us assume that individuals form inflation expectations according to the following mechanism (so-called "trigger mechanism"):

$$\pi_t^e = \begin{cases} = \pi^P = 0, & if\ \pi_{t-1} = \pi_{t-1}^e, \\ = \pi^D = \dfrac{b}{a}(y^* - \bar{y}), & if\ \pi_{t-1} \neq \pi_{t-1}^e. \end{cases} \qquad (13)$$

The term $\pi^D$ refers to the discretionary equilibrium inflation in the situation 2, i.e. to $\pi_2$, whereas $\pi^P$ refers to the inflation to which the policymakers informally pre-commits at the beginning of the period (here supposed to be zero). Assuming that in the first period the expected inflation is zero, this mechanism is similar (but not equivalent!) to the "tit-for-tat rule" (Axelrod 1984). This expectation mechanism is both plausible and advantageous because it causes the "punishment" effective only for one period.[19] The policymaker has an infinite horizon, which is again both plausible and advantageous because it allows us to avoid the "chain store paradox" (Blackburn and Christensen 1989, p. 18), i.e. a situation where the policymaker, setting the non-cooperative strategy of positive inflation in the last period because of absence of punishment in non-existing next period, causes a chain of non-cooperation by backward induction of both players till the current period.

With expectations formed this way, the policymaker creates his reputation. If he keeps his promise and sets zero inflation, he has gained reputation and his announcement that he will follow zero inflation policy in the next period will be believed, i.e. he gains credibility and will be rewarded by low expected inflation.

Now, consider the choice of the policymaker's strategy for the first period. Assuming $\pi_t^e$=0, if the policymaker chooses positive inflation $\pi^D$ instead of promised zero inflation, she surprises the public and achieves the costs of $L_1$ instead of $L_3$ (Bofinger 2001 calls this utility benefit "incentive effect of surprise inflation", Barro and Gordon 1983a call it "temptation"). However, costs of this violation is that the public will expect positive inflation in period *t+1* and the policymaker will have to validate it, thus discretionary equilibrium of situation 2 with costs $L_2$ instead of $L_3$ will emerge (Bofinger 2001 calls it "deterrent effect", Barro and Gordon 1983a call it "enforcement"). Using the equations (7), (9), (10) and (11), we can obtain the absolute size both of incentive effect (14)

$$L_3 - L_1 = \frac{1}{2}(y^* - \bar{y})^2 - \frac{1}{2}\frac{a}{a+b^2}(y^* - \bar{y})^2 = \frac{1}{2}\frac{b^2}{a+b^2}(y^* - \bar{y})^2, \qquad (14)$$

and deterrent effect (15)

[19] Note that if in the first period the policymaker surprises the public with positive inflation, the public will expect for the next period $\pi^D$ which the policymaker will validate. But, according to (13), both expected and realized inflation coincide and public will again expect zero inflation. Of course, this is somewhat unrealistic but it allows us to examine the multi-period game as a two-period game.

$$\frac{L_2 - L_3}{1+r} = \frac{1}{1+r}\left[\frac{1}{2}\frac{a+b^2}{a}(y^* - \bar{y})^2 - \frac{1}{2}(y^* - \bar{y})^2\right] = \frac{1}{2}\frac{b^2}{a(1+r)}(y^* - \bar{y})^2. \quad (15)$$

Because of its emergence in the period *t+1*, the difference between $L_2$ and $L_3$ must be discounted. The policymaker will pursue the policy of surprise inflation only if the incentive effect, i.e. current decline in costs, exceeds the deterrent effect, i.e. future rise in costs. The condition is given by (16):

$$r > \frac{b^2}{a}. \quad (16)$$

Thus, if the discount rate of the policymaker is "too high", the probability that she will opt for surprise inflation in the first period rises. Under the assumption that the discount rate is not "too high", it is reasonable to assume that the "cooperative solution" of situation 3 will emerge in all rounds of the game without any formal pre-commitment technologies and costly punishment arrangements. The natural punishment given by utility losses in case of reneging on the informal commitment to follow zero inflation suffices for the cooperative strategy to be stable.

The reputation model presented here can be interpreted both as positive theory and normative theory (Cukierman 1986, p. 15). From a positive point of view, the model – assuming the trigger mechanism as a plausible description of expectations building – tries to explain the existence of high inflation rates. However, there is a problem: the model satisfies the conditions of rationality and equilibrium only if the discount rate of the policymaker is not too high, given the parameters *a* and *b*. If the opposite is true, he will be in temptation to surprise the public, but if private individuals are fully informed, expecting zero inflation for the first period is not rational because of high probability of being fooled. As a result, individuals will not stick with the expectations mechanism given by (13), because then they would be systematically fooled. But then, there is no equilibrium.

Another problem regarding positive explanation is the plausibility and effects of different trigger mechanisms on inflation. Bofinger (2001, p. 191) points out that, depending on the concrete trigger mechanism and other parameter, it is possible that in some periods the policymaker may even follow a costly disinflation strategy in order to gain reputation and restore credibility.

From a normative point of view, the model (or its variations) can be interpreted as a device for derivation of optimal trigger mechanism that raises welfare. Then, the trigger mechanism in (13) is no more just a plausible assumption about how individual build expectations, but an object of deliberate design. Barro and Gordon (1983a) take another approach: using a little bit different form of target function, they show that the low inflation policy (i.e. following a rule of zero inflation) is not optimal strategy for the policymaker because incentive effect is higher than deterrent effect for any $r>0$. Thus, from the normative point of view, they derive an "optimal best-enforceable rule" $\pi^P$, i.e. such a rate of inflation, that, given the trigger mechanism in (13), if the policymaker pre-commits to, leads to equilibrium with this rate of inflation in all period. Not surprisingly, again, the higher the discount factor, the higher as well the optimal rule that turns out to be a weighted average between zero and inflation rate in discretionary equilibrium.

Blackburn and Christensen (1989, p. 18) and Waller (1995) argue that there are many possible punishment strategies (trigger mechanisms of expectations building), causing from a normative point of view a problem with multiple equilibria and a need of coordination of individuals among them. In other words, if they are more trigger mechanisms that all lead to the highest level of social welfare, how it is to happen that individuals will coordinate their actions in order to send a clear signal of punishment strategy to the policymaker and, if necessary, how would they behave in the event that they are surprised.

Let us now shortly discuss the properties of two plausible trigger mechanisms, the "real" tit-for-tat strategy of expectations building, and the trigger mechanism that punishes the policymaker for surprise inflation by forming high inflation expectations for all subsequent periods. Let us start with the latter: the trigger mechanism of expectations building (strict trigger mechanism) is then given by (17):

$$\pi_t^e = \begin{cases} = \pi^P = 0, & \text{if } \pi_{t-1} = \pi_{t-2} = \ldots = \pi_1 = \pi^P = 0, \\ = \pi^D = \dfrac{b}{a}(y^* - \bar{y}) & \text{otherwise.} \end{cases} \qquad (17)$$

Only if the policymaker starts with pre-committed inflation $\pi^P$ (here assumed to be zero), regardless of what individuals expect, she will be rewarded by zero inflation expectations for the next period where she faces the same condition. But if she once realizes positive inflation $\pi^D$, she will be punished by high inflation expectations for the rest of the game.

Assuming $\pi_t^e$=0, consider the choice of the policymaker in the period *t* (could be also the first period). The incentive effect of surprise inflation is loss reduction in the current period given by (18), which is the same as (14):

$$L_3 - L_1 = \frac{1}{2}(y^* - \bar{y})^2 - \frac{1}{2}\frac{a}{a+b^2}(y^* - \bar{y})^2 = \frac{1}{2}\frac{b^2}{a+b^2}(y^* - \bar{y})^2. \qquad (18)$$

The deterrent effect is now given by equation (19) via discounting the higher losses in all subsequent periods, i.e.

$$\sum_{i=t+1}^{\infty}\frac{L_2 - L_3}{(1+r)^{i-1}} = \left[\frac{1}{2}\frac{a+b^2}{a}(y^* - \bar{y})^2 - \frac{1}{2}(y^* - \bar{y})^2\right]\sum_{i=t+1}^{\infty}\frac{1}{(1+r)^{i-1}} = \frac{1}{2}\frac{b^2}{ar}(y^* - \bar{y})^2. \qquad (19)$$

The deterrent effect is with the stricter punishment mechanism greater than with the trigger mechanism (13), therefore, with incentive effect being the same, the policymaker will opt for positive inflation only if

$$r > 1 + \frac{b^2}{a}. \qquad (20)$$

The discount factor leading to positive inflation is now much higher that in the preceding case, thus, from the normative point of view, if the policymaker is supposed to have high discount factor, i.e. he places much less weight on future periods (for example, because he is not sure if he will be reelected or his term is limited to a very short period), the public should adopt the strict trigger mechanism. In reality, the "strictness" may vary from one-period-punishment up to the trigger mechanism presented here, the critical value of discount factor being between (16) and (20).

More interesting case is, however, the tit-for-tat trigger mechanism, given by (21).

$$\pi_t^e = \begin{cases} = \pi^P = 0, & \text{if } \pi_{t-1} = \pi^P = 0, \\ = \pi^D = \dfrac{b}{a}(y^* - \bar{y}), & \text{if } \pi_{t-1} \neq \pi^P = 0. \end{cases} \qquad (21)$$

Here, the public will expect the rate of inflation that was realized by the policymaker in the preceding period. This is a fair strategy – if the policymaker does not renege on commitment to follow zero inflation, she can be sure to have zero inflation expectations as well in the next period. If she reneges, she will be punished by positive $\pi_{t+1}^e$. However, unlike the trigger mechanism introduced by Barro and Gordon (1983a), the credibility will not be restored in *t+2* automatically. If the policymaker wants to regain credibility, she has to invest in her reputation by following a costly disinflation strategy, i.e. by delivering zero inflation when inflation expectations are positive.

The choice problem now is a little bit difficult because, theoretically, there are infinitely many strategies as time paths of cheating and credibility restoring, some of them with the same level of utility. Consider therefore only one simple question relevant for the policymaker that has lost his credibility and wants to regain it and hold for the rest of the game: shall he invest into the reputation and follow a disinflation strategy in time *t*? With $\pi_t^e$ positive, the costs of this strategy are

$$L_4 - L_2 = \frac{1}{2}\frac{(a+b^2)^2}{a^2}(y^* - \bar{y})^2 - \frac{1}{2}\frac{a+b^2}{a}(y^* - \bar{y})^2 = \frac{1}{2}\frac{(a+b^2)b^2}{a^2}(y^* - \bar{y})^2 . \quad (22)$$

The benefits are lower costs in the rest of the game discounted with his discount factor *r*, the size being the same as of the deterrent effect in (19):

$$\sum_{i=t+1}^{\infty}\frac{L_2 - L_3}{(1+r)^{i-1}} = \left[\frac{1}{2}\frac{a+b^2}{a}(y^* - \bar{y})^2 - \frac{1}{2}(y^* - \bar{y})^2\right]\sum_{i=t+1}^{\infty}\frac{1}{(1+r)^{i-1}} = \frac{1}{2}\frac{b^2}{ar}(y^* - \bar{y})^2 . \quad (23)$$

The policymaker should invest the costs of restoring credibility and regain reputation only if benefits exceed costs. This yields the following condition (24):

$$r < \frac{a}{a+b^2} . \quad (24)$$

The condition (24) is much stricter than the condition (20) – it is even its inverse value - which can be interpreted that a fair expectations building mechanism induces the policymaker to follow a disinflation strategy and to restore credibility only if – again - she has a very low discount factor.[20]

All reputation-building models presented here have shown that the key factor in determining whether the policymaker (the central bank) will follow low-inflation strategy is the discount factor. As this factor says how much are future period worth for the policymaker, it reflects the terms of contract of the policymaker, mainly the length, the condition under which he can stay in the office after his term has expired etc. The outcome of the models – i.e. that we should design such an institutional arrangement for monetary policy in which the discount factor will be low – can be interpreted as asking for long (or at least overlapping) period of contracts of the policymakers involved in monetary policy decision-making so that they have always in mind the long-term benefits of low inflation.

**7. Output Shocks and State-Contingent Rules: credibility versus flexibility**

Up to now, we have assumed that there are no output shocks. If we introduce them, there is a new role for monetary policy – to stabilize output via accommodating inflation. If a negative shock occurs and output declines, the public and the policymaker can be made better off if they allow for higher than expected inflation which partly compensates the decline in output. Rewriting (1) to include output shock *z* (assumed to be normally distributed with zero mean and positive and finite variance), we gain

$$y = \bar{y} + b(\pi - \pi^e) + z, \quad b > 0 . \quad (25)$$

Because the model is actually defined only for the supply side, shock *z* represents a supply shock (Bofinger 2001, p. 194). If we again assume rational expectations and no pre-commitment, we can derive a discretionary equilibrium inflation rate $\pi^D$, which is equivalent to $\pi_2$ in deterministic model:[21]

[20] The condition (24) is stricter than condition (16) only under certain additional assumptions about the relationship between a and b.

[21] Because of stochastic nature of the equation (25), the equillibrium inflation rate is computed via derivation of expected welfare loss function, see Bofinger (2001, pp. 195-197) or Lohmann (1992).

| | |
|---|---|
| $\pi^D = \frac{b}{a}(y^* - \bar{y}) - \frac{b}{a+b^2} z$ | (26) |

The equation (27) gives the output $y^D$ when the policymaker behaves according to (26):

$$y_D = \bar{y} + \frac{a}{a+b^2} z \qquad (27)$$

Here, we assume that individuals expect only the first part of (26) – inflation bias - which is the same as $\pi_2$ in the equations (8), because expected value of shock *z*, which is realized after the private sector sets its expectations, is zero. Thus, in times without shocks, the resulting inflation is equal the discretionary inflation bias $\pi_2$, whereas in times with shocks the policymaker will deviate from this rate.

The same discussion about pre-commitments and discretion applies here as well, however with slightly different conclusions: if the policymaker pre-commits to the zero inflation (for example, via some rule), there is an expected welfare gain in times without shocks because of absence of the inflation bias; however, at the same time, there is an expected welfare loss in times of shocks because the policymaker will not be able to accommodate them through change in inflation. As a result, there is a trade-off between rules and discretion, which some authors call credibility versus flexibility dilemma (Lohmann 1992). It can be shown that if shocks are small and relatively rare (variance of *z* is small), having a pre-commitment to zero inflation is preferable to having discretion (Waller 1995, p. 7; Bofinger 2001, p. 197).

Rogoff (1985) suggested that the trade-off is unnecessary if we introduce flexible rules, such as the one in (28), i.e. pre-commitments of the policymaker to follow zero inflation in times without shocks and accommodate shocks when they occur (so-called "state-contingent rules"). Thus, such a pre-commitment to the inflation according to (28) would raise welfare (but only under the assumption that being surprised in case of a shock does not induce some extra disutility as in the table 2):

| | |
|---|---|
| $\pi^P = -\frac{b}{a+b^2} z$ | (28) |

Lohmann (1992) argues that such a flexible rule is, of course, ex ante optimal. The question remains if such commitment can be formally legislated and, as a consequence, whether it will be credible. If there are costs of specifying the inflation rate to be set in the event of every possible contingency, the simple zero inflation rule may be preferable.

In reality, however, we observe monetary authorities following a rule similar to (28). In fact, (28) can be reinterpreted as a variant of Taylor rule (Taylor 1993), with negative output shocks leading to lower interest rates in order to encourage inflation. Inflation targeting central banks use "escape clauses" that allow them not to hit the targeted inflation ($\pi^*$) when shocks sudden and unpredictable. Thus, it seems reasonable to suppose that there is a way how to impose a credible state-contingent rule on the policymaker.

## 8. Roggof's Conservative Central Banker

If society dislikes being fooled, prefers low inflation and higher than natural output, there seems to be no solution in the basic dynamic inconsistency model. Formal pre-commitments or reputation building may help, but they do not raise output. However, if we leave the basic model, there is one obvious solution: if policymakers are in the temptation to increase the output predominantly via inflation (because they want to gain "free lunch") and if it lies in the natural propensity of democratically elected policymakers to do it, the public may prefer to charge the responsibility for monetary policy to a new political body (let us call it central bank) independent from the current policymaker, leaving the only possibility for the

policymaker to raise output by other, more costly policies as structural or appropriate fiscal policy (this would mean, however, raising the natural output than current output).
One of the relevant questions is how this new political body – a central bank – should be institutionally designed. The first attribute is clear – it should be independent from the policymaker, because if it were dependent, serving as "another hand of the policymaker", the problem would not be solved. The second attribute – its target function, objectives or preferences – remains for discussion. The public does not want to create "a second policymaker" with the same incentive structure, i.e. with temptation to engage in surprise inflation to raise output. Thus, some arrangement is necessary that makes the preference function of the central bank different from the policymaker's one.
Rogoff (1985) suggested that society should delegate the monetary policy to an independent central bank and select an agent to head it who is known to place a greater weight on inflation stabilization than the society as a whole does. In our basic deterministic model it means that such an agent would have a target loss function *L´*

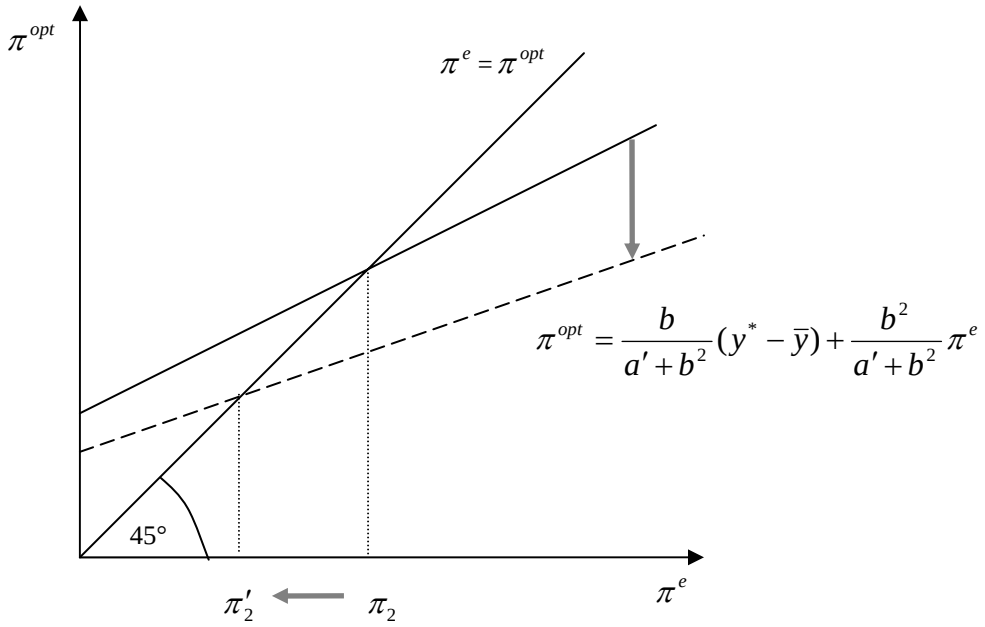
| | |
|---|---|
| $L' = \frac{1}{2}(y - y^*)^2 + \frac{1}{2}a'(\pi - \pi^*)^2, \quad y^* > \bar{y}, \quad a' > a\,.$ | ( 29) |

In this case, the reaction function of the political body responsible for monetary policy (now central bank) differs from the one of the policymaker. Because *a´>a*, the reaction function given by (30)

| | |
|---|---|
| $\pi^{opt} = \frac{b}{a' + b^2}(y^* - \bar{y}) + \frac{b^2}{a' + b^2}\pi^e$ | ( 30) |

is flatter. Dynamic inconsistency remains, but because the agent heading the central bank is more averse to inflation, the equilibrium $\pi_2'$ given by intersection of both reaction curves is lower than before (see figure 2). The higher the aversion of central bank given by *a´* is, the lower the current equilibrium inflation and the closer $\pi_2'$ to $\pi^*$ (assumed to be zero) is, therefore the social welfare rises.

**Figure 2: Conservative central banker**



Delegation does not eliminate the dynamic inconsistency problem, but it decreased the inflation bias; hence, there is again the possibility to raise social welfare via pre-commitment technologies or informal incentive schemes given by repeating the monetary policy game.
An interesting question is how conservative central banker reacts on supply shocks. Rogoff (1985) and Lohmann (1992) show that the conservative central banker, with lower discretionary equilibrium inflation, does not stabilize the economy in a socially optimal fashion. The higher *a*, the lower average inflation given by (26), but the more variable is the output given by (27). If pre-commitment to the optimal state-contingent rule is not possible, there is a trade-off: having conservative central banker has benefits through reduced inflation, but at the cost of distorted reaction on shocks. With large negative supply shocks the public would prefer higher inflation to that one realized by the conservative central banker. Rogoff (1985) shows that, given this trade-off, there is an "optimal" degree of the central bank's conservativeness.
Lohmann (1992) suggested a way how to escape the trade-off between flexibility and credibility. If we allow the policymaker to override the central banker's monetary policy decision if the shocks are "too large", the conservative central banker will accommodate large shocks in order to avoid being overridden. Override means costs for the central bank, for example in terms of loss of reputation, non-pecuniary benefits of power. The problem of this approach lies in the credibility of the policymaker to override the central bank only if shocks are too high. What prevents the policymaker to override the central bank's decision in any situation, for example to raise re-election chances via boosting output through relaxed monetary policy?
Treating this model in the institutional design perspective, Moser (2000) suggests that we should put the overriding mechanism under checks and balances scheme. One of the ways how to make the overriding scheme credible is to divide the power to override between two political bodies with different preferences with regard to monetary policy, both with power to veto. This may help to explain why some countries are successful in coping with time-inconsistency problem by creating an independent central bank, and why others are not.[22]

## 9. Performance Contracts for Central Bankers

Persson and Tabellini (1994), Walsh (1995) and Waller (1995) proposed another approach to the solution of dynamic inconsistency problem. The idea is to offer the central banker a performance contract, whereby the central banker's salary is tied directly to the performance of important macroeconomic variables such as GDP and inflation rate (Waller 1995, p. 8).
Thus, the monetary policy game should rather be viewed as a principal-agent problem. The agent (monetary authority) has, however, a set of preferences that do not yield the outcome preferred by the society (principal). Walsh (1995) suggested that rather than worrying about reputation building or seeking for conservative central banker, the society should provide the monetary authority with appropriate incentives (through performance contract), so that the monetary authority, when following its own interests, maximizes at the same time the welfare of the society. The performance contract works as good as the optimal state-contingent rule.
Rewriting (2) as utility function *U* (rather than loss function) of the central banker and including the basic salary *w* and a parameter $\lambda$ that reduces the basic salary when $\pi > 0$ we obtain (31):

[22] There are, of course, some other explanations. Posen (1993) argues that there is a third factor affecting both inflation performance and central bank independence, namely political pressures. When financial sector is politically strong enough, it can move the monetary policy towards low inflation through the channel of central bank independence. However, where this "opposition" to the government does not effectively work, creating an independent central bank does not help to combat inflation.

| | |
|---|---|
| $U = w - \lambda\pi - \frac{1}{2}(y - y^*)^2 - \frac{1}{2}a(\pi - \pi^*)^2, \quad y^* > \bar{y}, \quad a > 0, \quad w > 0, \quad \lambda > 0$ | (31) |

Using the Phillips curve with output shocks given by (25), we can compute the discretionary equilibrium inflation by maximizing *U* and assuming that the public rationally expects that inflation rate which results from maximizing (31) by the central banker.

| | |
|---|---|
| $\pi^{opt} = \frac{b}{a}(y^* - \bar{y}) - \frac{b}{a+b^2}z - \frac{\lambda}{a+b^2}$ | (32) |

By setting

| | |
|---|---|
| $\lambda = \frac{b(a+b^2)}{a}(y^* - \bar{y}),$ | (33) |

the society gets the same result as by pre-committing the monetary authority to follow a state-contingent rule given by (28). Having $\lambda$ in this appropriate size, the reduction in salary from creating an inflation surprise just offsets any benefits that would accrue from expanding output through the inflation surprise. At the same time, the ability of the central banker to stabilize economy is not distorted.

Following drawbacks of the optimal contract approach can be identified: first, if monetary authority is assumed to follow some utility function (or to follow some interests in general), the question is why the utility function should look like (31). Two answers are possible. If there is no central bank, only a policymaker (or the central bank is not independent), the wage term in (31) refers to the policymaker's pecuniary interests and the rest to her political interest (i.e. to reach small inflation and higher than natural output in order to be reelected). However, if we treat the monetary authority as independent from the government – which is mostly the case in reality – then if the wage term is introduced in order to motivate the central banker to act in the interest of the society, the question is whether the utility function should not be only a monetary reward function with incentives not to produce inflation and to stabilize output in times of shocks. The problem that will not be examined here is that central bankers may have non-pecuniary political interests as well (reappointment, prestige benefits), leading to a utility function similar to (31).

Second, in the model, the contract is agreed between principal (central bank) and agents (public), but in reality such a contract is only imaginable between some political body and central bank. The question that remains is which political body should bear the responsibility for signing the contract: if government should be the principal, we have principal-agent problem of second order, because the government is from the same point of view an agent of the public. Do we have a contract with our governments that functions well?

McCallum (1995) argues that if the principal is the government, performance contract approach does not solve the dynamic inconsistency, it merely relocates it. If the contract is to be enforced, then the government must impose a sanction on the central bank in times of high inflation – but it has an incentive not to do it (because imposing a sanction when the inflation is already high does not reduce it, i.e. does not raise the social welfare – the sanction has only a deterrent role). Here, again, credibility – now of our "second" principal, i.e. the political body - becomes important, which in turn depends on the political constitution and division of powers.

## 10. Conclusions

In this paper an overview of the main contributions into the dynamic inconsistency research program was provided. Models based on dynamic inconsistency provide some useful guidelines that, enriched by constitutional economics perspective in credibility building questions, may help to improve our knowledge about appropriate design of monetary institutions.

The main message of this paper is that the best way how to approach the question of an appropriate design of institutions for monetary stability is to combine several proposals that have been made so far. Rules can work only in the world of negligible external shocks and additionally require effective sanctions to be in place if the rules are broken. Clearly, the delegation solution to the inflation bias, i.e. the establishment of an independent and conservative central bank, can work optimally only if there are arrangements in place that ensure the optimal reaction to external shocks. However, these arrangements, for example overriding schemes or optimal performance contracts, create new problems and challenges, mainly the one of credibility of that political body that bears the burden of enforcing contracts and deciding to override central bank's decisions. Similarly, reputation building can work only if the conditions are safeguarded for such a long-term strategy, which in turn requires an institutional environment that enhances the long-term perspective of policymakers in charge of monetary policy.

Necessarily, the paper provided only limited number of issues related to institutional questions of monetary policy. Nevertheless, as the contributions discussed in this paper belong to the most discussed topics in academic or practitioners' forums, I believe that a comprehensive overview looking at potential synergies of individual approaches may be beneficial.

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