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Does a Higher Sacrifice Ratio Mean that Central Bank Independence is Excessive?*

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Recent empirical studies show that sacrifice ratios calculated during periods of inflation stabilization are usually higher in countries with higher levels of central bank independence (CBI). This led some economists to conclude that CBI does not produce a credibility bonus implying, at least implicitly, that CBI may be undesirable. Using a simple model in which higher CBI is positively associated with the probability that preannounced inflation targets will be delivered, this paper shows that welfare is higher when CBI is higher, refuting this view. This result holds independently of the sign of the association between sacrifice ratios and CBI. The paper also points out that both Lucas', as well as Neo - Keynesian theories of the Phillips curve imply that countries with more independent central banks should have higher sacrifice ratios. Potential biases in empirical measures of sacrifice ratios are discussed as well.

Key Words: Disinflation; Sacrifice ratios; Central bank independence; Credibility; Phillips curves.

JEL Classification Numbers: E31, E32, E58, E52.

1. INTRODUCTION

An interesting body of recent empirical literature on the real costs of disinflation attempts to measure these costs by estimating sacrifice ratios (Ball (1994) (1997)). The sacrifice ratio (SR) is the cummulative increase in the yearly rate of unemployment that is due to the disinflation effort divided by the total decrease in the rate of inflation. Some of this literature reports that OECD countries with more independent central banks have

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higher sacrifice ratios (Gartner(1995) and A. Fischer (1996)). Debelle and Fischer (1994) find that the sacrifice ratio during the post oil shock disinflation was larger in Germany than in the US. Fischer (1995, pp. 299-300) presents more extensive cross sectional evidence suggesting that there is a positive relation between the SR and central bank independence (CBI). He concludes that there is no "**credibility bonus**" in the sense that even independent central banks have to fight long and hard to disinflate after an inflationary shock has struck. A similar point is made in Posen (1998). The policy implication lurking behind those findings is that in countries with high independence, like Germany, CBI may be excessive.

This paper critically examines the implied link between sacrifice ratios and the (non) desirability of CBI. The argument is developed in two parts. First it is shown that, as a theoretical matter, the relation between social welfare and sacrifice ratios is not necessarily negative. More precisely it is shown that there always is a credibility bonus in the sense that the higher CBI, and therefore the reputation of policymakers, the higher is the expected value of social welfare. This result obtains independently of the magnitude of the SR and of the sign of its association with CBI. Hence even if the finding that countries with more independent central banks have higher sacrifice ratios is empirically correct, this does not imply that a high level of central bank autonomy is undesirable. Second, it is argued that there are serious reasons to believe that the empirical proxies used to measure sacrifice ratios provide a distorted picture of the net employment costs of monetary disinflations. The intuitive bases for those claims follow.

The relation between sacrifice ratios and welfare is non monotonic for at least two reasons. First, by focussing only on disinflation periods, sacrifice ratios detract attention from the fact that a higher SR also means that when monetary policy is expansionary it has a stronger positive impact on output. Second, by focussing on the **temporary** employment costs of disinflation the SR neglects the **permanent** benefits fom stable prices that are backed by a strong reputation for nominal stability. A full welfare analysis should take both factors into consideration. When this is done it turns out that, on average, a better record of dependability for achieving inflation (or other nominal) targets that is backed by a higher level of CBI **always** increases welfare. For simplicity of exposition this result is derived first in a one period, steady state, version of the model, in which the long term benefits of a better reputation are reflected only through its effects on the expected value of social welfare.

This analysis is then extended to an explicitly dynamic framework in which the economy starts from an initial position of high inflation and a policy decision has to be made about whether to disinflate or not. In such a case it is possible, in principle, that the current employment costs of disinflation are higher than the persistent future benefits of a higher

reputation and the associated stabler prices. In this case higher CBI and the associated higher reputation for nominal stability is still desirable under the relatively weak condition that the economy's social welfare function extends over an infinite horizon. [1]

Those points are illustrated within a relatively simple framework in which a higher level of CBI makes it more likely that preannounced nominal targets will be attained. Two basic ingredients of this framework are the slope of the short run Phillips curve and the dependability of monetary policymakers that is determined, in turn, by the level of CBI. The paper also derives the precise pattern of dependence of the SR on these parameters, and provides a possible explanation for the apparent positive association between sacrifice ratios and CBI within the contexts of both the Lucas' "islands" paradigm and the new Keynesian paradigm.

Altough they aim at isolating the increase in unemployment due to a deliberate disinflation policy, existing empirical studies do not distinguish between that part of the increase in unemployment that is due to the disinflation effort from the part that would have occured in any case because of non policy induced cyclical fluctuations. Ideally, one would have liked to obtain a "net" measure of the additional unemployment that is due only to the disinflation policy and to relate it to the additional reduction in inflation because of that policy. Existing measures of sacrifice ratios lump these two components together providing "gross" rather than (more relevant) "net" measures of sacrifice ratios. As a consequence, existing measures of the SR generally provide a distorted picture of the employment costs of monetarily engineered stabilizations. Orphanides and Wilcox (1996) and Bomfim and Rudebusch (2000) have stressed the logic and some of the consequences of the "opportunistic approach" to disinflation. The framework of the paper suggests that, when this method of disinflation is utilized, commonly used measures of the SR bias the output costs of disinflation upward.

The paper is organized as follows: Section 2 presents a strategic monetary policy framework for welfare evaluation under imperfect reputation. This framework is utilized, in section 3 to evaluate the relation between average welfare and the sacrifice ratio on one hand, and reputation and CBI on

[1] When the planning horizon is infinite this result is true for any discount factor. This is reminiscent of, and complements, a result obtained by Feldstein (1997) in the context of going from low inflation to price stability. Feldstein performs a cost benefit analysis of the long term benefits of price stability due to the removal of inflation induced distortions of saving and consumption decisions by means of a non indexed tax structure. He compares those benefits to the temporary employment costs of disinflation and shows that for a realistic range of US discount factors the benefits of disinflation outweigh the costs. I compare the latter costs to the general long term benefits of reduction in the inflationary bias of monetary policy and show that, for an infinite planning horizon, higher reputation is preferable for **any positive value** of the discount factor. See also Thornton (1996).

the other. The section demonstrates that sacrifice ratios cannot be used to evaluate the desirability of CBI. Section 4 extends the welfare analysis to an explicitly dynamic framework. Section 5 critically examines the relevance of existing empirical measures of the SR for evaluation of the employment costs of disinflation by means of policy induced monetary contractions. This is followed by concluding remarks.

2. A FRAMEWORK FOR WELFARE EVALUATION UNDER IMPERFECT REPUTATION [2]

Currently, monetary policymakers in many countries implicitly or explicitly preannounce some nominal targets. In some cases, like in the UK, Chile, Israel and Sweden, the preanouncement takes the form of an explicit inflation target.[3] In some cases, like in the US and Japan, there is an implicit understanding that monetary authorities aim at a "low" rate of inflation. In the not too distant past policymakers in Germany and Switzerland used to target some monetary stock.

For simplicity and focus I will abstract from some of those institutional differences and present a formal analysis in which the preannouncement refers to the rate of inflation. Since the different targeting methods ultimately aim at achieving a reasonable amount of price stability it is likely that most of the conclusions reached here will be robust to the precise identity of the assumed nominal target.[4] The basic motive for preannouncement of targets is to affect inflationary expectations, and through them nominal contracts, early on. Since targets are not always achieved their announcement usually has some, but not full impact on expectations. The reason is that the public is usually uncertain about the extent to which the preannounced target constitutes a commitment to conduct monetary policy so as to attain the target.

This uncertainty is modeled here by assuming that there are two types of policymakers denoted "dependable" (D) and "weak" (W) respectively. Both policymakers possess the **same** objective function. The only difference between them is that the dependable policymakers is truly commited to the target he announces whereas the weak one is not and chooses, therefore, his policy actions according to what is expedient expost, after expec-

[2]The analytical structure draws on Cukierman and Liviatan (1991) and, in particular, on section 2 in chapter 16 of Cukierman (1992). An extension of this basic framework that incorporates imperfect control of inflation and gradual learning appears in Cukierman (2000).

[3]Recent discussions of inflation targets appear in Haldane (1995), Leideman and Svensson (1995) and in Bernanke and Mishkin (1997).

[4]Clarida and Gertler (1997) produce evidence suggesting that the Bundesbank, in spite of its focus on M3 targeting, conducted policy so as to achieve an inflation objective with occasional deviations aimed at the stabilization of output and employment.

tations have been embedded into wage contracts. His actual policy choice corresponds therefore to the well known Kydland -Prescott (1977), Barro-Gordon (1983) discretionary policy. The actual proportion of dependable policymakers in the population is given by β. The public is unsure about the identity of the policymaker in office but, since expectations are rational, the public believes that the probability a D type is currently in office is also given by β. I shall refer to this probability as "reputation for dependability" or "reputation" for brevity.

Since politicians normally do not feel compelled to abide by preannounced targets as much as the central bank the "dependable policymaker" can be thought of as a central banker that has enough power to abide by the target, even in the face of political pressures whereas the "weak policymaker" is a central bank that cannot resist the pressures of politicians to behave in a discretionary manner. Thus, other things the same, there is a positive association between reputation and the level of CBI. In spite of the fact that it is aware of this association the public is not fully certain about the extent to which the preannounced target will be achieved. The reason is that, in addition to the letter of the law, actual independence is affected by numerous informal relations between the central bank and its political principals that are usually not fully evident to the public.

The timing of moves within each period is as follows: First the policymaker announces the inflation target for the period. Then inflationary expectations are formed and embedded in nominal wage contracts. Following that, the central bank (CB) picks the rate of inflation. Both policymaker types wish to maximize a social welfare function that is given by:

$$V \equiv -\left[A(N^* - N) + \frac{\pi^2}{2}\right] \; for \; N^* - N > 0 \tag{1}$$

$$V \equiv -\left[\frac{\pi^2}{2}\right] \; otherwise \tag{2}$$

where N, N^* and π are actual employment, desired employment and inflation respectively. A is a positive parameter that measures the relative importance attributed by policymakers to achieving their employment and price stability objectives. The higher A, the higher the relative importance attributed to the employment objective. The short run Phillips curve is given by:

$$N - N_n = a(\pi - \pi^e) \tag{3}$$

where N_n is the natural level of employment and a is a positive parameter that measures the effect of unanticipated inflation on the deviation of em-

ployment from its natural level. I assume that $s \equiv N^* - N_n$ is positive.[5] Hence, when employment is at its natural level only the first branch of the objective function in equation (1) is relevant so that the weak policymaker has an incentive to surprise the public by engaging in discretionary monetary policy. Substituting the Phillips curve into equation (1) the objective function of both policymakers may be expressed as:

$$V(\pi, \pi^e) = -\left[A(s - a(\pi - \pi^e)) + \frac{\pi^2}{2}\right]. \tag{4}$$

Note that, other things the same, higher inflationary expectations reduce social welfare and the objectives of policymakers. The reason, of course, is that the higher are those expectations the higher the actual rate of inflation that is needed to maintain a given level of employment.

2.1. Characterization of equilibrium policies

A weak type always announces the same inflation target as his dependable counterpart would have since otherwise he is unmasked already at the beginning of the game, and as demonstrated below, this raises inflationary expectations. Using the superscript "t" to denote an announced target and subscripts to denote types this implies

$$\pi_w^t = \pi_d^t. \tag{5}$$

But since he is not really committed to the target the weak policymaker chooses actual inflation, π_w, after expectations have been embedded in wage contracts, so as to maximize the objective function in equation (4). This maximization yields:

$$\pi_w = Aa \tag{6}$$

which is the well known discretionary solution when the public knows with certainty that the regime is discretionary. Since the proportion of dependable policymakers in the population is β, and since the public knows that a dependable policymaker always delivers the target, inflationary expectations after the announcement of the target are given by:

$$\pi^e = \beta\pi_d^t + (1 - \beta)Aa. \tag{7}$$

I turn now to a characterization of the optimal strategy of a dependable policymaker. The main difference between him and his weak counterpart

[5] This may be due to union power or to minimum wage legislation. A fuller discussion appears in chapter 3 of Cukierman (1992). The natural level of employment is the level that obtains in the absence of unanticipated inflation.

is that he chooses the target subject to the dependability constraint

$$\pi_d = \pi_d^t. \tag{8}$$

More precisely, D picks π_d so as to maximize equation (4) subject to the process of expectation formation in (7) and the dependability constraint in (8). The solution to this problem is

$$\pi_d = \pi_d^t = (1-\beta)Aa. \tag{9}$$

Note that the dependable policymaker partially accomodates the public's suspicions concerning his dependability and that the degree of accomodation is stronger the lower the reputation β. This is due to the fact that a D type always creates a recession and, given actual inflation, the recession is more severe the lower is reputation.[6]

The levels of welfare under the two policymaker types, using equations (6) and (9) in equation (4), are:

$$V_w(.) = -\left[As + \frac{(Aa)^2}{2}\left(1-2\beta^2\right)\right] \tag{10}$$

$$V_d(.) = -\left[As + \frac{(Aa)^2}{2}\left(1-\beta^2\right)\right]. \tag{11}$$

Note that the one shot level of welfare is higher under a weak than under a dependable policymaker. The reason is that, since inflationary expectations are between the discretionary rate produced by W and the lower target rate produced by D, unanticipated inflation is positive when W is in office and negative when D is in office. As a consequence W produces an expansion and D produces a contraction. But the level of welfare produced by either policymaker type is an increasing function of the proportion, β, of dependable policymakers in the population.. This is due to the fact that the higher this proportion, and therefore reputation, the lower are inflationary expectation and the higher, therefore, the level of employment for a given rate of inflation.

[6] By contrast a weak policymaker creates an expansion that is proportional to unanticipated inflation, which under him is given by $\beta^2 Aa$. I assume that $s - a(\pi - \pi^e) = s - (\beta a)^2 A > 0$ so that the first branch of the welfare function in equation (1) is relevant even when a W type is in office.
Note that in this one period benchmark model the policymaker type is revealed with probability one after the choice of **actual** inflation. Thus, after policy choices have been made reputation jumps to 1 if a dependable policymaker has been in office and goes to zero if a weak policymaker has been in office. This observation becomes particularly important when the policymaking horizon is extended to more than one period. Such a case is analyzed in section 4.

Thus, the proportion, β, of dependable policymakers has two conflicting effects on average welfare. On one hand when β is higher average welfare is smaller since the economy is more likely to experience recessions than expansions because it is more likely that a recession producing dependable policymaker is in office. On the other hand a higher β produces lower inflationary expectations which raises the average level of welfare attained under either policymaker type. A full welfare evaluation of the effect of β, and therefore of CBI, should take both channels into consideration. This is done in the following section by calculating the average level of welfare.

3. AVERAGE WELFARE, THE SACRIFICE RATIO AND CENTRAL BANK INDEPENDENCE

3.1. Average welfare and CBI

Average welfare is defined as:

$$EV(.) = \beta V(\pi_d, \pi^e) + (1-\beta)V(\pi_w, \pi^e) \tag{12}$$

Note that this concept takes into consideration the effect of β on welfare through the expectation channel as well as through its effect on the relative frequencies of recessions and expansions. Using equation (4) in equation (12)

$$EV(.) = -As + \beta\left[Aa(\pi_d - \pi^e) - \frac{\pi_d^2}{2}\right] + (1-\beta)\left[Aa(\pi_w - \pi^e) - \frac{\pi_w^2}{2}\right]. \tag{13}$$

Rearranging and using equation (7) this can be rewritten as:

$$EV(.) = -\left[As + \frac{1}{2}\left[\beta\pi_d^2 + (1-\beta)\pi_w^2\right]\right]. \tag{14}$$

The intuition underlying equation (14) follows. The beneficial effect of expansions in periods of weakness at the CB is fully offset by the detrimental effect of recessions in periods of strenght (or independence) at the CB leaving two welfare cost components in equilibrium. The first, As, is due to the positive discrepency between desired and natural employment and, as is well known, cannot be eliminated by means of monetary policy. The second is a weighted average of the welfare costs of the inflation biases in periods of weakness and in periods of strenght at the CB. A quick examination of equation (14), taking notice of equations (6) and (9), reveals that average welfare is an increasing function of β. This happens for two reasons. First, when β goes up the weight given to the **lower** inflation rate, π_d, goes up. Second, π_d itself goes down since the equilibrium inflation of a more independent, and therefore dependable, policymaker is a

decreasing function of her reputation. This is summarized in the following proposition.

PROPOSITION 1. *Average welfare is higher the higher is the reputation of monetary policymakers.*

An important immediate corrolary of the proposition follows:

PROPOSITION 2. *More independent central banks that are more likely to achieve preannounced targets, and enjoy therefore a higher level of reputation produce higher average levels of welfare.*

3.2. The sacrifice ratio and CBI

Within the context of the model disinflation can be thought of as a process in which a dependable policymaker comes into office and reduces the rate of inflation from the discretionary rate, Aa, to the preannounced (and optimally chosen) target rate, $(1-\beta)Aa$. The total decrease in the rate of inflation is therefore:

$$\pi_w - \pi_d = \beta A a. \tag{15}$$

Since initially the public is uncertain about the identity of the policymaker in office the mere announcement of a reduction in the rate of inflation does not immediatly generate full credibility. The employment cost of the disinflation policy is equal to the difference between the level of employment that would have materialized under the discretionary rate chosen by a weak policymaker and the actual level of employment chosen by a dependable policymaker. From equations (3), (6) and (9) the consequent increase in unemployment is given by:

$$N_w - N_d = \beta A a^2. \tag{16}$$

Hence the SR is given by:

$$SR \equiv \frac{N_w - N_d}{\pi_w - \pi_d} = a. \tag{17}$$

Thus, the SR is determined by the slope of the short run Phillips curve and, most notably, **does not** depend on the reputation of policymakers. Hence countries with higher CBI that have a better reputation for achieving price stability need not have lower sacrifice ratios. The theory **does not** support the presumption that more independent and therefore more reputable central banks should enjoy a credibility bonus in the sense that they

have lower sacrifice ratios. But, as demonstrated in the previous subsection it **does** suggest that they enjoy a credibility bonus in terms of **expected welfare.**

The preceding discussion raises an important question about the compatibility of the conceptual framework in this paper with the empirical finding that there is a positive relation between sacrifice ratios and CBI. Reconciliation of those two observations requires the slope of the short run Phillips curve to be an increasing function of CBI. Are there reasons to believe that, other things the same, this should be the case? The answer is a definite yes. There are at least two respectable theories which imply that countries with stabler monetary policies have better short run output - inflation tradeoffs. One is Lucas' (1973) "islands" paradigm according to which in countries with stabler monetary policies employment is more responsive to aggregate nominal shocks because a larger fraction of each shock is interpreted as representing a genuine increase in relative prices rather than an increase in the general price level.[7] The other is based on the new Keynesian idea that, due to menu costs, prices and nominal contracts in countries with more nominal stability are adjusted less frequently. As a consequence the temporary impact of a monetary shock on real economic activity is both stronger and longer (Ball, Mankiw and Romer (1988)). Since higher CBI is associated with more stable prices either theory implies that the higher CBI, the higher is the short run tradeoff coefficient. Recent evidence from New-Zealand in which the CB became substantially more independent since 1989 provides empirical support for this view (Hutchison and Walsh (1998)). Denoting CBI by I the crux of those theories can be compactly stated as follows:

$$a(I), \quad a'(I) > 0 \tag{18}$$

where $a'(I)$ denotes the partial derivative of a with respect to I.

The upshot is that the observed positive relation between sacrifice ratios and CBI is due to the long term impact of monetary policies with different degrees of stability on the slope of the short run Phillips curve.

3.3. Does a high sacrifice ratio imply that CBI may be excessive?

This basic question can now be answered by collecting the conclusions in some of the previous subsections. On one hand the theory provides an explanation for the positive association between sacrifice ratios and CBI that in no way contradicts the view that more independent central banks enjoy a higher reputation. On the other hand it implies that social welfare

[7] An extensive discussion of this mechanism appears in chapter 3 of Cukierman (1984). There, I refer to the slope of the short run Phillips curve as the "Lucas coefficient".

is **always increasing** in reputation and therefore in CBI. The precise answer to the question posed in the title of this subsection is therefore:

PROPOSITION 3. *Both the SR and social welfare increase with CBI. The magnitude of the sacrifice ratio is therefore a poor guide for the long run desirability or non desirability of CBI.*

3.4. Sensitivity analysis

It may be argued that the benchmark from which to measure the employment cost of disinflation is the natural level of employment rather than the high level of employment produced by a weak policymaker. In this case equation (16) is replaced by:

$$N_n - N_d = \beta(1-\beta)Aa^2 \tag{19}$$

and the SR becomes:

$$SR \equiv \frac{N_n - N_d}{\pi_w - \pi_d} = a(I)(1-\beta(I)). \tag{20}$$

The dependence of both a and β on CBI is stressed in the notation by writing both of them as functions of I and the presumption that reputation is higher the higher CBI implies that β is an increasing function of I. Although the SR is still an increasing function of CBI through its effect on the slope of the short run Phillips curve, it is a decreasing function of independence through the effect of independence on reputation. With this alternate conceptualization of the SR the dependence of reputation on independence implies that there should be a Fischer (1995) type "credibility bonus" which, **when taken in isolation**, would produce a negative relation between the SR and CBI. However to the extent that the impact of independence on the SR is dominated by its effect via the slope of the short run Phillips curve the overall relation between SR and CBI is still positive. Be that as it may, the conclusion of proposition 3 that the SR is an inappropriate guide for choosing the level of independence also holds for this alternate definition of the SR.

4. EXTENSION TO AN EXPLICITLY DYNAMIC FRAMEWORK

The welfare analysis in the previous section focusses on steady state situations in which the initial position of the economy is abstracted from. But when the difference in the timing of the costs and benefits of disinflation is explicitly taken into consideration it is conceivable that the rate of time

preference of the economy is so high that the present value of the longer term benefits of price stability and enhanced credibility is smaller than the initial employment costs needed to attain those desirable goals. In such cases the establishement of credibility via signalling of dependability may be too costly from a welfare point of view.[8] In terms of the model this implies that the accession of a dependable policymaker into office may be undesirable from a welfare point of view. This section utilizes the model in section 2 to take a more precise look at this question. This is done within an infinite horizon framework in which the social rate of time preference is given by $0 \leq \delta \leq 1$, and in which the level of welfare within each period is described by equation (1).

Any explicitly dynamic framework must specify the lenght of time a policymaker of a given type remains in office. There obviously are many ways to do that since a given type may remain in office any number of periods between two and infinity.[9] For pedagogical reasons I am going to examine first the case in which, once he, probabilistically, gets into office, any given type remains there with certainty for exactly two periods. In the third period nature, again, installs a D type in office with probability β or a W type with probability $1-\beta$ for the next two periods and so on. In this case any given type that gets into office enjoys a certain tenure interval of two periods. Obviously, as the interval of certain tenure increases, the social benefits from getting a D type that demonstrates his commitment ability at the outset increase since the economy then enjoys the benefits of high credibility for a longer time period. Hence if disinflation by a dependable policymaker is desirable under a two periods certain tenure interval (CTI) it is *afortiori* desirable under a longer CTI. The social benefits of dependability are largest when the CTI is infinite so that any given type that is randomly installed in office remains there forever. This case is examined later.

4.1. A two periods' certain tenure interval

In general, depending on parameter values, equilibrium in this case may be either separating or pooling. In a separating equilibrium it pays the weak policymaker to mimic his dependable counterpart during his first period of tenure only in the choice of announced target but not in the choice of actual inflation. As a consequence the type is revealed with certainty in the second period of the CTI. In a pooling equilibrium it pays W to mimic

[8] I use the term "establishement of credibility" to descibe the process through which a dependable policymaker establishes his credentials for dependability with probability 1. By contrast the term "reputation" refers to the actual and perceived average probability that a dependable policymaker is in office.

[9] I abstract from the case in which a given type remains in office for only one period since, in this degenerate case it never pays a dependable policymaker to establish his credibility.

his dependable counterpart in his first office period in both announced targets and actual inflation performance. In either case a policymaker that just got into office considers the effect of his actions on welfare only in the current and in the next period. This is due to the fact that under a two periods CTI actions affect reputation only within this interval. Hence it is sufficient to characterize equilibrium within tenure intervals of two periods.

4.1.1. Separating equilibrium

To characterize the separating equilibrium I shall start with the assumption that the parameters are such that equilibrium is separating and establish conditions on the parameters which assure that equilibrium is indeed separating. Since, under rational expectations, the public knows the parameters it also knows that equilibrium is separating. Consider now a situation in which nature installs a dependable policymaker in office for a two periods CTI. Since equilibrium is separating W does not mimic D and D knows that. Hence D can establish his crediblity at the beginning of the second period by just following the policy that maximizes his first period objectives. Given inflationary expectations in equation (7) this policy is given by equation (9). Similarly, since equilibrium is separating, a weak policymaker that comes into office will choose his policy in the first period so as to maximize only his first period objectives. This policy is given by equation (6). As a consequence the inflationary expectations in equation (7) are rational. In the second period a D type enjoys perfect credibility. He therefore announces and delivers a zero rate of inflation (this is obtained by inserting $\beta = 0$ in equation (9)). By contrast a W type has lost all his credibility in the second period and he inflates again at the discretionary rate Aa. Using those equilibrium strategies in equation (1) the present value of social objectives over the two periods under a dependable and a weak policymaker are given respectively by:

$$\begin{aligned} V_{2d}(\beta) &= -\left[(1+\delta)As + \tfrac{(Aa)^2}{2}(1-\beta^2)\right] \\ V_{2w}(\beta) &= -\left[(1+\delta)(As + \tfrac{(Aa)^2}{2}) - \beta^2(Aa)^2)\right]. \end{aligned} \tag{21}$$

The weak type will abstain from mimicking his dependable counterpart if the present value of his objectives when he follows the optimal separating strategy is larger than this present value under mimicking. Since both types have the same objective function a necessary and sufficient condition for separation is $V_{2w}(\beta) > V_{2d}(\beta)$. Rearranging, this is equivalent to

$$\delta < \beta^2. \tag{22}$$

This condition states that if the rate of time preference is sufficiently large in comparison to reputation equilibrium will be separating. Thus, a higher level of reputation due to higher CBI makes it more likely that equilibrium is separating.

Note that when the condition is satisfied a weak policymaker brings about a larger level of welfare (in present value terms) over his two periods tenure interval than his dependable counterpart. This is the two periods equivalent of a similar result obtained in the one period model of section 2 and its origin is the same. It basically arises because when the rate of time preference is sufficiently high (a low δ) the current employment costs caused by the serious disinflation attempt of a dependable policymaker are higher than the present value of the benefits of higher credibility and price stability in the next period. At first blush one may be tempted to conclude from this result that in such cases high CBI and the associated high level of reputation are excessive. But this intuition disregards the fact that, as can be seen from equation (21), the present value of welfare under either policymaker type is an increasing function of reputation. A full welfare evaluation should, as in section 3, take both factors into consideration. This can be done by calculating the expected value of social welfare over a typical two periods CTI. This is done in equation (23)

$$\begin{aligned} V_2(\beta) &\equiv \beta V_{2d}(\beta) + (1-\beta)V_{2w}(\beta) \\ &= -\left[(1+\delta)As + \frac{(Aa)^2}{2}\left(\beta(1-\beta^2) + (1-\beta)(1-2\beta^2+\delta)\right)\right] \end{aligned} \tag{23}$$

Differentiation of this expression with respect to β yields:

$$\frac{(Aa)^2}{2}\left(\beta^2 + 4\beta(1-\beta) + \delta\right) \tag{24}$$

which is unambiguously positive. The present value of expected social welfare over the entire infinite horizon of the economy is given by:

$$V(\beta) \equiv \sum_{t=0}^{\infty} \delta^{2t} V_2(\beta) \equiv \frac{1}{1-\delta^2} V_2(\beta). \tag{25}$$

A quick examination of the last three equations reveals that $V(\beta)$ is also an increasing function of β. This leads to the following proposition:

PROPOSITION 4. *When the certain tenure interval contains two periods more independent central banks that are more likely to achieve preannounced targets, and enjoy therefore a higher level of reputation, produce higher present expected values of welfare.*

Thus the basic result in proposition 2 carries over to an explicitly dynamic framework in which a given type remains in office for at least two periods. Although, in a separating equilibrium, the two periods short run costs of disinflation exceed benefits over this interval the expected value of welfare over such intervals, as well as over the entire planning horizon, is an increasing function of CBI and of the (positively related) level of reputation. Importantly, this holds no matter what is the size of the sacrifice ratio. Proposition 5 below shows that, in a separating equilibrium, this basic result carries over to any CTI.

4.1.2. Pooling equilibrium

It is shown in the appendix that a pooling equilibrium is not possible since it requires that the discount factor δ be larger than one.

4.2. A certain tenure interval with an infinite number of periods

In this case there is uncertainty about the type only at the outset. Once either a dependable or a weak policymaker gets into office he remains there forever and the public knows that. Since the cost of being revealed as weak to W extends now over many periods he has a stronger incentive to mimic his dependable counterpart. It is therefore more likely that there will **also** be pooling equilibria. As shown below this is indeed the case when the rate of time preference is not too high.

4.2.1. Separating equilibrium

As in the previous case I start from the assumption that equilibrium is separating and find conditions on the parameters under which this is indeed the case. Since equilibrium is separating, and since everybody is aware of that, the first period strategies of both types, as well as inflationary expectations are the same as in the two period's CTI. As a consequence, from the second period and on the type is revealed to the public with full certainty leading a dependable policymaker to maintain full price stability forever and a weak policymaker to inflate at the discretionary rate forever.

The corresponding present values of objectives (for $\delta < 1$) under the two policymaker types are:

$$\begin{array}{l} V_{2d}(\beta) = -\left[\frac{As}{1-\delta} + \frac{(Aa)^2}{2}(1-\beta^2)\right] \\ V_{2w}(\beta) = -\left[\frac{As}{1-\delta} + \frac{(Aa)^2}{2(1-\delta)} - \beta^2(Aa)^2)\right] \end{array}. \tag{26}$$

The weak policymaker will follow the discretionary policy, Aa, from the second period and on, and equilibrium will be separating provided $V_{2w}(\beta) > V_{2d}(\beta)$. Using the expressions in equation (26) this is the case in turn when

$$\delta < \frac{\beta^2}{1+\beta^2}. \tag{27}$$

Note (from (21) and (26)) that, the structure of dependence of $V_{2w}(\beta)$ and of $V_{2d}(\beta)$ on β in the case of an infinite CTI is identical to the structure of this dependence in the case of a two periods' CTI. It follows that the expected value of social welfare in the case of an infinite CTI is also an increasing function of β. As a matter of fact this is true for any CTI since variations in the lenght of the CTI only alter the terms that do not involve reputation (see equations (21) and (26)), but the structure of dependence on β is the same for **any** CTI. This leads to the following basic result:

PROPOSITION 5. *When equilibrium is separating more independent central banks that are more likely to achieve preannounced targets, and enjoy therefore a higher level of reputation, produce higher present expected values of welfare for all possible lenghts of the certain tenure interval.*

4.2.2. Pooling equilibrium

When equilibrium is pooling parameters are such that it pays the weak type to mimic his dependable counterpart. Hence in the first period of the infinitely long CTI

$$\pi_{w1=}\pi_{d1\equiv}\pi^p. \tag{28}$$

Since it is common knowledge that equilibrium is pooling the public knows that no matter who is the policymaker in office preannounced targets will always be delivered. As a consequence

$$\pi^e_{1=}\pi^t_1 \tag{29}$$

which implies that any change in the announced target is fully believed. It therefore pays the dependable policymaker to commit to a zero rate of inflation. As a consequence

$$\pi^p = 0 \tag{30}$$

and the corresponding present value of social welfare under a dependable policymaker is given by:

$$-\frac{As}{1-\delta}. \tag{31}$$

If he mimics D a W type gets the same present value. If he deviates to the discretionary rate in the first period the present value of his objectives is:

$$-\frac{As}{1-\delta} + \frac{(Aa)^2}{2(1-\delta)}(1-2\delta). \tag{32}$$

It pays W to mimic D when the last expression is smaller than the expression in equation (31). This is the case, in turn, when

$$\delta > \frac{1}{2}. \tag{33}$$

4.2.3. Summary and interpretation

The relation between the type of equilibrium and the underlying parameters when it is common knowledge that a policymaker type that gets into office remains there forever can be summarized in the following manner: For any discount factor higher than 0.5, equilibrium is pooling. In this case even a weak policymaker delivers price stability.

When the discount factor is smaller than 0.5 equilibrium is either separating, when the condition in equation (27) is satisfied, or there is no equilibrium in pure stategies when this condition is violated. An important difference between the pooling and the separating equilibria is that in the first **both** types choose policies that bring about price stability wheras in the second only a dependable type delivers price stability. This implies that when individuals in the economy are sufficiently patient (the rate of time preference is sufficiently low) the reputation of policymakers and the underlying level of CBI have no effect on welfare. This can be seen formally by noting that when equilibrium is pooling the present value of social welfare under both types is identical and given by equation (31).

On the other hand, in economies with relatively impatient individuals reputation and the associated high levels of CBI are desirable because they bring about higher present values of social welfare by making it more likely that a dependable policymaker will be in office.

4.3. What is the appropriate tenure interval?

Before concluding it is appropriate to stress that the infinite horizon CTI has been analyzed here as a limiting benchmark case rather than because of its realism. At the other extreme, in a two periods' CTI- there were only separating equilibria and higher levels of reputation and of CBI were therefore always preferable. As the CTI increases beyond two periods the range of discount factors for which there **also** are pooling equilibria, and for which reputation and CBI do not, therefore, matter, increases monotonically.

But even in the infinite CTI case there is a non negligible range of discount factors and of initial levels of reputations for which higher reputation and higher CBI are associated with higher present values of welfare. In a wider sense, longer CTI's, at least when dependable types are in office, reflect a better reputation which is more likely to last when the CB is more independent.

5. A REMARK ON EMPIRICAL ESTIMATES OF THE SACRIFICE RATIO

Altough they aim at isolating the increase in unemployment due to a deliberate contractionary monetary policy designed to stabilize inflation, existing empirical studies do not distinguish between that part of the increase in unemployment that is due to the disinflation effort from the part that would have occured in any case because of (non monetary policy induced) cyclical fluctuations. Ideally, one would have liked to obtain a "net" measure of the additional unemployment that is due only to the **monetary** disinflation policy and to relate it to the additional reduction in inflation because of that policy. Existing measures of sacrifice ratios lump these two components together providing "gross" rather than (more relevant) "net" measures of sacrifice ratios. As a consequence, it is likely that existing measures of the sacrifice ratio provide a distorted picture of the employment costs of disinflation by means of contractionary monetary policy.

This section illustrates the nature of the problem by extending the analytical framework in section 2 to include a real aggregate demand shock that exerts a temporary positive influence on both employment and the

rate of inflation. More precisely natural employment and inflation are given respectively by:

$$N_n = \bar{N}_n + \varepsilon \tag{34}$$

$$\pi = m + d\varepsilon, \qquad d > 0 \tag{35}$$

where ε is a zero mean white noise process, m is the rate of monetary expansion and $\bar{N}_n$ is the, supply determined, value of the natural level of employment. The policyinstrum ent is now m rather than π. Equation (34) states that the natural level of employment fluctuates around a constant trend value. I assume that the largest possible realization of ε is smaller than $s \equiv N^* - \bar{N}_n$ so that, given equation (1), there is always an incentive to inflate at the discretionary rate Aa. Equation (35) states that measured inflation is affected by both monetary policy and the level of the real aggregate demand shock.[10] The timing of events is identical to that of section 2 and is preceded by the realization of the shock ε.

Since they know ε prior to the choice of monetary expansion, both policymakers types can still attain their preferred rates of inflation by choosing monetary expansion so as to offset the effect of the shock on inflation. As a consequence the equilibrium values of preannounced targets, actual rates of inflation and expectations are identical to those derived in subsection 2.1 and are given by equations (5) through (9) respectively. I turn next to the characterization of sacrifice ratios (as they are often meaured empirically) within this framework.

5.1. Characterization of measured sacrifice ratios

As in subsection 3.2 disinflation can be thought of as a process in which a dependable policymaker comes into office and reduces the rate of inflation from the discretionary rate, Aa, to the preannounced (and optimally chosen) target rate, $(1 - \beta)Aa$. In the spirit of Ball (1994) the measured SR (denoted SR_m) is the deviation between the trend level of employment,

[10] The shock is "real" in the sense that it is not induced by monetary policy. The feature that makes it a "demand shock" is the fact that it induces a positive correlation between employment and inflation. One could also introduce an aggregate "supply shock" that exerts a positive influence on employment and a negative influence on inflation. But since my aim is to illustrate the nature of the problem rather than to present a general analysis I limit the discussion to the case in which there is only a demand shock. An alternative interpretation of the structure in the text is that there are both demand and supply shocks but that the demand shocks dominate the sign of the correlation between employment and inflation.

$\bar{N_n}$, and its actual level, N, divided by the total reduction in inflation due to the replacement of a weak policymaker by his dependable counterpart.

$$SR_m = \frac{\bar{N_n} - N}{\pi_w - \pi_d} = a(1-\beta) - \frac{\varepsilon}{\beta A a} \tag{36}$$

where the second equality is obtained by using equations (3), (6), (9) and (34).

5.2. Comparison of the measured sacrifice ratio with its "true" counterpart

Sacrifice ratios have been devised to capture the **additional** employment costs due to disinflation by means of monetary policy. This implies that a true measure of the SR should relate the difference in employment between a weak and a dependable policymaker to the difference between the rates of inflation produced by those different policymaker types. Such a measure (denoted SR_t) is given by

$$SR_t = \frac{N_w - N_d}{\pi_w - \pi_d} = a \tag{37}$$

where the second equality follows by inserting π_w and π_d into the short run Phillips tradeoff in equation (3) to obtain N_w and N_d and by using the resulting expressions in the definition of SR_t. Comparison of equations (36) and (37) reveals that

$$SR_m = (1-\beta)SR_t - \frac{\varepsilon}{\beta A a}. \tag{38}$$

Equation (38) shows that, although there is a positive association between them, the true and the measured sacrifice ratios are not identical. In particular the measured sacrifice ratio is affected by the, non monetary, real aggregate demand shock while the true SR is not. As a consequence the measured SR mixes up the effects of deliberate contractionary monetary policy on employment with the effects of other factors like the real aggregate demand shock ε. The direction of the bias between the two measures is ambiguous in general and depends both on the shock and on the level of reputation. When, prior to inflation stabilization, reputation is poor a negative realization of ε biases the mesured SR upward. Thus, if in line with the so called "opportunistic approach" to disinflation, stabilizations

are more likely to be attempted during downturns of the business cycle the measured SR may be biased upward.[11]

5.3. Sensitivity analysis

Equation (37) is not the only possible way to conceptualize the true SR. For example it may be claimed that the employment cost of disinflation by a dependable policymaker should include only the decrease in employment below the natural level rather than the (larger) additional unemployment he creates in comparison to his weak counterpart. A possible justification for not using N_w as a benchmark is that the level of employment produced by a weak type is not sustainable in the long run. This point of view leads to the following alternate definition of the true SR:

$$SR_t^{'} = \frac{N_n - N_d}{\pi_w - \pi_d} = (1 - \beta)a. \tag{39}$$

Correspondingly, equation (38) is replaced by:

$$SR_m^{\prime} = SR_t^{'} - \frac{\varepsilon}{\beta A a}. \tag{40}$$

This alternative conception of the true SR unambiguously implies that when, in line with the "opportunistic approach" to disinflation, stabilizations are attempted during periods of relative weakness in demand ($\varepsilon < 0$) estimated sacrifice ratios provide an upwardly biased picture of true sacrifice ratios.

5.4. Qualifications

The purpose of this section was to illustrate by means of a simple but precise example that conventionally measured sacrifice ratios very likely present a distorted picture of the employment costs induced by monetary stabilizations. But the analysis is suggestive and illustrative rather than definitive. A more complete analysis of the magnitude and the direction of the resulting biases should, at the very least, acknowledge the existence of supply shocks. An alternate, perhaps more direct, route to deal with this problem is to try to construct measures of sacrifice ratios that separate the movements in inflation and employment that are due to the the disinflation policy from those that would have occured in any case because of non monetary business cycle fluctuations in those variables.

[11] The conceptual foundations of this approach to disinflation are discussed in Orphanides and Wilcox (1996) and a comparison to more deliberate disinflation methods appears in Bomfim and Rudebusch (2000).

6. CONCLUDING REMARKS

The main result of the paper is that **there is a credibility** bonus in the sense that expected social welfare is a monotonically increasing function of CBI and of the (assumed) positively related level of reputation. This holds independently of whether the sacrifice ratio is positively or negatively related to CBI. In addition existing empirical measures of the SR offer poor guidance for evaluation of the **employment costs** of monetary disinflation. The paper also provides an explanation for a possible positive relation between the SR and CBI within the contexts of both the Lucas'(1973) and the new Keynesian paradigms.

The main policy lessons from the paper can be summarized as follows: 1. Even if correctly measured, sacrifice ratios alone do not provide good guidance for the evaluation of the social desirability of CBI. 2. Within the simple reputational framework of this paper CBI cannot be excessive.

My hunch is that these results transcend many of the specifics of the model used here but more sensitivity analysis is obviously desirable. For example, more realism and generality could be gained by allowing shocks of various types as well as imperfect control over the rate of inflation by the CB.[12]

Before concluding two, more general, qualifications are in order. The paper has deliberately abstracted from the welfare benefits of anticyclical monetary policy and from the industrial organization of labor markets. When, due to an information advantage on the part of policymakers, anticyclical policy is feasible the well known Rogoff (1985) tradeoff between credibility and flexibility appears. Rogoff and others have shown that in such a case the optimal level of CBI is usually at an intermediate value.

Second, the discussion in the paper implicitly presumes that labor markets are competitive. In the presence of inflation averse labor unions it may be optimal to have an intermediate level of CBI even in the absence of anticyclical monetary policy (details appear in Cukierman and Lippi (1999) and in Guzzo and Velasco (1999)). But there is no direct relation between those two qualifications and the literature on the empirical association between measured sacrifice ratios and CBI which is the point of departure of this paper.

[12] Such an extension is developed, albeit for different purposes, in Cukierman (2000). It could potentially be used to characterize some of the factors that determine the speed of disinflation and to examine the theoretical reasons underpinning the empirical finding that the SR is lower under "cold turkey" than under gradual stabilizations (see Ball (1994) and Blanchard (1998) for evidence and discussion).

APPENDIX

Proof that there is no pooling equilibrium in a two periods' certain tenure interval

When equilibrium is pooling parameters are such that it pays the weak type to mimic his dependable counterpart. Hence in the first period of the two periods CTI

$$\pi_{w1=}\pi_{d1\equiv}\pi^p. \tag{A.1}$$

Since they know that equilibrium is pooling the public knows that no matter who is the policymaker in office preannounced targets will always be delivered. As a consequence

$$\pi^e_{1=}\pi^t_1 \tag{A.2}$$

which implies that any change in the announced target is fully believed. It therefore pays the dependable policymaker to commit to a zero rate of inflation. As a consequence

$$\pi^p = 0 \tag{A.3}$$

and the corresponding present value of social welfare over a two periods' CTI under a dependable policymaker is given by:

$$-(1+\delta)As. \tag{A.4}$$

If he mimics D a W type gets the same present value. If he deviates to the discretionary rate, Aa, the present value of his objectives over the relevant two periods horizon is:

$$-(1+\delta)As + \frac{(Aa)^2}{2}(1-\delta). \tag{A.5}$$

It pays W to mimic D when the last expression is smaller than the expression in equation (A.4). This is the case, in turn, when

$$\delta > 1 \tag{A.6}$$

Since the discount factor is smaller than one there is no pooling equilibrium. ▌

REFERENCES

Ball, L. N., 1994, What determines the sacrifice ratio? In: Mankiw G. N. (ed.) *Monetary Policy,* University of Chicago Press, Chicago.

Ball, L. N., 1997, Disinflation and the NAIRU. In: Romer C. D. and D. H. Romer (eds.) *Reducing Inflation : Motivation and Strategy*, University of Chicago Press, Chicago.

Ball, L N., G. N. Mankiw, and D. H. Romer, 1988, The new Keynesian economics and the output-inflation tradeoff. *Brookings Papers on Economic Activity* **1**, 1-65.

Barro, R. J. and Gordon R., 1983, A positive theory of monetary policy in a natural rate model. *Journal of Political Economy* **91**, 589-610.

Bernanke, B. S. and F. Mishkin, 1997, Inflation targeting: A new framework for monetary policy? *Journal-of-Economic-Perspectives* **11**, Spring 1997, 97-116.

Blanchard, O., 1998, Optimal speed of disinflation: Hungary. In: Cotarelli C. and Szapary G. (eds.) *Moderate Inflation: The Experience of Transition Economies*, IMF and National Bank of Hungary.

Bomfim, A. N. and G. D. Rudebusch, 2000, Opportunistic and deliberate disinflation under imperfect credibility. *Journal of Money, Credit, and Banking* **32**, 707-721, November.

Clarida, R. and M. Gertler, 1997, How the bundesbank conducts monetary policy? In: Romer C. D. and D.H. Romer (eds.) *Reducing Inflation : Motivation and Strategy*, University of Chicago Press, Chicago.

Cukierman, A., 1984, *Inflation, Stagflation, Relative Prices, and Imperfect Information*, Cambridge University Press, Cambridge and NY.

Cukierman, A., 1992, *Central Bank Strategy, Credibility, and Independence : Theory and Evidence*. The MIT Press, Cambridge, MA.

Cukierman, A., 2000, Establishing a reputation for dependability by means of inflation targets. *Economics of Governance* **1**, 53-76, February.

Cukierman, A. and N. Liviatan, 1991, Optimal accomodation by strong policymakers under incomplete information. *Journal of Monetary Economics* **27**, 99-127.

Cukierman, A. and F. Lippi, 1999, Central bank independence, centralization of wage bargaining, inflation, and unemployment - Theory and some evidence. *European Economic Review* **43**, 1395-1434..

Debelle, G. and S. Fischer, 1994, How independent should a central bank be ? In: Fuhrer J. C. (ed.)*Goals, Guidelines, and Constraints Facing Monetary Policymakers*, Federal Reserve Bank of Boston, Boston, MA.

Feldstein, M., 1997, The costs and benefits of going from low inflation to price stability. In: Romer C. D. and D. H. Romer (eds.) *Reducing Inflation : Motivation and Strategy*, University of Chicago Press, Chicago.

Fischer, A. M., 1996, Central bank independence and sacrifice ratios. *Open Economies Review* **7**, 5-18.

Fischer, S., 1995, Modern central banking. In: Capie F. et. al. (eds.) *The Future of Central Banking*, Cambridge University Press, Cambridge and NY.

Gartner, M., 1995, Central bank independence and the sacrifice ratio: The dark side of the force. *DP number* 9506, University of St. Gallen, Switzerland.

Guzzo, V. and A. Velasco, 1999, The case for a populist central banker. *European Economic Review* **43**, 1317-1344.

Haldane, A. G., 1995, *Targeting Inflation*. Bank of England, London

Hutchison, M. M. and C. E. Walsh, 1998, The output-inflation tradeoff and central bank reform: Evidence from New-Zealand. *Economic Journal* **108**, 703-725, May.

Kydland, F. E. and E. C. Prescott, 1977, Rules rather than discretion: The inconsistency of optimal plans. *Journal of Political Economy* **85**, 473-92.

Leiderman, L. and L. E. O. Svensson, 1995, *Inflation Targets*. CEPR, London.

Lucas, R. Jr., 1973, Some international evidence on output inflation tradeoffs. *American Economic Review* **63**, 326-335.

Orphanides, A. and D. W. Wilcox, 1996, The opportunistic approach to disinflation. *Finance and Economic DP Series*, 96-24, Board of Governors of the Federal Reserve System, May.

Posen, A., 1998, Central bank independence and disinflationary credibility: A missing link? *Oxford Economic Papers* **50**, July.

Rogoff, K., 1985, The optimal degree of commitment to a monetary target. *Quarterly Journal of Economics* **100**, 1169-1190.

Thornton, D. L., 1996, The costs and benefits of price stability: An assessment of Howittt's rule. *Federal Reserve Bank of St. Louis Review*, March/April.