

The Limits of Transparency

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Abstract

This paper probes the limits of transparency in monetary policymaking along two dimensions: feasibility and desirability. It argues that, even central banks that are considered champions of openness are not very clear about their measures of the output gap and about their beliefs regarding the effects of policy on inflationary expectations. This is due mainly to limited knowledge about the economy. It implies that feasibility constraints on transparency are more serious than stylized models of the transmission mechanism would imply. In addition no central bank has made clear statements about its objective function, including in particular the relative weight on output versus inflation stabilization, the policy discount factor and the shape of losses from the inflation and the output gaps over the possible ranges of realizations of those variables. Through discussion of the reasons for this, the paper probes some of the feasibility constraints on transparency.

The second part of the paper abstracts from feasibility constraints and discusses the desirable levels of openness in various areas of the policymaking process like the bank's

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objective function, the bank's output target, forecasts of economic shocks, disagreements within the CB board, the bank's own ignorance and, last but not least, private signals about impending problems in parts of the financial system. The paper distinguishes between areas in which full transparency is desirable from areas in which intermediate levels are desirable.

1 Introduction

Transparency has become a widely acclaimed ingredient of good practice in monetary policy. The consensus view is that it is desirable, not only because it enhances the democratic accountability of the central bank (CB), but also because it affords better control of the public's expectations by the bank. This generally raises the efficiency of monetary policy and in many cases welfare as well. Central banks have become much more transparent than they used to be in the past. This is particularly true of inflation targeting (IT) central banks, many of which expend substantial effort to effectively communicate with the public and to convince it that they maintain a long term commitment to price stability.

Whether they target inflation or not, a main concern of central bankers is to maintain inflationary expectations and their variability at low levels or in their language "to anchor inflationary expectations". In the long run, building a reputation for being committed to price stability is achieved mainly by actually delivering price stability. However, the presumption of inflation targeters is that such a reputation can be built more quickly, and maintained more cheaply, by effectively preannouncing to the public a low inflation target and by living up to it. The hope is that preannouncement of a low inflation target, by putting a question mark on the dependability of policymakers if there subsequently is a substantial deviation from the target, at least partially commits them to achieve it and makes it, therefore, rational for the public to let the announcement influence their expectations.¹ Current wisdom is that, the more open is

¹Formal modeling of this idea appears in Cukierman (2000).

the bank about its goals, procedures and forecasts, the better the chances that the bank will be able to convince the public of its commitment to price stability, reducing the risk of having to go through a renewed costly phase of inflation stabilization.²

There is little doubt that there has been a lot of improvement and systematization in the conduct of monetary policy in many countries during the last fifteen years and that this led to low inflation.³ Transparency was one of the ingredients contributing to this success but it is hard to evaluate its relative share in comparison to other factors like substantial increases in central bank independence (CBI), globalization, the associated large increases in international capital flows, cementing of a consensus that low inflation is good for long run growth and, in some countries like the US, sheer luck in the form of sustained positive technological shocks.⁴ Although transparency is currently hailed as an important feature of best practice policymaking institutions there are several aspects of modern monetary policymaking that are not as transparent as current rethoric would lead us to believe. In addition there are circumstances in which excessive transparency is actually detrimental.

The objective of this paper is to probe the limits of transparency in monetary policymaking along two main dimensions; feasibility and desirability. Some aspects of the monetary policymaking process elude full truthfull public revelation for reasons to be discussed. One way to start to get a grip on those limitations is to examine the extent to which "best practice" central banks are really as open as their current professed enthusiasm about transparency appears to imply, and to use this evidence to flash out some of the objective feasibility constraints

²For inflation targeters transparency is an explicit part of the CB communication strategy. But even non inflation targeting central banks like the ECB and the Fed have recently become more open about their objectives and forecasts.

³A recent brief appraisal appears in Ferguson (2005).

⁴Ball and Sheridan (2004) report evidence supporting the view that there are no significant differences in macroeconomic performance between countries that adopted, and countries that did not adopt inflation targeting. The worldwide increase in delegation of both legal and actual authority over monetary policy to central banks and the reasons for this development are discussed in Cukierman (2005b).

on full transparency. This endeavor is in the spirit of "being transparent" about the feasibility of transparency. Sections 2 and 3 discuss existing limits on openness to the public with respect to economic structure and objectives respectively. To focus on the desirability of transparency, section 4 abstracts from those feasibility constraints by assuming that all forms and levels of transparency are feasible and examines which of those are likely to be optimal. Since the case in favor of transparency is well established the discussion in this part focusses mainly on the drawbacks of transparency.⁵

Before closing this introduction a disclaimer is in order. One should not construe the main message of this paper to be that the substantial increase in CB openness to the public over the last fifteen years was misguided. Given the high degree of opaqueness characterizing central banks twenty years ago and earlier it is highly likely that those changes improved matters.⁶ Rather the main message is that, since sufficiently high transparency is now in place and is part of the orthodoxy, time has come to take a more realistic, and perhaps, more balanced, look at the limits of its feasibility and of its desirability.

2 Opaqueness about the structure of the economy

There is currently a wide consensus that, subject to the constraints inherent in the structure of the economy, the CB should minimize an appropriately discounted value of expected losses where the period loss function is given by a weighted average of the output and the inflation gaps, and where the first gap is the deviation of actual output from its potential counterpart and the second gap is the deviation of inflation from its target.⁷ Transparency about the policy process

⁵See also Mishkin (Undated).

⁶An illustration of the high level of opaqueness typical of the seventies and earlier periods is found in Goodfriend (1986) who documents the substantial legal and other efforts expanded by the Fed to prevent publication of the minutes of the FOMC.

⁷It is recognized that, under special circumstances the bank may want to deviate from this benchmark (a recent discussion appears in Svensson (2003b)). The transparency aspects of such additional complications are

aimed at achieving this objective requires clarity about the structure of the economy. This section identifies two areas in which there is substantial murkiness about the economic structure underlying the choice of policy by the central bank and possible reasons for this murkiness. The first concerns the conceptualization of potential output and its measurement and the second concerns the lag between the choice of policy and its impact on inflation.

2.1 Opaqueness about potential output

Invariably, central banks use traditional measures of potential output which are based on the notion that potential output is a more sluggish variable than actual output. In practice this notion has been implemented by using various statistical smoothing devices like Hodrick Prescott filters or polynomial smoothers.⁸ Other approaches are based on the estimation of production functions sometimes in combination with measures of capacity utilization.

In parallel New Keynesians propose to conceptualize potential output as the level of output that maximizes the welfare of the representative individual under fully flexible wages and prices. The motivation is that, in the absence of other distortions, the flex nominal variables equilibrium is a first best since it eliminates the relative price distortions due to staggering. According to this logic, if monetary policy could induce firms to produce at (or nearer to) the levels of output they would have chosen under fully flexible prices and wages, welfare would be enhanced. But, in the presence of monopolistic competition and/or distortionary taxes the flex nominal variables equilibrium is not necessarily a first best.

To focus on the distortions due to staggering in isolation Woodford (2003, ch. 6) postulates the existence of other instruments (corrective subsidies and taxes) which assure that the flex nominal variables equilibrium is a first best. Under this condition deviations of actual

taken up in section 4.

⁸Those features characterize the business cycle chronology of the NBER, as well as recent attempts to develop a business cycle chronology for Europe (Artis et. al. (2003)).

output from the flexible prices and wages level of output creates distortions that are due only to staggering. The Calvo (1983) formalism makes it possible to characterize those distortions within a real business cycle framework and to demonstrate, using quadratic approximations, that welfare is a decreasing function of the distance between the sticky and the flex nominal variables equilibria.⁹ This notion of potential output has two attractive features. First, it is welfare based. Second it is particularly suited as a target for monetary policy since it directs attention to the temporary relative price distortions that monetary policy can handle relatively efficiently. Unfortunately real world taxes and subsidies are not set at levels that offset the monopolistic competition distortions. Once this is recognized the level of output that maximizes welfare no longer necessarily equals the flexible wage and price equilibrium. Benigno and Woodford (2005) show that in presence of those distortions the weights on the two stabilization objectives and the definition of the welfare-relevant output gap are altered.¹⁰

2.1.1 Is there a connection between traditional measures of potential output and the flexible price and wage equilibrium?

Even if we abstract from the fact that existing taxes and subsidies are not aimed at offsetting the monopolistic competition distortion, the short answer to this question is that, most likely, there is very little or no connection. Getting reliable measures of the flexible price and wage equilibrium level of output is a non trivial task that, at best, is in its infancy. On top of that flexible price/wage equilibria often are more volatile than sticky price/wage equilibria implying that policymakers should aim at making the level of output **more**, rather than **less**, volatile.¹¹

⁹An early formulation of this principle appears in Goodfriend and King (1997) and Rotemberg and Woodford (1997).

¹⁰They also show that, under those conditions, complete price stability is optimal under a narrower set of circumstances.

¹¹Cukierman (2005a). provides examples of cases in which the flexible price equilibrium is more volatile than the sticky price equilibrium.

But most central bankers appear to prefer less volatile to more volatile levels of output. As argued above, the practical implementation of "potential output" used to this day is firmly anchored on the notion that this concept is a smooth version of actual output implying, at least implicitly, that policymakers aim at reducing, rather than increasing, fluctuations in output. It is, therefore, not unlikely that, even if reliable measures of the flexible price/wage equilibrium had been available, most central bankers would resist such a policy. Cukierman (2005a) provides a partial rationalization for such resistance by showing that, in the presence of monopolistic competition on product markets the sticky price/wage equilibrium may welfare dominate its flexible counterpart.

2.1.2 Implications for the state of transparency with respect to the output gap

The previous discussion implies that there is quite a bit of murkiness about the notion of the output gap currently utilized by even the most transparent of central banks. But this is not because of a deliberate attempt by those banks to fool the public. Instead, this opaqueness is a reflection of the fact that there is a lot of uncertainty, within the economics profession, about how to conceptualize and to measure potential output.¹² In addition, the gulf between the conceptually attractive notion of potential output as the level of output that maximizes welfare and the measures of potential output utilized by central bankers in practice compound this uncertainty. Thus, the current state of knowledge about "true" potential output imposes severe objective limits on the ability of central banks to be transparent about the output gap utilized in making monetary policy decisions.

A structured way to think about those limitations is that potential output is a latent variable that has to be inferred from observations on other directly observed variables. An early

¹²This uncertainty is the root cause for the proliferation of methods for measuring it in practice. As emphasized by Kuttner (2004) most inflation targeting central banks do publish estimates of potential output. However the extent to which they base their policy decisions on the output gaps calculated from those figures is unclear.

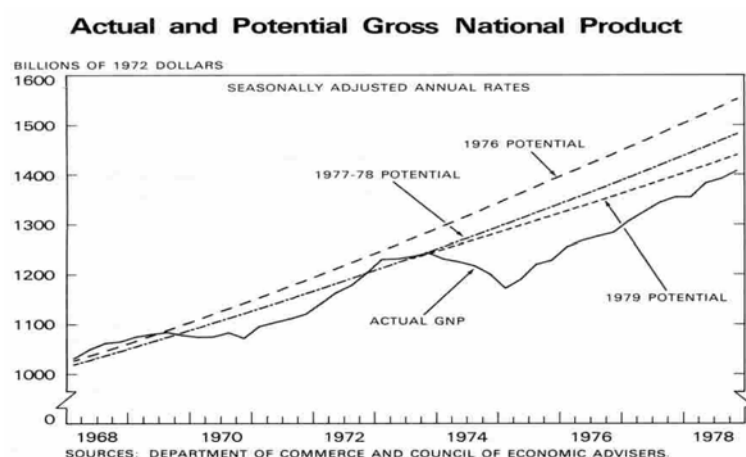
application of this approach to estimate potential output in the US from observations on output and inflation using a Kalman Filter algorithm appears in Kuttner (1994). But in practice central banks use many more signals than just those two variables to "guesstimate" potential output. Due to uncertainty about economic structure, this is often done in a much less structured way than the one implied by the systematic use of a Kalman Filter. Various combinations of judgemental forecasts, constant adjustments and eyeballing of numerous data series are used as well and the weights given to those different pieces of information are not always articulated explicitly even **within** the CB.¹³ Hence, a precondition for external transparency about the output gap is explicit internal articulation of how potential output is conceptualized and measured internally. External transparency requires a relatively simple and easily communicable measure of the output gap. But to produce such a measure it is often necessary to neglect information that could sharpen the internal guesstimate of the output gap. Thus, there is, given current procedures and knowledge, a tradeoff between accuracy in inferring the output gap and external transparency.¹⁴

Due to their inherent unobservability potential output and the output gap are not known with certainty even after the fact. This may lead to persistent policy errors that are recognized as such only much later on. Orphanides (2001, 2003) reports evidence of a significant (real time) overestimation of potential output during and following the oil shocks of the seventies. Enlightening documentation on the ex-post downward revisions of potential output appears in the 1979 Economic Report of the President (Chart 7, pp. 72-76), reported below, which vividly illustrates the magnitude and persistence of the revisions.¹⁵

¹³Two well documented examples of central banks that follow such procedures are the Fed and the Reserve Bank of New-Zealand.

¹⁴An enlightening discussion along those lines appears in Winkler (2000).

¹⁵Figure 2 in Orphanides and Williams (2005) reports a similar phenomenon for the relation between real time and subsequent estimates of the natural rate of unemployment.



Orphanides argues that by leading to a monetary policy stance which turned out to be, with the benefit of hindsight, excessively loose, the real-time overestimation of potential output aggravated inflation during the seventies. Somewhat symmetrically, the strong productivity gains recorded in the United States during the second half of the 1990s raise the possibility that the greater-than-expected increases in potential output could have allowed a less restrictive monetary policy stance than the one implied initially by real time estimates of the output gap and inflation.

Cukierman and Lippi (2005) show that, as a theoretical matter, even if policymakers use the most efficient available dynamic optimization and filtering methods, uncommonly large innovations to potential output will lead to large and **persistent** retrospective policy errors. In the spirit of Faust and Svensson (2001) transparency about such errors requires the expost publications of revised estimates of past potential output levels. Since the estimate of potential output is subject to continuous expost revisions this requires the publication, at each point in time, of the current estimates of all past levels of potential output. Although, in the stylized world considered in Cukierman and Lippi, this is feasible, the binding constraint on full trans-

parency in this case is likely to be the ability and willingness of most individuals in the economy to pay attention to such historical revisions. But once judgemental adjustments of the type discussed above are allowed, the task of providing such ex post revisions becomes difficult, if not infeasible, even for the CB.

2.2 Ambiguities about the lag between the choice of policy instrument and inflation

A working assumption that has become established among relatively transparent central banks is that the current choice of interest rate by the bank will affect inflation only two years down the road and later but **not** within the next two years. This working assumption is widely publicized and constitutes part of the communication strategy of prominent inflation targeters like the Bank of England, the Riksbank and other inflation targeters. Although consistent with purely backward looking economic structures, this working hypothesis is difficult to accept if, as is the case in New-Keynesian frameworks, inflation is at least partially responsive to current expectations of future inflation. In the presence of forward looking elements in the inflation equation, a current policy action is known to have an immediate effect on inflation provided it affects inflationary expectations. At the very least this contradiction between statements to the public and the consequences of forward looking elements does not help transparency regarding the views of the CB about the transmission mechanism.

How can this contradiction be explained? One possibility is that central bankers do not believe forward looking elements are important. Although this might have been the case before the forceful appearance of New Keynesian economics into the realm of monetary policymaking, I believe this is not very likely today, at least not for sophisticated central banks like the Bank of England.¹⁶ Another possibility is that the CB does not believe it can affect inflationary

¹⁶Empirical evidence for both the US (Rudebusch (2001)) and the Euro area (Ehrmann and Smets (2003))

expectations within short notice. Such belief was controverted in another inflation targeting country - Israel - in 2001/2002 when governor Klein reduced the interest rate by two percent and then jacked it back up within several months. Within a month or two of those interest rate changes inflationary expectations changed quite dramatically, first upward following the reduction in the interest rate and then back down, following the increase in the interest rate.¹⁷ Most likely expectations changed because of the signaling information contained in the actions of the CB. This experience suggests that the CB can affect inflationary expectations through the signaling channel which may operate through the interest rate, as well as through other channels. I am pretty confident that most major central banks are well aware of the existence of such signalling channels.

The most likely explanation for the statement about the two years lag is that this is an implicit statement about the unwillingness of the CB to stabilize inflation in the short run by manipulating inflationary expectations. This may be due to the bank's uncertainty concerning the impact of the interest rate (and other signals it might issue) on expectations. Although this position may have merit it is hardly transparent. Claiming that the two years lag is entirely "structural" when at least part of it is, most likely, based on an implicit, but deliberate, decision not to affect short run inflation via inflationary expectations may be efficient but does not appear to be consistent with the high transparency standards some inflation targeters profess to be following. Put differently, they are not as transparent about their own transparency regarding this matter, as one might conclude, at first blush, from their communication strategy.

suggests that, although the weight of forward looking elements is somewhat smaller than that of backward looking elements, it is significantly different than zero.

¹⁷Inflationary expectations in Israel are derived from the difference in yields between indexed and non indexed government bonds and are used as a leading indicator for monetary policy.

3 Opaqueness about segments of the loss function - importance and reasons

Many contemporary central banks have become quite transparent about their inflation target. However, in spite of the publication of inflation reports, minutes, speeches, and prompt press releases following monetary policy decisions, there is precious little public information about the relative importance, α , attributed by central banks to the stabilization of the output gap in comparison to stabilization of the inflation gap. There is also no information at all about the shape of CB losses as a function of those two arguments.¹⁸ This is true even for champions of transparency like the Bank of England (BE). To illustrate, while acting as Executive Director and Chief Economist of the Bank of England Vickers candidly recognized that those attributes of the loss function have not been put in the public domain and argued that it is infeasible to do so (Vickers (1998 p. 370)). To my knowledge this state of affairs has not changed much since 1998. On the other hand Svensson (2002, 2003a), an ardent believer in providing as much information as possible to the public, argues that the time has come for central banks to announce explicit loss functions, including the weight, α , on output-gap stabilization.

3.1 The relative weight on output gap stabilization

It is currently accepted that, whether they explicitly target inflation or not, the central banks of most developed economies act as flexible inflation targeters. In other words they choose the policy instrument so as to strike an optimal balance between the costs of variability in the inflation gap and the costs of variability in the output gap. Knowledge of the parameter α is therefore essential for evaluating how quickly the CB plans to steer the economy back to the

¹⁸ Admittedly, there is a recent academic literature that tries to infer the shape of the loss function from interest rate decisions and data on economic variables. But no information about the loss function has been provided **directly** from CB sources.

inflation target following a cost shock. The larger α , the longer the time period allowed by the CB to get back to the inflation target, and the smaller correspondingly is the variability of output. One formalization of this principle within a forward looking New-Keynesian framework appears in Clarida, Gali and Gertler (1999) but it applies equally well to systems with backward looking or a mixture of backward and of forward looking terms. Information about α is therefore essential for the transparent implementation of targeting rules of the kind advocated by Svensson (2003b) explaining his insistence on explicit formulation of this parameter.¹⁹

In spite of those weighty considerations central banks have resisted, to date, explicit publication of this parameter and, most likely, many even refuse to think in those terms for internal policy setting purposes.²⁰ There are several reasons for this lack of transparency. First, since in most central banks, policy is made by a committee it is normally the case that not all committee members share the same α . Agreeing **once and for all** on a value of α to represent the median or average position of the committee is likely to be a more controversial process than agreeing on the setting of policy at each particular point of time. The greater risk of lack of consensus tends to discourage attempts to reach a once and for all agreement.²¹ But even in the case of a unitary policymaker (either because all the authority is vested in one individual or because all committee members share the same views) the policymaker may shy away from formulating a precise value for α due to the formidable task involved in precise measurement of potential output and the output gap that enters the loss function (those problems were discussed in the previous section). Even a unitary policymaker may rightly hesitate to make a long term

¹⁹Similar arguments apply to the discount factor implicitly or explicitly utilized by the CB. A fuller discussion of transparency about the discount factors appears in the section on the desirable degree of transparency.

²⁰In private correspondence Willem Buiter (a former member of the bank of England Monetary Policy Committee) argues that, according to its charter, the Bank's mandate is clearly lexicographic in price stability. Hence the Bank's objectives cannot be approximated by a linear combination of quadratic functions of the inflation and output gaps.

²¹This difficulty is compounded if, in addition, committee members do not hold similar views about the structure of the economy.

commitment to a relative output gap weight to be attached to a highly unreliable output gap measure.²²

3.2 Shape of losses from the output gap

It is well known and widely acknowledged by central bankers that monetary policy has to be chosen under conditions of uncertainty. Recent restatements of this basic reality for the US and the UK appear, inter alias, in Greenspan (2004) and Bean (2005). It is also well known, that in the presence of uncertainty, rational decisions depend on the shape of the utility or loss function over the **entire range** of losses. Public knowledge about the shape of the CB loss function is therefore essential for the implementation of flexible inflation targeting **frameworks** of the type advocated, inter alias, by Bernanke and Mishkin (1997), King (1999) and Svensson (2003b). However almost all positive and normative analysis of monetary policymaking bypasses the need to know the entire shape of losses by assuming that losses are quadratic around potential output and the inflation target since, in this case, the certainty equivalence and separation principles apply.²³

Since quadratic loss functions are symmetric this amounts to **assuming** that central banks are equally averse to a positive output gap and to a negative output gap of the same absolute size. Recent empirical evidence suggests that during periods of low inflation of the type enjoyed by most industrial economies during the last two decades central banks responded more strongly to anticipated negative than to anticipated positive output gaps, implying that the output gap segment of the loss function rises more steeply with the output gap when the

²²Orphanides (2003) advocates taking the output gap completely out of the loss function because of such measurement problems.

²³A recent formulation of those results in linear economies with forward looking variables appears in Svensson and Woodford (2003). Certainty equivalence means that the optimal policy can be characterized by utilizing an efficient estimate of the state of the economy as if it was known with certainty. Separation means that the filtering and the optimization problems can be solved separately substantially simplifying the calculation of optimal policies and eliminating the need to know the entire shape of the loss function.

gap is negative than when the gap is positive. One implication of this, is that there should be a positive association between inflation and the variance of supply shocks. Cukierman and Gerlach (2003) test this implication empirically in a cross section of OECD countries and find support for it. Using over time data and a different parametrization of asymmetric losses Ruge-Murcia (2003) finds evidence in favor of a precautionary demand for expansions in the US. Anecdotal evidence also supports the existence of such a precautionary demand in the US. Blinder (1998, pp. 19, 20) states that: "In most situations the CB will take far more political heat when it tightens preemptively to avoid higher inflation than when it eases preemptively to avoid higher unemployment". To the extent that the Fed internalizes part of this asymmetry it should behave as if it possesses a precautionary demand for expansions.²⁴

This evidence raises two issues. One is normative and concerns the question of whether the Fed should partly or fully internalize the asymmetry in the preferences of the political establishment, and if so, whether it should be transparent about it. Those who believe that the Fed should respect the wishes of the majority as represented by elected officials would probably answer this question affirmatively.²⁵ The second issue is positive and relates to the transparency of the CB with respect to its loss function. Given the evidence above, and the complete absence of discussion of the shape of their loss functions by central bankers it appears that opacity rather than transparency governs this area. In particular, to my knowledge, no CB has produced a public statement clarifying that its losses are quadratic in the output gap, or alternatively admitted that this function is not symmetric. This raises an interesting positive question about the reasons underlying this opacity. This question is taken up in the next subsection.

²⁴Additional implications of asymmetric loss functions and evidence is surveyed in Cukierman (2004).

²⁵A broader discussion of this question appears in the next section on the desirable level of transparency.

3.3 Reasons for opacity about the output gap segment of the loss function

There are two possible, not necessarily mutually exclusive, reasons for opacity about the output gap segment of the loss function. One is that central banks are reluctant to state their preferences in terms of a variable that is subject, as we saw above, to serious conceptual and practical problems of measurement. Not the least of these is the fact that potential output, which is an essential component of the output gap, is not directly observable, not even on an ex post basis. As a consequence, a policy that appears as sensible in real time is judged with the benefits of hindsight, to have been a mistake. During periods of significant changes in potential output such ex post errors are quite substantial as shown empirically by Orphanides (2001) and analytically by Cukierman and Lippi (2005).

The second reason is that, in the presence of uncertainty about future shocks to the economy, the existence of asymmetric (in the output gap) CB preferences that are perceived by the public, leads to an equilibrium that exhibits an inflation bias even if the CB output target is equal to potential output on average (Cukierman and Gerlach (2003)).²⁶ Ruge-Murcia (2003) finds that this "precautionary" explanation of the bias provides a better description of US inflation during the last forty years than the classical Kydland-Prescott (1977), Barro-Gordon (1983) (KPBG) story in which the bias is due to a target level of output **systematically** above potential. Since the "precautionary bias" is less visible than the (currently) well known KPBG bias and since rates of inflation during the last decade have been remarkably low, most of the general public is likely to buy Blinder's (1998, p. 43) and Vicker's (1998) claim that, since the CB targets potential output, there is no bias. When this is the case, the bias may actually be smaller providing a potential explanation for the reluctance of some CB to be transparent about

²⁶The intuitive reason is that, since the CB is more averse to negative than to positive output gaps, monetary policy is biased towards expansionism. Under rational expectations this leads to an equilibrium in which both expected and average inflation are higher than the inflation target.

possible asymmetries in their objective functions.

4 How much openness should there be and with respect to what?

Previous sections have documented several areas in which even best practice central banks are not totally transparent and used those in order to probe the objective limits of transparency. This section abstract from those limits in order to focus on the the desirability of openness in various areas of the policymaking arena. In some instances the maximal level of openness or transparency appears to be optimal but in others full transparency is not necessarily optimal.

The case in favor of secrecy is particularly compelling when the CB possesses private information about threats to financial stability and much less so during normal times when the bank focusses only or mainly on flexible inflation targeting. Nonetheless, even in such times there are cases and issues with respect to which the optimal level of transparency is likely to be intermediate. This section illustrates some of those cases by selectively reviewing the recent literature on this issue. In other cases questions are raised but no firm position, one way or another, about them is taken. To some extent this reflects the fact that existing literature has been largely silent on those issues.

4.1 Openness about problems within the financial system

Central banks first came into being in order to avert financial crises and the related extreme fluctuations in interest rates. They were, and still are, expected to fulfill this function by acting as lenders of last resort in the face of extreme events that could endanger financial stability. The swift expansionary policies followed by the Fed following the stock market crash of 1987, the currency crises of 1998 and the September 11 2001 tragedy are dramatic attestation to the

fact that financial stability considerations occasionally become quite prominent. Most modern central banks are also legally responsible for maintenance of financial stability and normally obtain advance signals about threats to the stability of the financial system. The currently popular quadratic loss functions that depend on the output and inflation gaps obviously abstract from the financial stability objective that occasionally should affect monetary policy.

Two transparency related issues arise in this context. The first is whether it is desirable to specify in advance the contingencies and precise course of action to be followed by the bank in the event of threats to financial stability and the second is whether the bank should disseminate its private information about such threats in real time. The first question falls under the general heading of openness about deviations from simple rules and is taken up in a subsection carrying this name below. The current subsection focusses on the second issue.

In my view, it is, counterproductive and highly risky to publish advance signals about potential problems in parts of the financial system. Such publication may induce a run on the banks or other unpredictable movements in other parts of the financial system, thus forcing the bank to take more expansionary steps in defense of the system than in the case in which the information is temporarily withheld. In extreme cases it may even trigger a crisis that would have been averted in the absence of immediate openness. Even if the bank is able to take all the steps necessary to avert a crisis, publication of advance warnings may be misinterpreted by the public and lead to a panic.

It therefore appears that there is a strong case for withholding of advance signals about problems in the financial system from the general public until after the appropriate policy instruments have been successfully deployed. But once the crisis has been averted considerations of democratic accountability and of learning from past mistakes dictate openness. However the length of time till full dissemination of details will inevitably vary across different episodes and be subject to discretion.

The appendix illustrates those ideas more precisely by comparing welfare under a regime

of immediate transparency about potential solvency problems in the banking sector with welfare under a regime of delayed transparency about such problems. This is done by introducing a public signal into the Diamond and Dybvig (1983) model of bank runs.

Their model has three periods labelled 0, 1 and 2. In period 0 each individual deposits his funds in the bank without knowing whether he will be subject to a liquidity shock in period 1 or not. If he is subject to such a shock, he gets utility from consumption only in period 1. Otherwise he gets utility only from consumption in period 2. The productive technology is such that for each unit invested in period 0 and kept till period 2 (a long term investment) the return is $R > 1$. If interrupted in period 1 the salvage value of this investment is just 1. In the absence of runs, the demand deposit contract (DDC) raises welfare by optimally allocating consumption over time in the face of liquidity shocks while allowing all resources not allocated to satisfy liquidity demands to remain in the form of, high yield, long term investments.

In period 1 the CB gets a private signal suggesting there is a positive probability that the bank will be insolvent in period 2. Under immediate transparency this information is transmitted to the depositors already in period 1. Under delayed transparency, they learn about it only after the end of period 2. The appendix shows that, provided depositors were originally coordinated on the good no runs equilibrium, this equilibrium will prevail in the face of delayed transparency. Under the same circumstances and for reasonable parameter values, immediate transparency will trigger a run on the bank, interrupting long term investments, eliminating their associated high returns, and destroying the optimal insurance scheme provided by the DDC in the absence of runs.

Given the fundamentals, a factor that raises the probability of a socially inefficient run on the bank is the fact that, when hearing a public CB signal, each individual takes into consideration that all other individuals have also heard the same signal. Since each individual has a stronger incentive to withdraw funds when he believes the likelihood the others will do the same is higher, an adverse public signal about the bank's solvency coordinates individuals to

simultaneously run on the bank. This strategic complementarity compounds the adverse effect of immediate transparency about potential solvency problems.²⁷

This contrasts with the beneficial effects of transparency and coordination of private actions through public signals in the presence of investment complementarities stressed by Angelotos and Pavan (2004). The basic reason for the difference is that coordination of beliefs and actions in Angelotos and Pavan leads individuals to partially internalize external investment complementarities while here the coordination of beliefs and actions leads to the destruction of an optimal risk sharing arrangement.

4.2 Openess about the form of the CB loss function

Full transparency about the dynamic loss function of the CB requires clear formulation of the relative weight on output versus inflation stabilization, α , the discount factor between current and future objectives, β , and the shape of losses from both the inflation and output gaps.²⁸ In the absence of efficiency arguments against transparency, democratic accountability implies that the bank should be as open as possible about each of those components of the loss function. I am not aware of any efficiency arguments against openness with respect to both α and β . As a matter of fact, in the case of β there is even an efficiency argument in favor of openness in addition to democratic accountability. Full disclosure of β is likely to reduce, politically motivated, short term influences on CB policy thus raising de facto CB independence and credibility.

Current academic wisdom with respect to the shape of losses from the inflation and the output gaps is that they should be specified as being quadratic. The main virtue of such a specification is that it is tractable and leads to clear instrument rules. Are there arguments

²⁷Related and other consequences of informative public signals within a framework with both private and public signals are discussed in Morris and Shin (2005).

²⁸It will be recalled that, due to uncertainty, policy choices generally depend on the form of losses over the entire support of possible realizations of the inflation and output gaps.

against the quadratic? I do not see much harm in using the quadratic approximation for the inflation gap once the credentials of the CB as being committed to low inflation have been established. However during periods of inflation stabilization and credibility building it may be optimal to conduct policy as if upward deviations from the inflation target are more costly than downward deviations.²⁹

How about the specification of losses from the output gap? Here, the case for using the quadratic approximation is more problematic. At the conceptual level it is not clear at all why the output gap segment of the loss function should be symmetric. In particular why, **given inflation**, central banks should care to the same extent about positive and negative output gaps of the same absolute size is quite mysterious. I suspect that the main reason is the analytical tractability and the nice properties of quadratic loss functions, including in particular, certainty equivalence and the separation principle. One possible defense of the quadratic, along the lines of Woodford's (2003) impressive microfoundations, is that this is an approximation of the welfare of the representative individual. But if this individual possesses a precautionary demand for expansions - - in the sense that he is more averse to a measured negative than to a measured positive output gap of the same size - - the quadratic approximation might be missing an important component of welfare.

4.3 Openess about the output target of the CB

Some of the recent literature considers the possibility that the output target of the CB changes over time and that the CB has private information about the idiosyncratic fluctuating level of this output target. This target may fluctuate due to changes in the composition of the policymaking board, changes in the intensity of political pressures and changes in the bank's

²⁹This appeared to have been the actual policies of the Fed, the BE and the Bank of Israel during the stabilization of their respective inflations.

evaluation of unobservable economic fundamentals like potential output. The CB can choose to reveal all or part of those fluctuations to the public immediately or with some lag. Unless the bank establishes credible and fully transparent lines of communication with the public, even past changes in the output target are not fully revealed ex post through economic outcomes. The reason is that inflation control errors prevent the public from inferring CB prior intentions with full precision.

Faust and Svensson (2001) characterize the degree of transparency about the output target as the fraction of the variability of the control error that is revealed ex post to the public. The higher this fraction, the more precise is the public's subsequent forecast of future CB intentions, its output target and consequently inflation. When this fraction (labelled τ) is one the control error is revealed to the public with full precision and when it is zero none of it is revealed. Obviously, τ may assume any intermediate value between those two extremes. The higher it is the higher is the level of transparency. The CB is assumed to minimize the present value of losses associated with the deviations of inflation and of output from their respective targets.³⁰ Social welfare is taken to be represented by some appropriate average output target that does not depend on the idiosyncratic fluctuations in the output target of the CB.

Using a neo-monetarist transmission mechanism Faust and Svensson search for the socially optimal level of transparency as characterized by the value of τ . Due to the dynamic nature of the model and the requirement of rational expectations it is hard to characterize the optimal level of transparency analytically. Instead Faust and Svensson present results from a grid search of 100000 parameter combinations which suggest that, in about 80 percent of the cases, the unconditional expected present value of social losses is minimized under full transparency ($\tau = 1$). A main reason for this result is that, higher transparency, reduces the incentive of the CB to inflate, and with it the KPBG inflation bias.

³⁰For simplicity the inflation target is assumed to be zero and known with certainty by the public.

But this welfare dominance of full transparency about the CB output target is not robust with respect to the transmission mechanism of monetary policy postulated. In particular, when actual inflation is determined by the decentralized decisions of monopolistically competitive firms with partially sticky prices, as is the case in New-Keynesian models, current inflation depends, *inter alia*, on expected future inflation. As a consequence wider fluctuations in expected inflation cause wider fluctuations in actual inflation forcing the CB to direct its single policy instrument (the interest rate in this case) more towards stabilization of inflation and less towards stabilization of output. This generally raises the variabilities of both variables and worsens the tradeoff between the variability of inflation and that of real economic activity. But higher transparency about the fluctuating output target causes more variability of inflationary expectations which translates, through this mechanism, into a less desirable tradeoff between the variabilities of inflation and of output.

On the other hand, higher transparency, by reducing the incentive of the CB to stimulate output reduces the bank's inflation bias. Thus, more openness about the CB output target induces a familiar, Rogoff (1985) type, tradeoff between credibility and stabilization policy but through a different mechanism than the one considered by Rogoff. Those intuitive arguments are demonstrated precisely in Jensen (2002) who combines the Faust Svensson (2001) information structure with a framework in which actual inflation depends on future expected inflation. The upshot is that, in the presence of forward looking elements in price formation the optimal level of transparency about the CB output target may be attained at an intermediate level. This will be the case if the marginal credibility benefit of higher transparency decreases with the level of transparency, while the marginal cost, in terms of reduced stabilization ability rises with it.

Geraats (2005) also considers a framework in which actual inflation depends on expected inflation and in which transparency is characterized by the fraction of the output gap target that is revealed on average to the public through a noisy signal. Using a static framework she allows actual and perceived transparencies to differ by deviating a bit from the customary assumption

of rational expectations. In particular, she allows public perceptions about the variances of the output gap target and of the noise in the signal about this target to differ from the actual variances. As a consequence actual and perceived levels of transparency about the output gap target generally differ implying that the CB may send highly transparent signals that have little effect on inflationary expectations if perceived transparency is low.

Geraats (2005) shows that when actual and perceived transparencies are decoupled in this way, the CB has an incentive to choose maximum actual transparency and minimal perceived transparency. In other words the CB has an incentive to downplay the significance of its own statements about its output target in order to reduce their impact on the variability of inflationary expectations and, through them, on the variability of inflation. Although Geraats model is highly stylized it suggests that if the bank's statements are perceived to be more opaque than they really are the bank has no incentive to dispel such a belief.

4.4 Openess about forecasts of economic shocks

Obviously the question in the title is relevant to the extent that the CB has an information advantage about some shocks to the economy. The following discussion presumes this is the case.³¹ An important argument in favor of full and immediate release of this information is that it reduces the public's uncertainty about future inflation. On the other hand, depending on the relevant transmission mechanism in effect, full and immediate release of the bank's advance information about shocks reduces its ability to stabilize economic activity and inflation around their repective targets, or increases the magnitude of interest rate fluctuations required to achieve given levels of inflation and of output variability.

The basic reason is that, in the case of flexible inflation targeters, the CB aims to attain

³¹Romer and Romer (2000) present evidence that is consistent with the view that the Fed possesses such an information advantage.

two targets with one policy instrument. Although this does not create a tradeoff between inflation and output variability in the face of demand shocks it does create such a tradeoff in the face of supply shocks. In the second case, temporary withholding of private information about such shocks improves the tradeoff between inflation and employment variability in the presence of a neo-monetarist transmission mechanism. In the case of a neo-Keynesian transmission mechanism delayed publication of information about shocks does not alter the tradeoff between the variabilities of inflation and employment.³² But it allows the bank to attain the same combination of variabilities with smaller fluctuations in the interest rate. Since wider fluctuations in interest rates may reduce financial stability, immediate release of information about shocks may not be desirable also in the presence of a neo-Keynesian transmission mechanism.

The intuition underlying those results follows. In the case of a neo-monetarist transmission mechanism monetary policy affects the economy through unanticipated inflation. Given a particular supply shock, private information about the shocks gives the bank additional leverage in tailoring the size of the inflationary surprise to the magnitude of the realized shock in a way that, except for extreme cases, reduces the absolute value of the deviations of both inflation and employment from their respective targets. In the case of a neo-Keynesian transmission mechanism, monetary policy impacts the economy via changes in the nominal rate of interest which, given inflationary expectations and sticky prices, translates into changes in the real rate. The change in the real rate then affects output and through it the deviation of output from its target as well as the output gap which then affects inflation. Since the transmission mechanism does not operate via unanticipated inflation the tradeoff between the variabilities of inflation and of output is not affected by the release of information in this case. But, advance release of information raises fluctuations in inflationary expectations. Consequently achievement of the path of real rates chosen when information is withheld now requires wider fluctuations in the

³²The main difference between a neo-Keynesian and a new-Keynesian framework is that the former does not feature expected future inflation in the inflation equation whereas the latter does.

bank's nominal rate of interest. Further details appear in Cukierman (2001) and in Gersbach (2003).

In summary, there are arguments both in favor of, and against immediate release of private information about supply shocks. To the extent that the marginal benefits of transparency decrease, and its marginal costs increase with additional increases in the level of openness about supply shocks, the optimal degree of openness about such shocks is likely to be at an intermediate level.

The previous subsection has reviewed several frameworks in which the output target of the CB is private information. One (of several possible) reasons is that the output target of the bank is potential output but, due to the inherent unobservability of this variable and the constant arrival of new signals, the CB changes its estimate of potential output. Even if the output target of the bank changes only because it receives new information about the economy, the arguments of the previous subsection still apply. This implies that, in the presence of forward looking elements in the inflation equation, the optimal degree of openness about potential output may be at an intermediate level.

4.5 Openess about disagreements within the CB policy board

In most modern central banks decisions are made by a monetary policy committee. Prominent examples are the FOMC in the US, the Monetary Policy Committee (MPC) in the UK and the Governing Council (GC) of the ECB in the Euro area. Obviously, committee members may disagree on various dimensions of the policy process like the economic outlook, the relative importance of inflation versus output stabilization and the balance of inflationary risks in comparison to the risk of recession. The question taken up in this subsection is how open should the CB be about the precise details of those disagreements.

The main argument in favor of full and speedy disclosure of the views of each committee

member is democratic accountability. But speedy publication of all the arguments raised by different committee members for or against a given policy also has serious drawbacks. First, it may give to the non specialist general public, the impression that the monetary policy process is more uncertain than it really is. Sims (2002) argues realistically that most of the public is rationally inattentive. But, due to the tendency of the press to highlight conflicts, the public is more exposed to them than to routine developments and most people tend to pay more attention to conflictual than to other situations. Thus, rational inattention is more likely to apply to consensual situations distorting the public's view of the degree of cohesion within the CB policymaking body. Second the knowledge, by committee members, that their positions and arguments will become public information within a short period of time may inject short term political and personal career factors into their deliberations and voting behavior. This is likely to contaminate the monetary policy process with considerations other than the public interest.³³

It thus appears that the optimal level of transparency as reflected, *inter alia*, in the publication of minutes and of the individual votes of committee members is very likely to be at an intermediate level. This was highlighted by an exchange between Willem Buiter (1999), member of the Bank of England MPC at the time, and Otmar Issing (1999) from the Governing Council of the ECB, during the early days of the ECB. As is well known, the Bank of England publishes minutes and votes of individual committee members while, to this day, the ECB does not. Buiter argued in favor of publication of both items while Issing argued against. Issing did not take a position in favor of full opacity but opposed the publication of votes. In reaction to a previous version of this paper Buiter expressed the view that transparency should be as high as feasible on grounds of democratic accountability in all branches of government including the CB. This still leaves open the possibility that, from the point of view of the efficiency of monetary

³³Sibert (2003) considers the effects of vote publications on the private incentives of committee members to build up reputation for toughness against inflation under the (implicit) assumption that the public is equally attentive to all the information items released by the CB.

policy, the optimal level of transparency in this area may be intermediate. The appropriate level may well vary between different countries depending on their political systems, fiscal institutions and economic shocks.

Prior to reaching a decision policy discussions and disagreements within a committee are a healthy manifestation of efficient decision making and democratic principles for two reasons. First it allows information pooling and a better understanding of the tradeoffs involved by more committee members. Second it makes it possible for different views regarding the relative social costs of alternative objectives to affect policy choices. But, once a democratic decision has been made it is, in my view, important that the Bank's leadership speak with largely one voice. Excessive real time publicity of professional and other disagreements may undermine the long term credibility of the Bank reducing its effectiveness as a flexible inflation targeter. In this respect I am in agreement with the following statement.

"Longer-term, it would appear preferable to build up credibility and a reputation for the institution as a whole, rather than to tie it too closely to the particular individuals at the helm" (Issing (1999)).

However, after sufficient time has elapsed detailed records of the decision making process should become publicly available, both for democratic accountability reasons, as well as to make it possible to learn from past mistakes.

4.6 Openess about deviations from a simple rule

One advantage of simple rules is that they are easily communicable to the public making it easy to maintain transparency about the strategy to be followed by the CB. During normal times a simple Taylor type rule in which the CB responds to some combination of the inflation gap, the output gap, and the lagged value of the interest rate may suffice. However, in the presence of unusual events which threaten the stability of the financial system, the bank may

want to respond to other variables as well. For example, it may be efficient for monetary policy to respond to sufficiently large domestic or international financial crises, abrupt changes in stock market values or major terrorist attacks of the September 11 type. Such events cannot be predicted or even clearly formulated in the form of specific contingencies in advance.

As eloquently argued by chairman Greenspan (2004) in his address to the AEA, in the face of such Knightian uncertainty, it is hard or even impossible to formulate in advance the course of action to be followed by the bank. Even a staunch believer in transparency like Svensson recognizes that there may be instances in which it will not be possible or desirable to credibly communicate the reaction function of the CB to the public in advance. The reason is that such a commitment may unnecessarily tie the hands of the CB when some completely unexpected events realize. To address this problem Svensson (2003) proposes a "general targeting rule" in which only the target variables, the targets and the loss function are specified without any commitment to a particular reaction function.

Thus, in the presence of Knightian uncertainty, there is a fundamental tradeoff between being fully transparent *ex ante* about how policy will be conducted and being able to react efficiently to events that could not have been formulated sufficiently precisely in advance. It is very likely that in such situations the full transparency associated with the formulation of a reaction function that depends **only** on events that can be clearly formulated in advance will not necessarily be optimal since it restricts the ability of the bank to efficiently react to isolated but important events that cannot be accurately formulated in advance.

4.7 How open should the bank be about its own ignorance?

As we saw in some of the earlier sections central banks operate under substantial uncertainty with respect to the structure of the economy, the measurement of economic variables, the consequences of their actions and, to some extent, even with respect to their own internal forecasts

and objectives. One danger is that, while attempting to be as open as possible, the bank may give the impression to the public that it knows more than it actually does. In particular, the obligation to be totally open to the public may lead to rationalization of decisions via econometric models that do not not fully reflect the information that has led to a particular forecast or decision.

As argued by Alan Budd (1998, p. 382.), a member of the Bank of England Monetary Policy Committee at the time, the inflation forecast produced by the bank relies on both formal and informal methods and is based on inspection of many more variables than those that enter into the bank's econometric model.³⁴ However, for the purpose of external communications it may be more expedient to appeal only to the econometric model. The Bank of England is aware of the risk that it may appear to be more confident than it really is and tries to reduce it by publishing fan charts that are supposed to transmit some of the limits of the bank's knowledge to the public. Those procedures are useful and pointed in a sensible direction. But they underscore the fact that, even when it sincerely tries to be transparent, the CB navigates on a narrow line between being clear and concise and between full openness about its own limitations and internal procedures.

5 Conclusion

There has been a dramatic transformation in the attitude of central banks to openness during the last two decades. In the case of the Fed this is vividly illustrated by two statements made by the same chairman - Alan Greenspan - at a fifteen years interval. In a 1987 testimony to Congress Greenspan says:

"Since I have become a central banker I have learned to mumble with great incoherence.

³⁴Since the point estimate of inflation also reflects the information not incorporated into the econometric model, the consequences (but not the details) of this information for the forecast are transmitted to the public.

If I seem unduly clear to you, you must have misunderstood what I said".³⁵

Fifteen years later in opening remarks at a conference on transparency at the Federal Reserve Bank of St Louis he says:

"Openness is an obligation of a central bank in a free and democratic society" (Greenspan (2002), p.6).

In spite of those advances contemporary CB are not as transparent about important aspects of their decisions as some of them profess to be. Paraphrasing Shakespeare's famous phrase from Julius Ceasar (about the name of honour) the most vocal advocates of transparency appear to like its name somewhat more than what they are able or willing to deliver in practice.³⁶ Following the introduction, the first two sections of the paper try to distinguish cases in which this is due to objective constraints from other cases and, in the second class of cases, to evaluate whether departures from full transparency are justified. A subsequent section abords the difficult question of the optimal degree of transparency in various areas of the monetary policymaking process. The broad conclusion here is nuanced in the sense that, in some areas of the monetary policymaking process, full transparency is desirable. But in other areas the optimal level of transparency is likely to be at an intermediate level.

Evaluation of the degree of transparency of central banks about some aspects of the economic models they use, reveals that even the most vocal supporters of transparency are rather vague about potential output and the effect of their policies on the formation of inflationary expectations. To a large extent this reflects their limited knowledge about potential output and the short run impact of interest rate changes on inflationary expectations rather than

³⁵I owe this quote to Geraats (2005). One interpretation of the quote is that Greenspan was trying to ridicule the tendency of the Fed to be secretive but an equally plausible interpretation is that he was just conveying the, then current, state of affairs without taking a position on it.

³⁶In their evaluation of inflation targeting regimes Faust and Henderson (2002) reach a broadly similar conclusion. Ben Friedman (2003) argues that the very designation of the policy framework utilized by flexible inflation targeters as "inflation targeting" is itself not fully transparent since it highlights one component of the CB objective function and largely neglects to mention the output target component.

deliberate withholding of information. In other words, the "science of monetary policy" is not yet in a stage at which it can replace the "art of monetary policy". A broader aspect of this is the fact that the economic structure changes over time and it takes time to detect those changes and to incorporate them into explicit models. In the mean time policymakers use constant adjustments, eyeballing and other rules of thumb. As a consequence there are feasibility constraints on transparency and central banks retain discretion.

Even the most open contemporary central banks are remarkably silent about the relative weight they assign to output versus inflation stabilization, their policy discount factor and the shapes of losses from the inflation and output gaps over the possible ranges of realizations of those losses. It is likely that this is due to a combination of feasibility constraints, as well as of a belief, that in some areas, excessive openness is harmful. One difficulty in putting those attributes of the loss function in the public domain is that, in most central banks, policy decisions are made by committees whose members are likely to have different priorities. Putting all this information in the public domain requires, first that the board members would agree to formulate their policies in such terms, and given the first condition, that they agree on the loss function parameters before they observe the state of the economy. I suspect that most board members of modern central banks are likely to resist such "systematization" of monetary policy.

I close the paper with a remark about one likely perverse effect of high transparency about short term fluctuations in inflation when credibility is high. Once the credentials of the CB as a guardian of price stability are well established most of the public is unlikely to pay day to day attention to fluctuations in the rate of inflation.³⁷ An important exception to this statement is that individuals in the financial community continue to monitor inflation, and in particular the views of the CB about its future path, not because they care much about its precise low

³⁷The public is rationally inattentive. Using Shannon's information theory, Sims (2002) proposes this idea as a complement to Lucas' aggregate-relative confusion and sticky prices theories of the effects of money on output

level, but in order to sharpen their forecast of future changes in the short term interest rate. In a low and credible inflation environment, the individuals that monitor inflation are those who have a particular stake in short term fluctuations in the CB rate while the others pay little or no attention to it. Widely publicized inflation reports sensitize the rationally inattentive individuals to inflation, leading to wider fluctuations in inflationary expectations. As explained in subsection 4.3, in the presence of forward looking elements in price formation, this worsens the policy tradeoff between stabilization of inflation and of output.

6 Appendix: The effect of a public signal in a variant of the Diamond Dybvig model of bank runs

This appendix illustrates some consequences of immediate transparency about potential solvency problems in banking for the ability of banks' demand deposit contracts to efficiently provide liquidity insurance while enabling individuals to take advantage of higher returns on long term investments. This is done within the context of a Diamond Dybvig (1983) demand deposit contract.

Their model has three periods (0, 1 and 2), a single homogeneous good and a continuum of individuals on the $(0, 1)$ interval. Each individual is endowed with one unit of the good in period 0 and none in subsequent periods, and has access to a productive technology that yields $R > 1$ in period 2 for each unit invested in period 0. If production is interrupted in period 1 the salvage value is just the initial investment.

To model unexpected demand for liquidity each individual is assumed to derive utility from consumption only in either period 1 (a type 1) or only in period 2 (a type 2). The type is revealed to the individual only in period 1 and remains private information throughout the three periods. Thus, due to liquidity shocks, type 1 individuals have to discontinue their two

periods investment, and forego the higher return on their long term investments. Except for this difference everybody is alike. In particular, a type 1 individual possesses a strictly concave utility function $u(c_1)$ and a type 2 individual possesses the utility function $\rho u(c_2)$ where $1 \geq \rho \geq R^{-1}$. $u(c_t)$, $i = 1, 2$, is assumed to display relative risk aversion larger than one everywhere.³⁸

Expost a fraction $t \in (0, 1)$ of individuals turns out to be of type 1 and each agent has an equal and independent probability of being of this type. In the absence of aggregate risk, and provided there is expost observability of types, there is room for efficient pooling of risks across individuals. Such pooling allows a fraction $1 - t$ of individuals to maintain their long term investment while providing liquidity to the type 1 agents when they need it. Diamond and Dybvig show that in such a case the optimal insurance contract would provide $c_1^* > 1$ to types 1 and $R > c_2^* > c_1^*$ to types 2. This contract makes it possible to exante smooth consumption between the high and the low return periods and affords, therefore, higher utility than the autarkic equilibrium. However, since types are not observable expost such an optimal insurance contract is not feasible.

Diamond and Dybvig show that, in the absence of bank runs, the allocation achieved via the optimal insurance contract can also be achieved by a demand deposit contract (DDC) that allows each agent to withdraw a fixed claim equal to c_1^* in period 1 or a fixed claim equal to c_2^* per unit deposited in period zero. Since the bank has access to the same technology as individuals, it invests all the deposited funds for two periods but liquidates a part, as needed, in order to accommodate withdrawal demands in period 1. An essential feature of the DDC is that withdrawals tenders are served sequentially in random order until the bank runs out of assets. The DDC has (at least) two possible equilibria. One in which all type 1 agents withdraw c_1^* each in period 1 and all type 2 agents withdraw c_2^* in period 2. Feasibility of this contract implies

³⁸The utility function is also assumed to satisfy the Inada conditions, $\lim_{c_i \rightarrow 0} u'(c_i) = \infty$ and $\lim_{c_i \rightarrow \infty} u'(c_i) = 0$ where the primes denote partial derivatives.

that

$$(1 - t)c_2^* = (1 - tc_1^*)R. \quad (1)$$

$(1 - tc_1^*)$ represents the amount of resources left in the long term investment after the bank has satisfied the liquidity demands of type 1 individuals in period 1. The bank realizes a return R on those. Hence total resources for distribution in the last period are $(1 - tc_1^*)R$ making it possible to pay out $c_2^* = \frac{(1 - tc_1^*)R}{1 - t}$ to each individual in the second period. Efficient allocation of resources across periods (and types) implies

$$u'(c_1^*) = \rho R u'(c_2^*) \quad (2)$$

Equations (1) and (2) jointly determine the parameters, c_1^* and c_2^* of the Diamond-Dybvig DDC.³⁹ This equilibrium dominates the autarkic equilibrium by allowing a welfare superior allocation of consumption between the high and the low return periods and the types.

The second equilibrium is one in which, fearing that the bank will run out of assets in period 2, the type 2 agents also withdraw their deposits in period 1. When all individuals try to withdraw their deposits in period 1 the bank is prevented from taking advantage of the high return, R , and eventually runs out of assets already in period 1. Those that come first get c_1^* each and the rest get nothing making it individually rational for all individuals to withdraw in period 1. Anticipating such an equilibrium all individuals run on the bank in period 1. This destroys the risk sharing among agents and eliminates the possibility of obtaining the higher return, R , since all long term investments are interrupted. To the extent that they anticipate this adverse equilibrium, individuals do not deposit any funds at the bank in the first place, eliminating the risk sharing and consumption smoothing afforded by the DDC.

As stressed by Morris and Shin (2003) and others which of the two equilibria will actually

³⁹The Inada conditions assure that both c_1^* and c_2^* are positive.

obtain crucially depends on what each individual believes about the beliefs that other individuals hold regarding the nature of equilibrium. When a single individual believes that other individuals believe the second equilibrium will arise it is individually rational for him to run on the bank in period 1. When this the case for all individuals, they all withdraw their deposits in period 1 and the "run on the bank" equilibrium is therefore a self fulfilling prophecy. On the other hand, if each individual believes that only type 1 individuals will withdraw their funds in period 1 it is individually rational for him to withdraw his funds only if he is a type 1. In this case the good, optimal risk sharing equilibrium, is implemented by the DDC. Since, in this case, the DDC welfare dominates the autarkic equilibrium, individuals will deposit funds at the bank even if there is a positive probability of a run provided this probability is not too large.

Suppose now that in period zero all individuals believe that the good equilibrium will arise. Hence they all deposit their resources in the bank. Suppose further that in period 1 the CB obtains private information indicating that, due to moral hazard problems or inefficient management at the bank, there is a probability, θ , of insolvency in which the return on the assets of the bank in period 2 will be only $r_2 < R$. Consider now the consequences of two alternative regimes. An "immediate transparency" regime in which the CB releases this information already in period 1 and a "delayed transparency" regime in which this information is released only at the end of the second period, after the actual realization of the return in period 2.

In the first case each individual learns that there is a positive probability that the bank may not be able to pay c_2^* to each individual in period 2. The expected value of funds held at the bank till period 2 now becomes

$$c_2^r \equiv \frac{(1 - tc_1^*)}{1 - t} ((1 - \theta)R + \theta r_2) < \frac{(1 - tc_1^*)}{1 - t} R = c_2^*.$$

When θ is sufficiently large and/or r_2 sufficiently low, $c_2^r < c_1^*$. In such a case, even if he continues to believe that all other type 2 agents do not withdraw in period 1, it pays each type 2 individual

to withdraw his funds in period 1 and carry them over, using his own costless storage technology, to consume in the second period. In this case immediate transparency precipitates a run even if each individual is not fully rational in the sense that he does not adjust his belief about the beliefs of others in view of the public signal emitted by the CB. With full rationality the public signal also shifts each individual belief about the beliefs of other towards a higher likelihood of a run. This may induce a run even when $c_2^r > c_1^*$.

Under the delayed transparency regime there are no runs in period 1. If the insolvency state does not realize, all type 2 individuals are paid in line with the DDC in period 2 and the first best insurance scheme is implemented. If the insolvency state does realize some of the type 2 individuals get paid less than c_2^* . In this case, although some resources are dissipated through private banking rents, the economy still reaps the benefits of liquidity insurance and higher overall returns from long term investments. By contrast, when it induces a run in period 1, immediate transparency leads to the interruption of long term investments and to the elimination of the higher returns associated with those investments.⁴⁰

⁴⁰A model of bank runs that relates the probability of bank runs to the form of the DDC but does not feature a public signal appears in Goldstein and Pauzner (2005).

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