MONETARY POLICY GAMES, INSTABILITY AND INCOMPLETE INFORMATION

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Abstract: Central banks, in executing monetary policy, while pursuing traditional objectives, such as the control of inflation, may try also to promote financial stability. In this paper, we explore a simple monetary policy game played between the central bank and the financial sector. The central bank can be of two types, one traditional and the other concerned with controlling the financial markets; however, the financial sector is unsure which, due to incomplete information. The conclusion of the paper is that for small shocks to inflation there is a pooling equilibrium, whereas for larger shocks there is separation. In the latter case, central bank concern for the stability of the financial sector is outed. We conclude by relating our results to the recent worldwide financial crisis.

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1. Introduction and Overview

It is now well established that the primary focus of central bank policy is the control of price inflation, in most major economies, via an explicit inflation-targeting regime, and that other considerations such as reductions in excessive asset price volatility or excessive volatility in financial sector earnings should only be a by-product of policies that ensure price stability and control of *price* inflation (i.e of the price index of currently produced flows of goods and services). This consensus is surprising, to say the least, because the initial purpose of setting up central banking institutions were historically to combat the impact of volatility and the panics that ensued from the bursting of asset bubbles and financial *asset* inflation. In addition, most central banks at least in the developed world are now independent and therefore able to pursue the type of policy they wish to choose, always keeping inflation control as the centre point of their policy regimes. It is widely believed that the fight against inflation has proved successful, at socially acceptable costs, during the so-called Great Moderation. However, the ongoing banking and financial crisis of recent years has focused attention on the central banks' more historic role. From the outset of the financial crisis, it has been questioned "how well central banks have discharged their twin duties as the guardians of financial stability and as defenders of price stability" (*The Economist*, 20th Oct 2007, Special Report, p. 3).

Since Bagehot there has always been some implicit recognition that central banks need to take financial instability seriously although the current consensus seems to be that this should *not* be an explicit part of its objective function. Indeed, the creation of the Federal Reserve System in 1913 was catalysed by a financial panic (the failure of the Knickerbocker Trust Company in 1907). Earlier attempts in the United States, to create a centralised institution that could mimic a Central Bank, both during 1791-1811 (the First Bank of the United States) as well as during 1816-1836 (the Second Bank of the United States), failed since it was considered too centralising an institution particularly by the southern states. Between 1836 and 1913 the United States had no Central Bank with authority to intervene during periods of asset bubbles and financial panics. The preamble to the Federal Reserve Act of 1913 was clear that financial instability needs to be minimised and that the Fed must take this into consideration while setting up its primary objectives. It was only in 1977 that the explicit 'goals of maximum employment, stable prices and moderate long-term interest rates' were added to the Federal Reserve Act and inflation control became enshrined as its core macroeconomic policy objective (Ferguson (2003). But even here the 'goal' of moderate long-term interest rates implied that equity prices should be moderate too, since very low interest rates would be a catalyst to asset price bubbles.

More recently, the debate has been on whether price stability is sufficient to foster financial stability, or whether a trade-off exists (at least in the medium-run), and if the latter is the case, whether asset prices should be explicitly targeted. It is questioned whether monetary policy should exercise its influence in order to counter asset price bubbles, when they begin to grow (i.e. even before forecasts to inflation are affected) or to explicitly mitigate their effects after they unwind.

Asset price targeting (proposed in the early stages of the debate, for example in Blanchard (2000)) has been promptly rejected as a relevant policy response especially by central banking practitioners. The several conceptual and implementation-based problems with regard to including asset prices in the policy-relevant price index (i.e. asset price targeting) present in the academic literature are concisely provided by ECB (2005. pp. 56-57). In particular, asset-price targeting tends to establish a rather 'mechanical' policy response that may give rise to moral hazard problems[1] and, additionally, asset prices tend to be a bad proxy for future goods prices[2]. Furthermore, asset-price determination and forward-looking monetary policy may give rise to 'inflation indeterminacy'[3], and it may, in fact, be considered as the monetary policymaker double-counting consumer price pressures in its information set[4]. Another disadvantage in the use of a price index that includes asset prices is the need to determine a relevant weight given to prices of current consumption goods and assets. Traditionally, the method used focuses on expenditure shares, and the resulting weight of asset prices may be higher than 90 percent, leading to a highly volatile monetary policy. Some other methods used relate the shares to forecasting ability of future consumption prices. The resulting weights may vary considerably with respect to the method in use [see, for example, Bryan, Cechetti, O'Sullivan (2003)]. Finally, as stated in ECB (2005) any attempt by the central bank to affect asset prices in a systematic way seems to be pointless, making the presumption that "monetary policy cannot control the fundamental factors which affect asset prices in the long run" (ECB (2005), p. 57).

The conventional view of the debate accepts that asset price misalignments are difficult to recognise and that central banks should act just against the adverse consequences of a bubble unwinding which creates unemployment [see e.g. Greenspan (2002), Bernanke and Gertler (2001)]. Smaghi (2009) states that "financial stability is best ensured through instruments other than the policy interest rate and in the context of a broader framework of macro-prudential supervision, yet, nevertheless, a central bank should actively monitor asset prices and credit flows". He reports that in this way timely and useful information can be extracted, which helps to "better calibrate the course of monetary policy and to avoid the risk of being 'behind the curve' " (Smaghi (2009)). Bean (2004) accepts that it is a strenuous task for policymakers to identify whether asset price booms and busts are triggered by

[1] Since monetary policy would be expected to stabilise asset prices, investors' risk taking behaviour would increase [see e.g. Goodhart and Huang (1999)].

[2] Two main reasons are identified against the use of asset prices as a proxy for future goods prices. First, in the case of the inclusion of asset prices in the pertinent price index, in theory, such an index should include all assets, comprising also the value of consumer durables and human capital. Second, movements in asset prices may not relate to future inflation expectations. Then, in a central bank's effort to device the appropriate reaction to asset price inflation, it has to determine the fundamental value of assets promptly and accurately [see, for example, Filardo (2000), as well as Diewert (2002) and Smets (1997)].

[3] Inflation expectations can become self-fulfilling, under certain conditions, when central bank policy responds to asset price movements since asset prices are partly affected by expectations about future monetary policy. This may lead to inflation indeterminacy and potentially high inflation volatility [see Bernanke and Woodford (1997)].

[4] The benefit of explicitly targeting asset prices which tend to be a 'deficient' proxy for future consumer prices seems unclear, if central banks credibly and successfully pursue their consumer price stability objective, stabilising, thus, future inflation expectations [see, for example, Bernanke and Gertler (2001), also Cecchetti, Genberg and Wadhwani (2003)].

changes in fundamentals and, therefore, engage in appropriate pre-emptive action, especially in the early stages of the upswing. However, even at stages when a bubble is large enough to be identified, he recognises that due to the lags inherent in the monetary transmission mechanism “raising official interest rates will be counterproductive if the bubble subsequently bursts” subjecting the economy to the “twin deflationary impulses of the asset price collapse and the effect of the policy tightening” [Bean (2004) p. 15].

Gruen, Plumb and Stone (2005) suggest that a central bank’s tightening of interest rates may cause a bubble to burst more severely, and, thus, increase the potential detrimental effects to the economy. They provide further evidence to support the view expressed by Bean (2003) that monetary policy cannot make a ‘single automatic response’ to asset-price developments. In particular, Gruen, Plumb and Stone (2005) study a model of an economy in which a bubble in asset prices results in increases in aggregate output and inflation, considering a bubble that in each future period either continues its development or bursts, with known probabilities. Since monetary policy can impose an effect to the economy only with a lag, the monetary policymaker faces two conflicting policy options, namely either to use restrictive policy in order to reduce inflation and output pressures (and possibly encourage the bursting of the bubble), or to implement accommodative monetary policy in order to prepare for the eventual unwinding of the bubble. In their model the optimal policy depends on the specific characteristics of the process that the bubble follows, as well as the nature of the costs created by its unwinding[5]. They, yet, reach the conclusion that the appropriate monetary policy relies heavily on the policymakers’ judgment, as under certain circumstances the central bank should better “lean against the bubble”, while under others this policy response would be counterproductive. They, finally, point out that, given the information available, it may be difficult to distinguish in real time which of the above is the case.

The opposite view advocates the merits of the so-called ‘pre-emptive’ monetary policy conducted as the bubble builds – in relevant literature parlance, as financial imbalances accumulate. Such conduct of monetary policy would aim to forestall the potential adverse consequences in the aftermath of a crisis. This is especially true when low and stable inflation is thought to mask threats to the economy that make the financial system more vulnerable and which cannot be captured necessarily by an output gap measure [see e.g. Borio (2005), and White (2006)].

Borio and Lowe (2002) examine the annual asset-price movements in 34 countries beginning in 1962, looking at 38 crisis episodes, only using data that are available ex ante. They form an index of imbalances based on a credit gap (defined as credit growth deviations from trend), an equity price gap, and an output gap aiming in identifying incipient declines in asset prices, which may create significant real output losses. They argue in favour of the use of such an index as a guide for proactive monetary policy action. A similar index is used for the US during the 1920s by Eichengreen and Mitchener (2003), who show that it provides explanations of the severity of the Great Depression.

[5] Stockton (2003), however, commenting on an earlier version of the above, argues that since monetary policymakers are confronted with great uncertainty with respect to the existence of bubbles, even more about their stochastic characteristics, it is unlikely that the informational requirements for optimal policy in the model of Gruen, Plumb and Stone (2003) will be satisfied

The analysis of Borio and Lowe (2002) justifies the presence of two completed asset price cycles since the 1970s. They, thus, extract two main results, namely, first, that asset-price and credit cycles often progress concurrently, and, second, that cycles seem to increase in magnitude. They contend that low inflation generates optimism about the economic environment, which may further inflate asset prices in response to an increase in productivity growth than will normally be the case. Equally, an increase in demand increases the likelihood of a rise in asset prices, in the case of a central bank being credibly committed to price stability. They argue that a credible commitment to price stability, in the short-run, renders product prices less sensitive to an increase in demand, the opposite holding for output and profits, while the absence of inflation may influence monetary policymakers to delay restricting monetary policy as demand pressures build. They reach the conclusion that asset prices provide useful information and that individual as well as aggregate asset prices should be used as a tool for conducting monetary policy.

Cecchetti (2003) also argues in favour of monetary policy reacting to asset-price misalignments so as to counter potential instability, yet exercising caution. He refutes the opposite view by pointing out three main points. First, he argues that even though equilibrium asset values are difficult to estimate, asset price misalignments still need to be identified by monetary policymakers, similarly to potential GDP, for example that is routinely measured irrespective of the difficulty in estimation. He, further, does not accept that monetary policymakers should ignore the possibility of the development of bubbles in asset markets and expect them to be eliminated by efficient financial markets. Second, he stresses that a monetary policy reaction is justified even under the possibility that excessively activist monetary policy may be destabilising to the economy. He argues, in fact, that this rather necessitates considerable caution in the extent of the monetary policy action. Third, he points towards the existence of central-bank communication problems in an effort to justify a response to a potential bubble, but contends that these are no more severe than communication issues raised by normal interest-rate increases aiming at stabilising prices and growth in the medium term[6].

Bordo and Jeanne (2002a), (2002b) are in favour of a monetary policy reaction to asset price booms, as they view that pre-emptive actions so as to contain asset-price misalignments, in fact, provide insurance against the high economy-wide costs of lost output in the event of the bubble bursting. They argue that policymakers must try to defuse asset-price booms either when there is a high risk of a bust (and the consequences it may bring considerably damaging to the economy) or when the cost of such an attempt is estimated to be low in terms of foregone output. They point-out that the more optimistic investors get, the higher the risk of a market-sentiment reversal becomes. However, a higher cost is attached to monetary policy actions of

[6] Cecchetti (2003) also presents empirical evidence on the conduct of monetary policy in the U.S. by examining transcripts and minutes of the Federal Open Market Committee (FOMC) investigating references to keywords referring to asset-market valuations. He finds that the frequency of these references to be correlated with a measure of the equity-market overvaluation. His results show that as equity-market valuations were rapidly rising during the 1990s, the frequency of discussion in the FOMC about the equity market increased to a great extent. He, further, estimates a policy reaction function for the US and provides evidence that the interest-rate levels during the period from 1990-2003 showed positive correlation with a measure of overvaluation of the equity market and negative with a measure of banking-system stress.

'leaning against the wind of investor optimism'. Therefore, they contend that monetary policymakers need to evaluate not only the probability of a crisis occurring, but also the extent to which monetary policy is capable of reducing this probability.

In line with the above debate, we adapt the second view through a policy option model and evaluate pre-emptive monetary policy when a central bank potentially considers financial stability as an explicit policy objective. In our model, financial stability is achieved when the financial sector does not make excessive profits (which could lead to an asset price bubble) nor does it make too high a loss (leading to potential bankruptcy and government bail-out). Accepting that the effect of the policy instrument is transmitted through the financial sector, a central bank recognises that respective reactions from the financial sector can either enhance or hamper the implementation of monetary policy towards the real economy. The loss function of the central bank could *potentially* include a term, which seeks to minimise the deviation of the financial sector's profits from a target value. The variance of the financial sector's profitability needs to be reduced since it may contribute to undesired volatility from either excessive profits (and executive bonuses) leading to asset bubbles or to a financial collapse and tax-funded intervention, which has a long-term cost to the aggregate economy and the public sector. To capture the relevant transmission mechanism, we construct a simple model of the strategic interaction between a central bank and the financial sector in a closed economy.

Following the tradition that started with Barro and Gordon (1983), we represent the central bank and the financial sector as playing a monetary policy game of incomplete information. This paper evaluates the effect that vagueness about central bank preferences with respect to financial stability may have on the behaviour of both the central bank and the financial sector. In this context it is investigated whether central banks should state clearly their intention to conduct monetary policy pre-emptively against perceived financial imbalances, or in contrast exercise 'strict inflation targeting'. This kind of analysis is justified, primarily, by the fact that central banks have, in general, been reluctant to publicize any explicit objective function used as a guide for policy, and also because central banks, fail to adopt and aim at financial stability as an explicit objective, even though they demonstrate serious concerns about the stability of the financial system.

We therefore assume that there could be two types of central banks. One type of central bank targets just inflation, accepting the view that price stability promotes economic stability in the medium to long-run [see e.g. Bernanke (2006)]. For this type and in the context of the analysis in this paper, for a central bank to act by a rule is equivalent to using discretion [see Barrett, Kokores and Sen (2008) and Kokores (2009) Chapter 7]. Another type targets both inflation and financial stability, in line with the Bordo and Jeanne (2002) concluding remark that "financial stability presents a direct challenge to the rule paradigm because it may require occasional deviations from simple rules – i.e. policies that are sometimes based in a complex way on discretionary judgement".

The literature in favour of pre-emptive monetary policy against financial instability puts forward the conclusion that the monetary authorities should exercise their policy with more flexibility and over longer policy horizons. This paper extends the conclusions in Barrett, Kokores and Sen (2008) and Kokores (2009) Chapter 7 that when a central bank addresses financial stability as a principal and systematic component of its decision making process, namely as an explicit monetary policy objective, then discretionary policy yields better results, in terms of controlling inflation, anchoring inflation expectations and imposing more prudence to the operation of the financial sector, compared to the policy when conducted under commitment to a rule.

The literature that extended the seminal work of Barro and Gordon (1983a, 1983b), also incorporates the effect of uncertainty of one player about an aspect of the other player's behaviour, in the context of analysing the interaction between the monetary authorities and the public. Among others, for example, Barro (1986), Vickers (1986), Drazen and Mason (1994), Briault, Haldane and King (1997), Demertzis and Hallett (2004), build models in which the public is uncertain about the central bank's preference for the conduct of monetary policy, either as the preference between output and inflation stabilisation or its ability to commit. In these types of models the uninformed player (the public) is trying to infer the type the informed player (the central bank) may be from the actions taken by the later. When the central bank chooses its actions it takes into consideration the uncertainty faced by the public and it may also conceal its true preference from the public by mimicking the behaviour of a different type of central bank.

These issues are also investigated in the model of this paper, but we refrain from using the assumption that the uninformed player (the financial sector) can draw inferences about the central bank's behaviour by viewing the central bank's actions. In other words, we do not allow in this model for any signalling behaviour from the part of the central bank. Finally, we do not make the assumption that the central bank can accept or be presented with the option to sign any binding contracts of any form.

Furthermore, the strategic interaction is repeated infinitely with the aim to evaluate the role of reputation by analysing a repeated game in the lines of Barro and Gordon (1983b). To our knowledge, the extant literature on pre-emptive monetary policy against financial instability does not incorporate the above concerns of a strategic interaction between the central bank and the financial sector, the uncertainty of the financial sector about the central bank preferences, and the role of reputation of the central bank in the conduct of policy and, thus, does not unfold in a similar manner.

In this model since the financial sector does not know what type of central bank it faces, even a central bank that prefers to pre-empt financial instability may choose in equilibrium, for suitable levels of parameters, to mimic a 'strict inflation targeting' central bank in order to built its reputation as such, and thus, affect inflation expectations in the future, and have a stronger impact on the stability of the financial sector. This results in a pooling equilibrium. When exogenous shocks are high though, the non-traditional central bank reveals its objective function via a separating equilibrium.

In Section 2, we build the core model, in Section 3 introduce non-performing loans (termed as bad debts) and evaluate the effect they may have in the interaction between the central bank and the financial sector, and Section 4 is the conclusion.

2. The Model

Assume a game is played between a central bank, B, and the financial sector, S. Let t denote time. B is type 1 or type 2, with probabilities p and $1–p$, respectively. B knows which type it is, but this is private information and S knows only the probability of each type. The game is therefore one of incomplete information.

S chooses the long-term rate of interest, R, at t=0, and B chooses the short-term rate of interest, i, at t=1. Let π denote the rate of inflation at t=1. We assume π is subject to a random shock, ε, of mean zero, variance σ_ε^2 and support $(–\infty, \infty)$. In choosing R at t=0, S knows only the distribution for ε, whereas, in choosing i at t=1, B knows both the distribution for ε and its realised value. Let x measure B's monetary stance, and let E denote the expectations operator for expectations formed rationally at t=0.

Assume:

$$\pi = E\pi + \varepsilon - x \,. \tag{1}$$

Since $E\varepsilon$=0, it follows from (1), on taking expectations:

$$Ex = 0 \,. \qquad\qquad 33 \tag{2}$$

If there were no shock (i.e. no new information) and monetary stance was 'neutral', the public would raise wages and prices in line with inflation expectations. The random shock, ε, disturbs this behaviour and is countered by x.

Let r denote the real short-term rate of interest, i.e. let

$$r = i - \pi \,. \tag{3}$$

Assume:

$$x = F(r) \qquad\qquad (0 < F' < 1) \,. \tag{4}$$

According to (4), monetary stance is determined by the real short-term rate of interest, while the restriction on F' means an increase in the nominal short-term rate of interest lowers the rate of inflation. Underlying (3) and (4) is a transmission mechanism from i to r to the real economy, and so to π, with feedback to r.

Substituting (3) into (4) and (4) into (1) shows that, given F, $E\pi$ and ε, choice of i determines π, and so too x. In determining strategy, B, could as equally set a target for x as choose the level of its instrument, i.

Let

$$F(r^*) = 0 \,. \tag{5}$$

If $r>r^*$, monetary policy is restrictive and, if $r<r^*$, it is expansionary. Assume, for simplicity:

$$x = \frac{r - r^*}{\beta} \qquad\qquad (\beta > 1) \,. \tag{6}$$

Here, β is an inverse measure of how effective the real short-term rate of interest is in controlling inflation, while the restriction on β follows from the restriction on F in (4).

Let i_0 be the short-term rate of interest at t=0, a2nd recall that i is the short-term rate of interest at t=1. Assume i_0 (but not i) is known to S when S chooses the long-term rate of interest, R, at t=0. At t=2, S obtains (gross) profits per dollar:

$$P = (1+R)^2 - (1+i_0)(1+i)\,. \tag{7}$$

However, for the sake of simplicity, and because nothing essential is involved, we use the approximation:

$$P = 2R - i_0 - i\,. \tag{8}$$

Letting 'var' denote variance, note, from (1), (2), (3), (6) and (8):

$$\begin{aligned} EP &= 2R - i_0 - Ei \\ &= 2R - i_0 - r^* - E\pi. \end{aligned} \tag{9}$$

$$\begin{aligned} \mathrm{var}(P) &= \mathrm{var}(i) \\ &= \mathrm{var}(r+\pi) \\ &= \mathrm{var}[(\beta-1)x+\varepsilon]. \end{aligned} \tag{10}$$

According to type, B's utility function is:

Type 1: $U_1 = -(\pi - \pi^*)^2$ (11a)

Type 2: $U_2 = -(\pi - \pi^*)^2 - \alpha(P - P^*)^2 \qquad (\alpha > 0)$ (11b)

where π^* and P^* are targets for the rate of inflation and profits, respectively, and we assume $P^* \geq EP$.

Let B choose x=x_1 if type 1 and x=x_2 if type 2.

<u>Choice of x at t=1</u>

It is convenient and inessential, as shown above, to regard B as choosing x rather than i, on observing $E\pi$, ε, i_0, r^*, β and R. Substituting from (1), (4), (6) and (8) into (11):

$$U_1 = -(E\pi + \varepsilon - x_1 - \pi^*)^2 \tag{12a}$$

$$\begin{aligned} U_2 &= -(E\pi + \varepsilon - x_2 - \pi^*)^2 \\ &- \alpha\{2R - i_0 - r^* - E\pi - [\beta - 1)x_2 + \varepsilon] - P^*\}^2. \end{aligned} \tag{12b}$$

Type 1

Differentiating (12a) with respect to x_1 and equating to zero:

$$x_1^* = E\pi + \varepsilon - \pi^* \tag{13}$$

$$U_1^* = 0. \tag{14}$$

Type 2

Pooling

In this case, x_2*=x_1*, and so:

$$\begin{aligned} U_2^* &= -\alpha\{2R - i_0 - r^* - E\pi - [(\beta-1)x_1^* + \varepsilon] - P^*\}^2 \\ &= -\alpha\{P^* - EP + [(\beta-1)x_1^* + \varepsilon]\}^2 \\ &= -\alpha\{P^* - EP + [(\beta-1)(E\pi + \varepsilon - \pi^*) + \varepsilon]\}^2 \\ &= -\alpha[P^* - EP + (\beta-1)(E\pi - \pi^*) + \beta\varepsilon]^2. \end{aligned} \tag{15}$$

Separation

Differentiating (12b) with respect to x_2 and equating to zero:

$$E\pi + \varepsilon - x_2 - \pi^* + \alpha(\beta - 1)\{2R - i_0 - r^* - E\pi - [(\beta - 1)x_2 + \varepsilon] - P^*\}$$
$$= 0$$

$$\begin{aligned}&[1+\alpha(\beta-1)^2]x_2 \\ &= E\pi + \varepsilon - \pi^* + \alpha(\beta-1)(2R - i_0 - r^* - E\pi - \varepsilon - P^*).\end{aligned} \tag{16}$$

Let

$$H = 1 + \alpha(\beta - 1)^2. \tag{17}$$

Then, from (16) and (17):

$$x_2^{**} = \frac{E\pi - \pi^*}{H} + \frac{[1-\alpha(\beta-1)]\varepsilon}{H} - \frac{\alpha(\beta-1)(P^* - EP)}{H} \tag{18}$$

$$\begin{aligned}&U_2^{**} = -(E\pi + \varepsilon - x_2^{**} - \pi^*)^2 \\ &-\alpha[P^* - EP + (\beta-1)x_2^{**} + \varepsilon]^2,\end{aligned} \tag{19}$$

where x_2** is given by (18).

Assume the game which starts at t=0 is repeated infinitely, at t=1, t=2,... with a discount factor of δ per period. Pooling by B of type 2 improves control of inflation expectations at t=1 and maintains an option to pool in the future. Thus pooling has an option value which derives from control of inflation expectations.

<u>Choice of *R* at t=0</u>

Let σ_P denote the standard deviation of P, the profits per unit of currency obtained by S. We assume competition drives the expected value to $k\sigma_P$, so

$$EP = k\sigma_P \qquad (k > 0). \tag{20}$$

At this level for expected profits, the market finds the chances of bankruptcy just acceptable.

From (9) and (20), choice of R is governed by:

$$\begin{aligned}&k\sigma_P = 2R - i_0 - r^* - E\pi \\ &R = \frac{i_0 + r^* + E\pi + k\sigma_P}{2}.\end{aligned} \tag{21}$$

In choosing R, S takes into account the effect on Eπ and σ_P of how, according to type, B will choose x. This includes a rational assessment of the probabilities of pooling and separation, as well as how B of type 2 will choose x under pooling and separation.

<u>Eπ at t=0</u>

Recall that B is type 1 with probability p and type 2 with probability $1–p$. From (2), (13) and (18), if B of type 2 chooses pooling with probability q and separation with probability $1–q$:

$$\begin{aligned}
0 &= Ex \\
&= [p+(1-p)q]Ex_1* + (1-p)(1-q)Ex_2** \\
&= [p+(1-p)q+\tfrac{1}{H}(1-p)(1-q)](E\pi-\pi*) \\
&\quad -\tfrac{1}{H}(1-p)(1-q)\alpha(\beta-1)(P*-EP).
\end{aligned}$$

$$E\pi-\pi* = \frac{(1-p)(1-q)\alpha(\beta-1)}{pH+(1-p)qH+(1-p)(1-q)}(P*-EP). \tag{22}$$

Thus, since by assumption $P^*\geq EP$, it follows from (22):

$$E\pi-\pi*\geq 0$$

and when P*=EP:

$$E\pi-\pi*=0\,. \tag{23}$$

<u>Lemma</u>

$$\frac{\partial}{\partial\varepsilon}(U_2*-U_2**) = -A_1(E\pi-\pi*)-A_2(P*-EP)-A_3\varepsilon\,, \tag{24}$$

where A_1, A_2, $A_3 > 0$.

<u>Proof</u>

Recall $\alpha>0$, $\beta>1$, and so $H>1$, while also $P^*\geq EP$. From (15) and (19), applying the envelope theorem:

$$\begin{aligned}
&\frac{\partial}{\partial\varepsilon}(U_2*-U_2**) \\
&= -2\alpha\beta[P*-EP+(\beta-1)(E\pi-\pi*)+\beta\varepsilon] \\
&\quad +2(E\pi+\varepsilon-x_2**-\pi*) \\
&\quad +2\alpha[P*-EP+(\beta-1)x_2**+\varepsilon] \\
&= -2\{[\alpha\beta(\beta-1)-1](E\pi-\pi*) \\
&\quad +\alpha(\beta-1)(P*-EP)+[\alpha(\beta^2-1)-1]\varepsilon \\
&\quad +[1-\alpha(\beta-1)]x_2**\}.
\end{aligned}$$

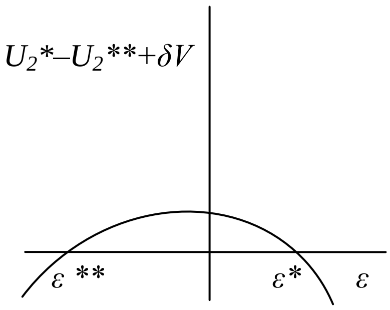
Substituting from (18), we have after some manipulation:

$$\begin{aligned}
&\frac{\partial}{\partial\varepsilon}(U_2*-U_2**) \\
&= -\frac{2}{H}\alpha^2\beta(\beta-1)^2[(\beta-1)(E\pi-\pi*)+(P*-EP)+\beta\varepsilon].
\end{aligned} \tag{25}$$

On the right hand side of (25), the coefficients of $E\pi–\pi^*$, $P^*–EP$ and ε are negative, which proves the lemma.

Let the option to pool have value V. It follows that the option to pool at t=2 discounted to t=1 has value δV. For B of type 2, pooling in comparison with separation may lower inflation expectations and maintains the option to pool in the future. Type 2 chooses pooling at t=1 if and only if:

$$U_2 * - U_2 ** + \delta V \geq 0 . \tag{26}$$



If $P^*=EP$, which according to (23) means $E\pi=\pi^*$, B of type 2 finds no advantage in pooling, since pooling achieves no lowering of inflation expectations. If $P^*>EP$ and the discount factor, δ, is sufficiently high, there exist critical values for the shock to inflation, $\varepsilon=\varepsilon^{**}<0$ and $\varepsilon=\varepsilon^*>0$, such that B of type 2 chooses pooling for $\varepsilon^{**}<\varepsilon<\varepsilon^*$ and separation for $\varepsilon<\varepsilon^{**}$ or $\varepsilon>\varepsilon^*$.[1] In this case, as depicted in the diagram above, $\varepsilon^*<-\varepsilon^{**}$. Intuitively, separation is triggered by extreme shocks, more especially positive shocks.

3. Bad debts

We vary the model by supposing a proportion, γ, of the loans made by S are bad debts. Specifically, at t=2, S obtains (gross) profits per dollar:

$$P=(1-\gamma)(1+R)^2-(1+i_0)(1+i)\,. \tag{27}$$

Again we use a linear approximation to (27):

$$P=2R-i_0-i-\gamma\ . \tag{28}$$

Here, γ is a random variable with mean $E\gamma$ and variance σ_γ^2.

We investigate a shock to P via γ rather than as in Section 2 to π, i.e. a shock to the profitability of S rather than to inflation. Thus ε=0 in Section 2.

From (1), (2), (3), (6) and (28):

$$\begin{aligned} EP &= 2R-i_0-Ei-E\gamma \\ &= 2R-i_0-r^*-E\pi-E\gamma. \end{aligned} \tag{29}$$

$$\begin{aligned} \mathrm{var}(P) &= \mathrm{var}(i+\gamma) \\ &= \mathrm{var}(r+\pi+\gamma) \\ &= \mathrm{var}[(\beta-1)x+\gamma]. \end{aligned} \tag{30}$$

According to type, B's utility function is again given by (11).

<u>Choice of x at t=1</u>

B chooses x on observing $E\pi$, i_0, r^*, β, R and γ. Substituting from (1), (3), (6), (28) and (29) into (11):

$$U_1=-(E\pi-x_1-\pi^*)^2 \tag{31a}$$

$$\begin{aligned} U_2 &= -(E\pi-x_2-\pi^*)^2 \\ &-\alpha[P^*-EP+(\beta-1)x_2+\gamma-E\gamma]^2. \end{aligned} \tag{31b}$$

Type 1

Differentiating (31a) with respect to x_1 and equating to zero:

$$x_1^*=E\pi-\pi^* \tag{32}$$

$$U_1^*=0. \tag{33}$$

Type 2

Pooling

In this case, $x_2^*=x_1^*$, and so, from (31b):

$$\begin{aligned} U_2^* &= -\alpha[P^*-EP+(\beta-1)x_1^*+\gamma-E\gamma]^2 \\ &= -\alpha[P^*-EP+(\beta-1)(E\pi-\pi^*)+\gamma-E\gamma]^2. \end{aligned} \tag{34}$$

Separation

Differentiating (31b) with respect to x_2 and equating to zero:

$$E\pi - x_2 - \pi^* = \alpha(\beta - 1)[P^* - EP + (\beta - 1)x_2 + \gamma - E\gamma]$$

$$\begin{aligned}&[1+\alpha(\beta-1)^2]x_2\\ &= E\pi - \pi^* - \alpha(\beta-1)(P^* - EP + \gamma - E\gamma).\end{aligned} \tag{35}$$

Let

$$H = 1 + \alpha(\beta - 1)^2. \tag{36}$$

Then, from (35) and (36):

$$x_2^{**} = \frac{E\pi - \pi^*}{H} - \frac{\alpha(\beta-1)(P^* - EP + \gamma - E\gamma)}{H} \tag{37}$$

$$\begin{aligned}&U_2^{**} = -(E\pi - x_2^{**} - \pi^*)^2\\ &-\alpha[P^* - EP + (\beta-1)x_2^{**} + \gamma - E\gamma]^2,\end{aligned} \tag{38}$$

where x_2^{**} is given by (37).

<u>Choice of *R* at t=0</u>

Through competition EP is as before given by (20). Thus, from (29):

$$\begin{aligned}&k\sigma_P = 2R - i_0 - r^* - E\pi - E\gamma\\ &R = \frac{i_0 + r^* + E\pi + E\gamma + k\sigma_P}{2}.\end{aligned} \tag{39}$$

Again, in choosing *R*, S takes into account the effect on Eπ and σ_P of how B will choose *x*.

<u>Eπ at t=0</u>

(22) and (23) again hold, with the same derivation as before.

<u>Lemma</u>

$$\frac{\partial}{\partial\varepsilon}(U_2{*}-U_2{**}) = -A_1(E\pi-\pi{*}) - A_2(P{*}-EP) - A_3(\gamma-\gamma{*}), \qquad (40)$$

where A_1, A_2, $A_3 > 0$.

<u>Proof</u>

Recall α>0, β>1, and so H>1, while also $P{*}\geq EP$. From (34) and (38), applying the envelope theorem:

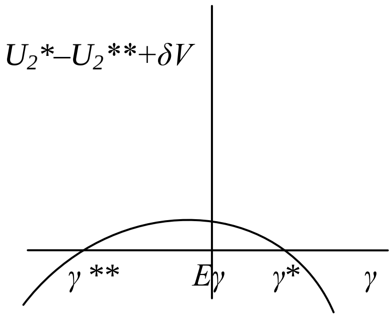
$$\begin{aligned}&\frac{\partial}{\partial\gamma}(U_2{*}-U_2{**})\\ &= -2\alpha[P{*}-EP+(\beta-1)(E\pi-\pi{*})+\gamma-E\gamma]\\ &+2\alpha[P{*}-EP+(\beta-1)x_2{**}+\gamma-E\gamma]\\ &= -2\alpha(\beta-1)(E\pi-\pi{*}-x_2{**})\end{aligned}$$

Substituting from (37):

$$\begin{aligned}&\frac{\partial}{\partial\gamma}(U_2{*}-U_2{**})\\ &= -\frac{2}{H}\alpha^2(\beta-1)^2[(\beta-1)(E\pi-\pi{*}) \qquad (41)\\ &+(P{*}-EP)+(\gamma-E\gamma)].\end{aligned}$$

On the right hand side of (41), the coefficients of $E\pi-\pi{*}$, $P{*}-EP$ and $\gamma-E\gamma$ are negative, which proves the lemma.

Once more, B of type 2 chooses pooling at t=1 if and only if (26) holds.



Again, if $P{*}>EP$ and the discount factor, δ, is sufficiently high, there exist critical values for the proportion of bad debts, $\gamma=\gamma{**}<E\gamma$ and $\gamma=\gamma{*}>E\gamma$. B of type 2 chooses pooling for $\gamma{**}<\gamma<\gamma{*}$ and separation for $\gamma<\gamma{**}$ or $\gamma>\gamma{*}$. In this case, as depicted in the diagram above, we have $\gamma{*}-E\gamma<-(\gamma{**}-E\gamma)$. Intuitively, as in Section 2, separation is triggered by extreme shocks, more especially positive shocks.

4. Conclusion

In recent years, asset prices have surged while consumer price inflation has remained muted. The exceptional rise in asset prices, (starting with Japan and the Nordic countries in the early 1990s to the housing 'boom' of the first half of this decade particularly in the US and UK), coupled with moderate and stable inflation for goods prices calls into question the efficacy of the traditional model of inflation targeting. It is no longer possible to assert that controlling (consumer or producer) price inflation is a sufficient condition for controlling asset price bubbles. The bursting of these bubbles create exceptional volatility, and the return of booms and bust cycles in GDP independent of the success of central bank in keeping inflation low has motivated the new thinking behind the type of models we propose and analyse.

In reality, central banks implicitly agree that both price stability and financial (asset price) stability are important to the conduct of monetary policy by Central Banks. As Lars Nyberg (Vice riksbankschef) of the Swedish Central Bank stated in a major speech: " Many central banks, including the Swedish Riksbank, now have dual tasks: maintaining price stability and promoting financial stability" [7]

In a recent newspaper interview, Mervyn King the Governor of the Bank of England also expressed similar sentiments. Discussing excessive profitability, income and bonuses of the financial sector he is reputed to have said in an interview with the Telegraph newspaper: "We must get rid of the idea that "if something is growing rapidly, it must be good. Every supervisor should say: 'The banks I should worry about are not only the ones that are losing money but the ones who are making a lot of money.' He goes on: "What I've tried to do my whole time at the Bank is to set general rules. You can't rely on the wisdom of individuals. Before I leave, I want to make sure that the right framework is in place for monetary policy, financial stability and banking supervision ------------"[8]

However, in practice, central banks are loathe to explicitly state that they pursue dual objectives which are potentially additive in the loss function they wish to minimise. Central banks still maintain, under the fig leaf of credibility, that financial stability is (almost) always attained when there is price (monetary) stability, so that an independent objective in the policy reaction function is unnecessary. The reasons for such opaqueness could be attributed to factors stressed in traditional public choice models. Central banks (and the Ministries of Finance) still maintain strong and positive ties to the financial sector, including 'changing places' from one institution to another, and therefore any open suggestion that the monetary authorities are explicitly targeting financial instability per se may not look good. Although there is considerable discussion on the relationship between 'Main Street and Wall Street', explicit recognition within the loss function is still an anathema to policy makers.

Traditional monetary policy games (starting from Barro and Gordon, 1983), as explored in the literature prior to this paper, are between the central bank and the

[7] http://www.riksbank.se/templates/Page.aspx?id=25751
[8] http://www.telegraph.co.uk/finance/economics/8362959/Mervyn-King-interview-We-prevented-a-Great-Depression...-but-people-have-the-right-to-be-angry.html#

public, and involve central bank targets of price and output stability. Price stability, like property rights, is a necessary part of the fabric of a successful economy, i.e. it determines future output as well as its distribution. The similar, and almost as strong, case made for financial stability (Borio, 2005, White 2006) has motivated us to explore games between the central bank and the financial sector. In a light hearted paper, written for the IMF, Frenkel (2009) characterizes changing fashions in international finance by claming "Things are hot, then they are not, in the world of international money". Of the five issues, which are changing in the theory and practice of international finance and monetary policy, he identifies one of them as: inflation targeting is 'out' and asset price bubbles are 'in' in terms of future analyses[9].

Of two types of central bank in our model, one targets just inflation and the other both inflation and financial stability. Our main purpose is to identify under what circumstances would there be a pooling equilibrium where both types behave in a similar fashion and when would there be a separating equilibrium where the central bank keen on reducing excessive profit variance of the financial sector would reveal its true loss function under a separating equilibrium.

We have assumed, following the core literature, that the weights based on financial (in) stability (α, alpha, in the model above) is fixed. It would be an interesting and fruitful extension to consider the case where α is state contingent and could change. Such models of rational ambiguity have been explored in the literature (Demertzis and Hallett (2004)) in the context of a standard loss function of the Central Bank where the private sector forms (rational) expectations of the weights that they believe the central bank places on each policy objective given the state of the economy. This methodology would be particularly appropriate in our context since the two types of Central banks would pursue alternative policies depending on the shocks to the system and the financial sector would need to form appropriate expectations and bear the cost of learning.

Not surprisingly, with the short-term rate of interest as the central bank's single instrument, the addition of a target reduces the attention given to each. Yet the targets matter. As with price inflation, financial instability (or asset price bubbles) can have quite strong implications for the future growth of output and its distribution. Alternative, microeconomic ways, such as regulation, can help achieve targets, but are inevitably limited or intrusive, so there remains a residual role for the central bank. Our conclusions are that, with incomplete information, the central bank may wait for rather extreme circumstances, typically involving upward price movements, before acting to protect the financial sector and reveal its true preferences. In terms of stylised facts, the ECB could be depicted as a 'traditional' central bank while the Bank of England could in principle have behaved as the other type, which also targets financial stability and seeks the reduction of earnings volatility of the financial sector. Future work that attempts to document this behaviour on the part of the UK's Monetary Policy Committee in the recent financial crisis is planned.

[9] The other four issues which are in the process of being changed are: the G7 to G20, corners hypothesis to intermediate exchange rate regimes, currency manipulation to reserve accumulation, excessive privilege of the dollar to multiple international reserve currencies.

Notes

1. Assume $P^*>EP$. The RHS of (25) has the form: $-a\varepsilon - b$, where a,b>0. On integrating, we obtain for the LHS of (26): $-a\varepsilon^2 - b\varepsilon + c$, c a constant. Equating to zero, the roots, ε^{**} and ε^*, are given by the formula:

$$\varepsilon = \frac{-b \pm \sqrt{b^2 + 4ac}}{2a}.$$

We show c>0 for δ sufficiently large, in which case the roots, ε^{**} and ε^*, are real and subject to the given conditions, as depicted in the diagram. Set ε=0. Recall that q is the probability that B of type 2 chooses pooling. Taking pooling as the norm, we approximate: q=1. Then, from (15), (18), (19) and (22):

$$\begin{aligned} c &= U_2{}^* - U_2{}^{**} + \delta V \\ &= -\alpha(P^* - EP)^2 \\ &\quad + [\tfrac{1}{H}\alpha(\beta-1)]^2(P^*-EP)^2 \\ &\quad + \alpha[1-\tfrac{1}{H}\alpha(\beta-1)^2]^2(P^*-EP)^2 \\ &\quad + \delta V \\ &= -\tfrac{1}{H}\alpha^2(\beta-1)^2(P^*-EP)^2 + \delta V. \end{aligned} \tag{42}$$

To find V, we approximate: ε=0, i.e. for the sake of argument we suppose extreme shocks are rare. V is given by:

$$V = U_2{}^* - U_2{}^{**} + \delta V,$$

where, in evaluating U_2^*, $E\pi = \pi^*$ and, in evaluating U_2^{**}, $p=q=0$ in (22), so

$E\pi = \pi^* + \alpha(\beta-1)(P^*-EP)$.

Thus:

$$\begin{aligned} V &= \alpha^2(\beta-1)^2(P^*-EP)^2 + \delta V \\ &= \frac{\alpha^2(\beta-1)^2(P^*-EP)^2}{1-\delta}. \end{aligned} \tag{43}$$

Comparing (42) and (43), c>0 if:

$$\frac{\delta}{1-\delta} > \frac{1}{H} = \frac{1}{1+\alpha(\beta-1)^2}.$$

For example, we have c>0 if δ>½.

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