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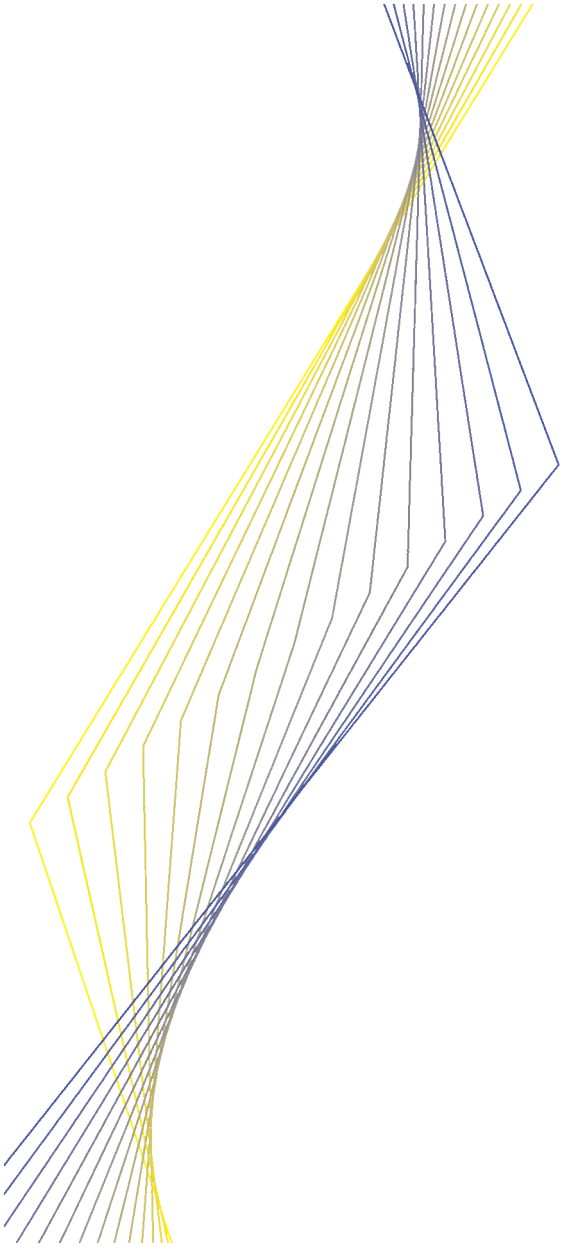

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MONETARY POLICY AND THE ZERO BOUND TO INTEREST RATES: A REVIEW[1]

BY TONY YATES[2]

October 2002

1 *This paper has benefited a great deal from conversations, comments and email communications with Ignazio Angeloni, Peter Andrews, Charles Bean, Claus Brand, Willem Buiter, Gunter Coenen, Spencer Dale, Paola Donati, Marvin Goodfriend, Alex Jung, Hans-Joachim Kloeckers, Klaus Masuch, Roberto Motto, Massimo Rostagno, Frank Smets, Peter Tinsley, Jan Vlieghe and Michael Woodford. This paper has also benefited from insightful comments from an anonymous referee, for which I am grateful. I thank these individuals without implicating them in any of the views or errors remaining in this paper, which are my responsibility alone. Importantly, the views in this paper should not be taken to be those of the ECB, the ESCB, the Bank of England nor any of their respective monetary policy or other decision-making bodies.*

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Abstract

This paper reviews the literature on what the zero bound to nominal interest rates implies for the conduct of monetary policy. The aim is to evaluate the risks of hitting the zero bound; and to evaluate policies that are said to be able to reduce that risk, or policies that are proposed as means of helping the economy escape if it is in a zero bound 'trap'. I conclude that policies aimed at 'cure' are arguably more uncertain tools than those aimed at 'prevention', so prevention is a less risky strategy for policymakers. But since the risks of hitting the zero bound seem quite small anyway, and the risks of encountering a deflationary spiral smaller still, it is conceivable that inflation objectives that typify modern monetary regimes already have more than enough insurance built into them to deal with the zero bound problem.

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Non-technical summary

A large literature evaluating the performance of alternative interest rate rules or alternatives to interest rate based stabilisation has grown up as central banks have pursued low rates of inflation. The views expressed in this paper could be summarised in the following set of statements.

The bound to nominal interest rates is given by the value to which the marginal utility of real balances tends. The zero figure comes from thinking that the transactions benefits to holding extra real money balances eventually diminish to nothing. But the bound may be higher than zero if there are anonymity benefits to holding cash that don't diminish to zero; or lower than zero if there are either significant costs of storing or managing real balances that kick in at some point, or non-pecuniary benefits to holding the other riskless alternative, bonds.

In the absence of perfect alternatives to interest rate stabilisation, policy faces the task of choosing an inflation rate to balance the costs of inflation and output variability against the costs of inflation itself.

The consensus in the literature on the risks of hitting the zero lower bound seems to be that the risk is small down to inflation rates close to those currently pursued by central banks, but gets much larger below that. The risk of a deflationary spiral seems to be very small indeed. The distinction is important. Many shocks that will force interest rates down to the zero bound will not be large enough to tip the economy into a deflationary spiral.

A key unknown in the calculation of the risks is the shape of the distribution of shocks that hit the economy and are propagated into shocks to desired interest rates. This must temper the comfort we draw from the studies so far carried out. Optimal policy would probably argue for a choice of inflation rate that is 'robust' to making mistakes about that distribution, and point to higher inflation than otherwise.

But computing the risks of hitting the zero bound doesn't tell us about optimal policy until we evaluate the benefits of avoiding the zero bound, as against the costs of inflation. Those central banks that have either privately or publicly quantified inflation objectives may already have taken out enough insurance in this regard.

Studies of the risks of hitting the zero bound (and diagnoses of 'pathologies' associated with interest rate rules) are hampered by the fact that they study commitment to rules that no central bank does, (or, under the circumstances considered, could) commit to. They therefore overstate the risks. Moreover, studies of the 'perils' or 'pathologies' of interest rate rules do not tell us about the risk of hitting the zero bound at some inflation rate: choosing higher inflation would not provide an insurance against these catastrophes. But to repeat, these catastrophes again come out of simulating the pursuit of interest rate policies that are not credible. They are therefore either curiosities or a positive explanation for why central banks don't commit to policies of this form.

The central bank could engage in 'money rains' or monetary financing of the fiscal deficit. On the one hand, it would be counter-productive to commit to reversing money rains ('money drains'?) in the future. But on the other, the central bank might find it hard, once it has rained money in this way, to convince the private sector that it would not rain money (in whatever form) in normal times.

'Tinsley' style options that penalise the central bank for breaking a commitment not to raise interest rates in the future are likely to be ineffective at best, and harmful at worst. Financial penalties on the central bank and the public purse would have to be enormous to persuade the private sector that it was no longer in the interest of the central bank to raise rates. It is plausible to think that long rates could even increase, rather than fall, if penalties embedded in these options were large enough.

The central bank can clearly opt to exploit portfolio balance effects in markets for longer-term government, private sector, or even foreign assets. The most persuasive argument here is Goodfriend's argument that such purchases would increase broad liquidity in the market and reduce real rates. If these effects exist, they may already be at work anyway in normal times, and would certainly be open to policymakers to exploit at any interest rate, not just zero. The drawbacks are that the effects of interventions like this are very uncertain, may be unstable, and actions like this will expose the central bank to significant fiscal losses that the private sector as a whole will have to underwrite; they may also distort price signals in the market for risk.

A related proposal advanced by Svensson is to commit to an exchange rate depreciation, underpinned by portfolio balance effects in foreign exchange, and a rising path for the price level. How effective the exchange rate peg is will depend on how much intervention the central bank would have to engage in (relative to an amount that would be consistent

with stabilisation objectives) before the point at which portfolio balance effects start to kick in is reached. A central bank understood to be committed to some notion of price stability may either not have or not wish to seek the option of credibly committing to debasing its currency. McCallum's proposal for a time-varying exchange rate target is subject to an analogous set of problems.

Conventional fiscal stabilisation carries with it many familiar costs: of implying larger microeconomic distortions from stronger automatic stabilisers; of interfering with the ongoing time consistency of monetary and fiscal policy. 'Fiscal dominance' may be more likely to occur in a deflationary spiral than in normal times, but is more likely to be a consequence of policy failure, rather than an option for systematic policy. This said, the burden of pursuing monetary policy objectives is already shared out between monetary and fiscal policies, by virtue of the fact that fiscal instruments have monetary policy consequences, so a further step in the fiscal direction may not be so radical.

Commitments to history-dependence in interest rate rules can help reduce the risk of hitting the zero bound, but do not provide a means of escape from it. Whether such commitments can be credible depends on whether you think central banks can 'just do it' (as Woodford, (1999) and McCallum, (1998) clearly believe) or will be expected to be susceptible to changes of heart (as Svensson, (1999) believes). Commitments that 'turn on' when the zero bound bites (as suggested by Reifschneider and Williams (2000), and simulated by Hunt and Laxton (2002)) are likely to be less effective in so far as they don't allow the central bank to build a reputation for sticking to its history- dependent promises.

Overall, the risks of being trapped at the zero bound to interest rates are probably small, and probably overstated. But the returns to policy alternatives are decidedly uncertain as most of their proponents have recognised. Given the uncertainties around the estimates of the risk of a 'deflationary trap', as Fuhrer and Sniderman (2000, p845) put it "prevention is likely easier than cure", or, in the words of Ueda, of the Bank of Japan board: "Don't put yourself in the position of zero interest rates".[1] Alternatives to 'prevention' are of course more interesting for monetary authorities for whom prevention is too late. But how much 'preventative' medicine to take depends on evaluating the social preferences for inflation and output variability, relative to inflation. It's conceivable that inflation objectives that typify modern monetary regimes already prescribe more than enough of this kind of medicine.

[1] Cited by Fuhrer and Sniderman (2000, p846).

Monetary policy and the zero bound to interest rates: a review[2]

1 Introduction and overview

Researchers and central banks[3] have debated openly whether the zero bound to nominal interest rates means that low inflation, aside from the benefit it brings, may imply a cost in terms of higher inflation and output variability.[4] The concern is that at low inflation rates central banks will be less able to counteract the effect of large deflationary shocks, since the zero bound constrains the amount by which they can cut nominal, and therefore real interest rates. Or worse, that a large enough shock could push the economy into a 'deflationary spiral', where inflation and expected inflation fall, nominal interest rates at some point come up against the zero bound, real interest rates rise, aggregate demand and expected inflation fall even further, real rates rise by yet more, and so on.[5]

Whether there is a trade off between inflation on the one hand and inflation and output variability on the other will depend on whether there are substitutes to conventional interest rate policy at the zero bound. In the absence of policy alternatives, this trade-off will depend on the properties of interest rate rules and of the disturbances that those rules

[2] There are many excellent reviews of the literature already, from which this paper has benefited. See, for example, Amirault and O' Reilly, (2001), Goodfriend, (2000), Johnson *et al* (1999), McCallum, (2000), Svensson (2001), Finicelli *et al*, (2002).

[3] See, for example, the minutes of the January 2002 FOMC meeting, which include the following reference, and are worth quoting at length: "….. members discussed staff background analyses of the implications for the conduct of policy if the economy were to deteriorate substantially in a period when nominal short-term interest rates were already at very low levels. Under such conditions, while unconventional policy measures might be available, their efficacy was uncertain, and it might be impossible to ease monetary policy sufficiently through the usual interest rate process to achieve System objectives. The members agreed that the potential for such an economic and policy scenario seemed highly remote, but it could not be dismissed altogether. If in the future such circumstances appeared to be in the process of materializing, a case could be made at that point for taking pre-emptive easing actions to help guard against the potential development of economic weakness and price declines that could be associated with the so-called 'zero-bound' policy constraint.' And see a speech by Kazuo Ueda, (2001) member of the Board of the Bank of Japan, (at http://www/boj.org.jp/en/press/] where he says, for example, that "The BOJ has been groping for policy options that are valid near a liquidity trap. Life would have been very easy for the BOJ had simple increases in the monetary base led to a significant rise in the general price level. Instead the BOJ has been thinking very hard and carried out a variety of policy measures, attempting to over come the difficulty generated by the liquidity trap."

[4] Of course there may be other costs of pursuing low inflation not connected with the risk of hitting the zero bound, associated, for example, with downward nominal rigidities in prices or wages, or with the possible overstatement of true inflation in published measures. But I am going to say nothing about those issues in this paper.

[5] Analogous to the scenario painted by Wicksell.

are designed to stabilise. The significance of this trade-off (if there is one) for optimal policy will depend on how costly inflation is relative to inflation and output variability.

This paper evaluates what the literature to date has had to say on these questions. In short, I conclude the following:

Quantitative studies suggest that the risks of encountering the zero bound are quite small – in the region of 5 per cent – when policy aims at inflation rates similar to the objectives some pursued by many central banks, and moreover that the risks of succumbing to a deflationary spiral are negligible. This said, studies tend to show that those same risks increase a great deal as average inflation rates fall toward zero.

The risks of hitting the zero bound appear to be demonstrably smaller still if central banks commit to inducing persistence in interest rates, which increases the central bank's leverage over real rates and reduces the need for nominal rate cuts.

The menu of alternatives to cutting interest rates includes: more active fiscal stabilisation; taxes on money to lower the zero bound to interest rates; money 'rains' or transfers to the private sector; using open market operations to buy up long government bonds, or private sector assets, or even to buy assets denominated in foreign currency in the hope of devaluing the exchange rate; or, finally, writing options that promise to hold interest rates at the zero bound for a definite period of time.

How much comfort should central banks with explicitly quantified low-inflation objectives draw from this work? On the one hand, taken at face value, the work so far provides some reassurance. Yet on the other there is the preoccupation with the experience of Japan, which many argue is indeed an economy 'trapped' at the zero bound, if not yet one in a deflationary spiral.

The risks of hitting the zero bound – however small – are in one important respect overstated in the literature. They are calculated studying economies when the central bank is committed and believed to be committed to interest rate rules that in practice no central bank implements (or would ever implement). Ad hoc deviations from the rules that studies use would almost certainly reduce the apparent risks of hitting the zero bound. Such deviations, since they are rational, would be expected.

On the other hand, estimates of these risks depend critically on estimates of the shape of the distribution of shocks that are likely to hit the economy and be propagated into changes in desired interest rates. This distribution is a key unknown. The logical approach is for policy to take out insurance in the form of higher average inflation to cope with the possibility that the estimates are based on distributions that are too narrow.

Higher inflation looks even more attractive a policy choice when we consider how uncertain is the efficacy of the policy alternatives (discussed at length in the paper). As Fuhrer and Sniderman (2000:p845) put it "prevention is likely easier than cure".

However, this is not to say that those central banks that have quantified inflation objectives are following 'targets' (or whatever one should call them) that are too low. Insurance carries with it a premium: in this case the welfare costs of inflation itself. The amount of insurance central banks should therefore take out depends on a careful analysis of the benefits that come with lower outcomes for inflation and output variability, relative to the costs of the higher associated inflation. Central banks could never hope to reduce the chance of avoiding the zero bound *to zero*. And the costs of inflation would make it undesirable to try. It is perfectly conceivable, therefore, that the objectives that typify modern monetary regimes already have more than enough insurance built into them to accommodate the problem of the zero bound to interest rates.

The rest of the paper is set out as follows: section 2 decribes a stylised version of the monetary policy problem in which the implications of the zero bound for optimal policy become clear. Section 3 recapitulates the literature that explains what brings about the zero bound to nominal interest rates, and what could make the floor differ from zero. Section 4 reviews the studies that have examined what the risks of hitting the zero bound are at different inflation rates (accompanied by an Appendix which sketches the studies in a little more detail), or have identified 'perils' of following interest rate rules. Sections 5-10 go through the alternatives to interest rate policy so far suggested: Gesell money or a 'carry tax' (5); money 'rains' (6); exploiting the home economy portfolio balance channel by buying long bonds or shares (7); stimulating the economy via a devaluation of the exchange rate (8); selling options to the private sector that embody a promise not to raise rates in the future (9); and stimulating the economy through conventional debt financed reductions in taxes or increases in spending (10).

2 The zero bound: where does it come from and is it really zero?

Suppose there are only two assets: money and default-risk-free government bonds. Money yields some service.[6] Suppose that the extra service you get from an extra unit of money declines as you accumulate more real balances. Suppose too that the only cost to holding money is that you forego the chance to earn interest on government debt. The lower the interest rate foregone, the larger are optimal real balances of currency. The Government could try to offer less than zero interest rates on its debt, but no-one would swap money for that debt. Money pays a certain and zero nominal interest rate stream, and carries with it no other costs.

Imagine instead that holding real balances does involve some cost: for example, that the only currency is gold, and storage space and security guards are costly. In this circumstance, as real balances got larger and larger, and the transactions costs reducing service yield of an additional gold bar fell, the storage cost would start to dominate. If the marginal costs of managing gold balances were constant, then the central bank would be able to lower interest rates to a negative number equal to this cost. Once the transactions reducing benefit had fallen to a point where it was negligibly small, I would be willing to hold bonds instead of gold, even at a negative interest rate, since by doing so I could avoid paying for storage and security.

The floor to nominal interest rates is therefore given by the costs of holding currency. Can we say anything about the shape of this cost function in a modern economy? In the limit, we could think of infinite levels of real balances as infinitely costly to handle, monitor and store. If this is the limiting case, then it seems equally plausible to believe that the marginal cost of managing real balances must at some point rise from a quantity that is negligible at levels of real balances held at inflation rates typical of modern developed economies, to something significant. It seems plausible too to think that the costs of handling real balances are larger in economies with more primitive financial systems. (It is cheaper to store paper money than gold bars). Beyond that it is hard to say more. McCallum (2000) is sceptical that the marginal costs of managing real balances would amount to something that could lower the floor to interest rates by more than a few basis points.

[6] It could cut transactions costs, or help with "shopping time" (McCallum and Goodfriend, 1987); it could be required "in advance", in a manner originally suggested by Clower (1969). Or we can think of it providing some other unmodelled utility [Sidrauski (1967)].

Another possibility is that bonds may provide a service to holders not captured by the interest rate, perhaps a form of liquidity service not perfectly substitutable for that provided by cash. If there were any benefit to holding bonds of this sort then (leaving aside the costs of holding cash for a moment) the observed interest rate could fall to a level equal to minus the benefits from holding bonds. At this below-zero interest rate, I'd still be willing to hold bonds, as the 'liquidity service' would compensate me for the payments I have to make to the Government for the privilege (the negative interest rate).

Yet another possibility is that some of the benefits from holding *cash* do not asymptote to zero as real balances increase. That there might be some portion of the returns to real balances that are constant, and not diminishing. This could be true for those who hold cash to facilitate criminal economic activity, or to engage in legitimate activity that requires complete anonymity to make it attractive.[7] The benefit of holding the 1 millionth euro in cash for this purpose could be no less than the benefit from holding the tenth. Both provide the same anonymity service.[8] The more important is anonymously financed activity in the economy, the larger the portion of cash holdings that will be held with these benefits in mind, and the higher will be the floor to nominal rates.[9][10][11]

So the zero bound will be *lower* than zero to the extent that there are, at some point, significant costs of managing real balances, and to the extent that there are non-pecuniary benefits of holding bonds. And it will be *greater* than zero to the extent that there are, for

[7] Dreheman *et al* (2002) cite examples like gambling or legal sex-related industries.
[8] In fact, if I were a cash-holding criminal, the costs of my criminal activity being detected by my deciding to hold my wealth in interest-bearing, but more visible assets would not only not decline, they may even be increasing in real balances if all my real balances were confiscated as a result! If I have a million ill-gotten pounds, and contemplate putting that million into interest bearing assets, I risk being found out and losing a million pounds. If I have two million, and contemplate putting those into bonds, then I risk losing two million if I am found out.
[9] Drehmann *et al* (2002) and Rogoff (1998) have suggested that holdings of notes and coins by those engaged in criminal activity may be significant, especially if the prevalence of very high denomination notes is used as an indicator. High-denomination note holders might distinguish criminals from those who engage in activity they simply don't want to disclose, even though it is legal, since high denominations would be inconvenient as a medium of exchange for those activities.
[10] But of course, the more important are criminals in cash holding, the higher is the socially optimal inflation rate, since inflation serves as a tax on criminal activity, and would bring with it the social benefits associated with reducing crime.
[11] There are, of course, bearer bonds, where the owner is not identified. But bearer bonds are still surely more likely to lead to identification since they will be exchanged amongst a smaller group than will cash, and, by virtue of that, will not serve as a medium of exchange for anonymously engages in or criminal activity.

the average economic participant, some significant (e.g. anonymity) benefits from holding cash that do not diminish as real balances rise.

Note that the bound to interest rates, which occurs at the point where the marginal net benefits to holding money flatten out, also generates the 'optimum quantity of money' in the sense of the Friedman rule. In an economy where there are no frictions, and no need for stabilisation policy, positive interest rates constitute a tax on money, and since money is socially productive by assumption, erodes welfare. So the zero bound is the fulcrum of two competing objectives of policy. One drives inflation towards the Friedman rule, to preserve the value of money; the other drives inflation up above it, because the central bank needs to use interest rates stabilisation to make the inflation rate stationary about its optimal rate.

This model of the zero bound is the foundation for our analysis of the risks and welfare consequences of hitting a zero bound and the efficacy of policies to escape it. Wallace (2000), in his comment on McCallum (2000), questions whether the metaphors used in these models are adequate enough to capture what he sees as the real motivation for individuals holding money: namely, that exchanges conducted with money can be done "without knowledge of individual histories." The models he comments on do not describe the imperfections in monitoring credit histories that could give money some value, and are, he argues, therefore internally inconsistent.[12]

I make the following remarks by way of a defence of the literature. First, is the money metaphor any less adequate or internally consistent than other parts of the story modern macroeconomics tells about the world? Wallace singles money out for special attention because the interest-rate floor puts the properties of money and other assets under the spotlight. But macroeconomics (and the use to which we put it in our study of the zero bound) is built out of a house of such cards, (or internal contradictions) not just one.[13] Second, regardless of where our macroeconomic house of cards is weakest, what does the applied theorist and policymaker do about it anyway? Without an alternative workhorse model, perhaps the best we can do is to proceed, but with a degree of caution, noting that our models and our conclusions built on them will be fraught with imperfections. In order

[12] See also Wallace (2001) where he describes his disquiet with workhorse monetary models – and the unsoundness not just of zero bound analysis but other monetary questions – in more detail.
[13] For instance: our model includes firms, although we say nothing about why firms exist; our model includes Governments and public monetary authorities, though we say nothing about why they exist either; we assume markets, yet ignore the delicate equilibria that underpin the property rights that create them; and agents trade, although there is nothing generating an incentive to specialise and exchange….

for us to find some other way forward, we would need for it to be shown conclusively that an alternative model of the zero bound would invalidate policy analysis based on existing monetary foundations.

3 What is the risk of hitting the zero bound?

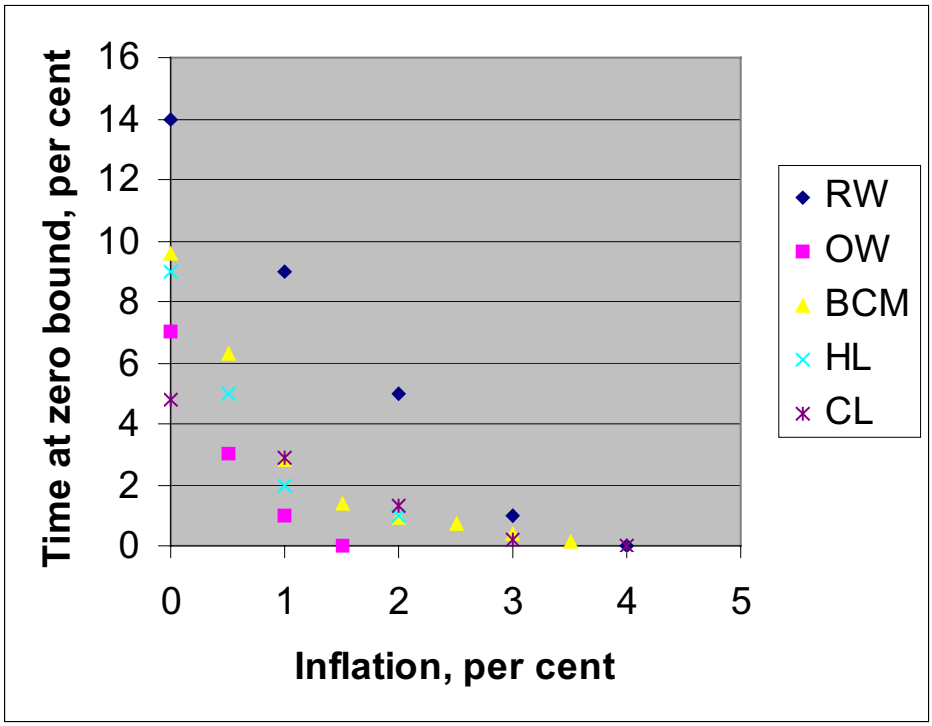
One strategy for assessing the risk of hitting the zero bound is to use historical or cross-country experience and look at how often the zero bound is encountered. But I am going to largely ignore this approach. Inferring anything useful from historical evidence is difficult. Relevant historical episodes (like the US in the 1930s) were the product of an economic environment and a regime that differs from today's in ways it is hard to be precise about. This complicates the task of replaying history with today's monetary policy, which is the relevant counter-factual. Looking at other countries is fraught with the same difficulty. Japan's nominal interest rates have been close to zero for some time. But what that tells us about optimal policy in the US or in Europe is not obvious. It is plausible to argue that Japan's monetary institutions differ in many ways from the arrangements that surround, for example, the policy of the euro area, or the Bank of England. And there are those that argue that Japan's monetary conjuncture is the result of many factors other than the design of monetary policy.[14]

An alternative is to construct a model of the monetary policy problem and imagine the consequences of policy targeting different inflation rates, and conjecture further that there is no alternative to interest rate stabilisation.[15] This is an approach that has been followed by Cozier and Lavoie (1994), Fuhrer and Madigan (1997), Black *et al* (1998), Orphanides and Weiland (1998), Wolman (2000), Reifschneider and Williams (2000), Hunt and Laxton (2002).[16] It is an approach that I will argue is also open to criticism, but the one I will concentrate on here.

[14] For a recent commentary on Japan's monetary policy, see Erceg *et al* (2002) and the references therein.
[15] Some (but not all) of these studies do allow for automatic fiscal stabilisers to work in the absence of monetary policy.
[16] Some of the results in Hunt and Laxton (2001) are also presented in a box authored by Hunt in Chapter 2 of the IMF *World Economic Outlook*, May, p93, entitled 'Can inflation be too low?', within the essay 'Monetary Policy in a low inflation era', by Terrones and Sgherri.

Results from these studies are compiled into chart 1 below:

Chart 1: the risks of hitting the zero bound



The consensus emerging from these studies,[17] which use different models and different policy rules, suggest the following: that targeting inflation rates of 2 per cent or above implies a small risk of hitting the zero bound. A ballpark figure is that the central bank might expect rates to be held at zero for between 1 and 5 per cent of the time at 2 per cent inflation. They imply very small risks indeed of the economy entering a deflationary spiral. Hunt and Laxton (2002), the only ones to report this explicitly, report that at 2 per cent there is virtually no chance of the economy entering such a spiral. But the median study also suggests that the risk is significant at inflation rates lower than that, and that the

[17] A brief summary of each study appears in the Appendix. The numbers behind Chart 1 appear in Table 1 at the end of the paper. Note that these numbers are approximate and based on my own estimates from what is presented in the papers cited. The most important change I have made is an adjustment to the assumed equilibrium real interest rate to make the studies as comparable as possible. (They take different positions on this issue).

chance of the zero bound binding increases exponentially as the inflation target is lowered. Estimates of the length of time rates are likely to spend held at zero when the central bank pursues a zero inflation target range from about 15-30 per cent. If such a target is followed, Hunt and Laxton report that the central bank can expect to endure a deflationary spiral for around 10 per cent of the time.[18]

The conclusions in these studies, and indeed our conclusions more generally about the risks of hitting the zero bound, are going to depend on many factors. But we might single out the following; an assumption about the variance of shocks in the future; an assumed equilibrium real interest rate; what we suppose about the rule the central bank follows (if any) in setting monetary policy; and of course on a particular representation of the economy, which propagates the shocks into distributions for desired interest rates.

The distribution of shocks

The shape of the distribution of shocks hitting the economy that policymakers wish to stabilise will be crucial in determining how the likelihood of hitting a zero bound to interest rates rises as the mean inflation rate falls. We can conduct thought experiments where we imagine that the costs of an inflation policy are given by the portion of the distribution of desired nominal interest rates which turns out, for the distribution of the shocks in the economy, to be negative and, therefore, infeasible.

Think of a linear, static economy subject to shocks that are uniformly distributed between two values. In this kind of economy the distribution of desired interest rates would also be uniform. Policymakers could choose a range of inflation outcomes above a certain point for which there was no sacrifice in terms of the variability of inflation or output since the shocks would never be large enough to prompt an interest rate likely to hit the zero bound. Below a certain point, the uniformity of the distribution of shocks would mean that the cost in terms of variability (of output and inflation) of reducing inflation by each extra amount would be some constant positive number.[19] Each one percentage point move down in the inflation target would shift an equal portion of the probability of desired interest rates into 'negative territory'.

[18] Calculating the 'risk' of hitting the zero bound in this way is more of an art than a science. But it gives a flavour of two more compelling statistics in a way that is comparable across studies: the portion of the ex-ante desired interest rate distribution that is ruled out by the zero bound; and the increase in the variability of inflation and output.

[19] Up to the point where the mean inflation rate is so low that every value of the uniformly distributed shocks is expected to imply zero interest rates, after which point there is no extra variability implied by choosing even lower inflation.

The larger the variance of this uniform distribution of shocks, other things equal, the higher the inflation rate at which positive costs of inflation reduction would start to kick in. If the shocks were normally distributed, then the marginal cost in terms of variability of a unit of inflation reduction would itself be normally distributed, rising from zero at some infinitely high mean inflation rate, (when a negligible part of the distribution of desired rates crosses the zero bound) up to a maximum , and then asymptoting to zero again at infinitely negative inflation (where since almost all the distribution of desired rates is negative anyway, there is no cost to reducing inflation further . Suppose we begin from a point where we imagine that the mean interest rate is five per cent and the mean, target inflation rate is two per cent. A reduction in the target of one percentage point will put some portion of the distribution of desired rates below zero; a further reduction will put an even larger portion of the distribution below zero. And so on.

So, in short, the dispersion of the distribution of shocks (which will be a sufficient statistic for the dispersion of interest rates under active monetary policy in this linear static world) will determine the portion of the distribution of desired rates that is negative, at some inflation rate. It will therefore determine the cost of a given inflation rate. And the shape of the distribution – how fast the tails thin out - will determine the shape of the schedule that plots the marginal cost of inflation reduction against inflation.

Equilibrium real interest rates

The higher the equilibrium real interest rate, the higher the equilibrium nominal interest rate associated with an inflation objective, and, for a given distribution of shocks, the lower the probability of interest rates hitting the zero bound for a given size of shock. A higher equilibrium real interest rate therefore lowers the cost of a given inflation rate. If the distribution of shocks is normal, an increase in the equilibrium real interest rate would reduce not only the cost of a given inflation rate, but also the marginal cost of a unit of inflation reduction.[20] Alternatively, if the distribution of shocks were uniform, the marginal cost of inflation reduction would not depend on the equilibrium real rate, (although the average cost of a given inflation rate would). Contemplating the effect of a change in equilibrium real rates is analogous to contemplating a change in the inflation target. Both change the equilibrium nominal interest rate, of course.

[20] Unless the mean inflation target is such that the mean interest rate is less than zero, in which case the cost of reducing inflation from that point will be higher, the higher is the equilibrium real interest rate.

Not all changes in the equilibrium nominal interest rate make more room for interest rate cuts. An increase in an inflation risk premia would raise the equilibrium nominal interest rate, but that premia would be built into nominal rates at all times, and raise the floor to interest rates by the same amount.

To recall, optimal policy will equate the marginal benefits of steady-state inflation reduction with the marginal costs coming from hitting the zero bound and impairing inflation and output stabilisation. Clearly, the interaction of two sources of ignorance – the shape of the distribution of shocks, and the equilibrium real interest rate, both of which we will expect to influence the marginal cost of inflation reduction – are going to make this calculation extremely uncertain. The dispersion (variance), symmetry (skewness) and the thickness of the tails (kurtosis) of the distribution of shocks are all important unknowns in this calculation.

The studies cited at the beginning of this section typically assumed normal distributions for shocks, calibrated to have variances in line with the variance of past, estimated disturbances. These assumptions are probably the only convenient benchmark to use in evaluating the risk of hitting the zero bound. But there is no reason to expect assumptions like this to be reliable. For example, if the normality of residuals is (and it surely often is) used as a criterion for choosing good models from bad, we can't tell much from discovering, at the end of the process of model-building, that we have 'shocks' that appear to have been normal in the past. We would need other evidence independent of the model to do that. Even if we had such evidence, we could not guarantee that any information we get about the shape of the distribution in the past is going to be a reliable guide to the shape of the distribution in the future. None of our theories tell us that.

To repeat, knowing something about the shape of the distribution of shocks is the key to assessing the risk of hitting the zero bound, and the marginal cost of inflation reduction at a given inflation rate. Uncertainty about those distributions is going to lead to uncertainty about the optimal inflation rate. Ideally, the design of a policy that aims to balance the costs of inflation against the risk of hitting the zero bound would take account of the inherent uncertainty about the shape of the distribution of shocks.[21]

[21] One complicating factor is that the distribution of shocks to desired interest rates may be related to the choice of the average inflation rate. It is hard to find a coherent economic argument for a mechanism like this. One plausible rationale for why the variance of shocks might increase as the inflation target falls might be that the degree of nominal stickiness may increase as the inflation rate falls. See, for example, Ball, Mankiw and Romer (1988). This would increase the short

Real rates related to steady state inflation?

The equilibrium real interest rate may itself be related to the choice of the average inflation rate. This can be rationalised in a 'money in the production function' model. In such a world, money provides firms with a transactions service analogous to the benefit the McCallum-Goodfriend (1983) 'shopping-time' model tells us money confers on consumers. (Money can help firms save time 'shopping' for inputs, just as it can help individuals 'shopping' for consumption goods. High inflation changes the relative price of real balances and other factors, and induces firms to substitute out of real balances into, say, capital. This lowers the marginal product of capital and, in a closed economy, lowers real interest rates.[22]

McCallum (2000) attempts to calibrate this effect. His results are, in his own words "unlikely to provide much reassurance to policymakers"(p879): his calculations suggest that reducing the inflation rate from 10 per cent to zero increases the real rate by only 7 basis points.[23]

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impact of a given change in interest rates on real variables, but reduce the impact of interest rates on nominal variables, but at any rate would change the distribution of desired interest rates for a given set of shocks. Note that Klaeffling and Lopez (2002) contemplate the opposite case, that high inflation implies a larger variance of demand shocks. They cite the widely documented correlation between the level and variance of inflation [pointing us to Okun (1971, 1975), Taylor (1981) and Ball and Cecchetti (1990)] in support of the idea. (Although in my view there is some way to go before we interpret the increased variance of inflation as an increased variance of shocks. I would conjecture that this phenomenon is more likely to reflect either an actual or perceived lack of concern for inflation variation on the part of those policymakers that tolerate higher inflation, rather than a higher variance of shocks to which policymakers in high inflation rate countries have to respond.)

[22] Another route by which inflation could affect real rates is very loosely described by the following: if inflation affects growth, and growth itself is related to the real rate, then lower inflation could raise the real rate.

[23] However, I would add this qualification to McCallum's gloomy assessment. The amount of "reassurance" (or the amount by which a rise in the real rate might translate into a fall in the risk of hitting the zero bound) 7 basis points could provide depends on the shape of the distribution of shocks (and therefore of desired nominal interest rates). If the economy is already at a point where the density function of desired interest rates is high (or thick) at the zero bound, then 7 basis points will lower the risk of hitting the zero bound a good deal. If the density function is very thin at the zero bound, then shifting up the real rate by 7 basis points will have very little effect on the risk of hitting the zero bound. By extension, think of the effect on the optimal inflation rate. If shocks were uniformly distributed, and the economy was already at the point where the marginal benefit of inflation-reduction equalled the marginal cost, then neither a 7 basis point, nor a 100 basis point rise in the real rate would change the optimal inflation rate. Recall from the above that the optimal inflation rate equates the marginal benefit with the marginal cost of a unit of inflation reduction. And that the marginal cost of a unit of inflation-reduction is given by the slope of the density function of desired rates. However, if the slope of the density function of the shocks at the current optimal inflation rate was quite steep, then contemplating even a small rise in the real rate could imply a significant change in the optimal inflation rate.

From a distribution of shocks to a distribution of desired nominal interest rates

Anything that shrinks the variance of desired rates relative to the variance of shocks will reduce the cost of a given inflation rate and reduce the costs of inflation reduction, at least for distributions with thin tails and fat middles. The ingredients that do this are the model of the economy and the policy rule. So it is natural to organise our questions about the risk of hitting the zero bound around these two factors.

Policy rules and history-dependence

In rational expectations models central banks that announce (and can commit to) interest rate rules embodying history-dependence can reduce the amount by which they need to move the nominal interest rate to bring about a given change in real interest rates. In so doing they can therefore reduce the variance of desired nominal interest rates for a given variance of shocks. This in turn implies reducing the chance of hitting the zero bound at a given inflation rate.

Woodford (1999) explains the case where interest rates are set as a function of lagged interest rates.[24] When the central bank lowers interest rates today, (say, in response to a demand shock), private agents will expect interest rates to be lower tomorrow too. This will have two beneficial effects. The first is that expected future inflation will be higher because policy will be looser for longer. The second is that long nominal rates will be lower. Both effects lower real rates, relative to a normal policy rule, for a given change in nominal rates. And this in turn implies that the amount by which the central bank needs to reduce rates to offset the demand shock will be lower.

But interest rates are not special in this regard. The beneficial effects through expectations can be got by setting interest rates as a function of the history of any variable. Moreover, research in this area has yielded up two forms of commitments. Not only can we can think of promises to follow particular interest rate rules with historical arguments in them (what we might call "interest rate rule history-dependence"), we can also conceive of a commitment that the central bank will find an optimal rule subject to an objective that itself has historical terms in it ("objective or contractual history-dependence"?); or more precisely, one that weights historical terms more than does the underlying social objective

[24] He attributes the original argument to Goodfriend, (1991).

function.[25] Central banks subject to a contractual history-dependence will find themselves, of course, behaving like central banks with interest rate rule history-dependence.

Reifschneider and Williams (2000) illustrate the benefits of two types of related history-dependence. One takes the form of adding to a conventional simple interest rate rule involving inflation and output gap deviations, but also terms in lagged inflation and lagged output gaps, (and then searching for the optimal coefficients on all of them). Another 'turns on' only when the zero bound constraint binds.[26] While the interest rate is at the zero floor, the central bank accumulates a gap between the actual and desired level of rates. If the central bank commits to leaving rates low (in proportion to this cumulated gap) once the recession is over, then the expectations channel works in the way described above. Future inflation will be higher, and real rates lower during the recession, etc. etc.

Similar beneficial results have results have been obtained by those who have studied interest rate rule or contractual history-dependence that focuses on a concern for a price-level target.[27] A price-level target requires that policy commit to reversing the effects of past shocks that have lead prices to deviate from target. A demand shock that leads to prices being below target will cause agents in the future to expect inflation to be higher. And this will bring about a reduction in real rates that acts to reverse the effect of the demand shock.

If the distribution of shocks is such that a normal-like (thin tails, fat middle) shape is imparted to the distribution of nominal interest rates, history-dependence is likely to reduce the cost of inflation reduction at a given inflation rate. To recall, the cost of inflation reduction is going to be given by the height of the density function of interest rates at zero interest rates. And shrinking the variance of nominal interest rates will lower the height of that density function at zero interest rates.

[25] Batini and Yates (2001) dwell on these two types of commitments, and present history-dependent examples of both in the course of discussing price level targeting. But examples of both types of course predate that paper, and can be found in Vestin, (1999), Svensson, Ditmar *et al* (2000), Gaspar and Smets (2000) and others.
[26] Hunt and Laxton (2002) consider a similar type of price-level target rule, that they class as a 'one-off intervention': an amendment to a Taylor rule that only takes effect if the zero bound constraint binds. (see page 17).
[27] See Batini and Yates (2001), Ditmar *et al* (2000), Gaspar and Smets (2001), Svensson, (1999), Vestin (1999), Wolman (1998,2000).

For example, Reifschneider and Williams'(2000) simulations show that the cost of reducing inflation by two percentage points is greatly reduced by introducing history-dependence into the interest rate rule, both in terms of inflation and output variability.[28] Although the authors don't say so, this is an artifice, in my view, of (quite reasonably) using shock distributions with tails that thin out. To stress again a point I made earlier, it seems likely that *any* policy that shrinks the variance of interest rates relative to some other policy will reduce the marginal cost of inflation reduction[29] at the starting inflation rate, provided that the distributions of shocks that involve tails that get thinner away from the mode.[30] And the reasoning here is the same as the reasoning I used in the simple example above when contemplating the effect of a change in the variance of shocks. The thought-experiment that contemplates shrinking the variance of interest rates relative to the variance of shocks by improving the policy rule is the same as a thought experiment where we hold the rule constant and shrink the variance of the shocks. Both shrink the variance of desired interest rates.

History-dependence and the forward-lookingness of expectations

The benefits of 'interest rate rule' or 'contractual' history-dependence will depend on how closely the process by which expectations are formed resembles the model-consistent version so far assumed; and, to the extent that expectations are forward- looking, how credible a strategy history-dependence is.

There are an unlimited number of ways that expectations formation can differ from the rational, model-consistent expectations that are at work in the way the benefits of history-dependence have so far been described. So it is difficult to make general statements about how the net benefits of history dependent policy rules will change once we depart from the model-consistent variety. But with this caveat in mind we could hazard two predictions by way of an illustration.

First, the less forward-looking are expectations, the weaker will be the effect on future expected nominal rates and expected inflation of committing to a price level target, for example. To be more specific, we could imagine a (very particular) spectrum of

[28] See, for example, figure 9, page 961.
[29] And provided that the initial inflation target is one that involves a mean desired nominal interest rate that is positive.
[30] Another example is in the same figure 9 of Reifschneider and Williams, which shows that the marginal cost of inflation reduction is lower for Henderson-Mckibbin (HM) rules than for Taylor rules. Comparing like for like, HM rules generate lower inflation and output variability than Taylor rules. HM rules also imply a lower cost of reducing inflation from 2 to zero.

expectations formation processes. At the one extreme, we have model consistent expectations, where the effect of price level (and other history-dependent) targets is as I have described it here. At the other is an economy where expectations are set purely as a distributed lag of past inflation rates. In the middle are economies where expectations are set as weighted sums of the model-consistent and past inflation rates.[31] For economies with a high weight on past inflation in expected inflation, a low inflation rate which causes an undershoot of a price level target will generate only a weak boost to expected future inflation, and therefore, other things equal, the nominal interest rate cut required in the first place will have to be large.

Second, and in contrast, to the extent that backward-lookingness in expectations informs nominal contracts, a given stimulus to future inflation could have a larger effect on aggregate demand, (by reducing real factor prices) and, therefore, require less history-dependence in the first place.

History-dependence and credibility

Turning to the issue of credibility. Suppose a central bank really faces an inflation target, but commits to a price-level target in order to gain extra stabilisation power. The benefits of history-dependence following a deflationary shock (say, when there is a price level target) come about because agents expect policy to be loosened, and therefore expect future inflation to be higher, which in turn reduces real rates now, and therefore reduces the amount by which the central bank needs to cut nominal rates to bring about the real rate stimulus it needs. However, when the time comes to loosen policy and generate the inflation agents expected when the deflationary shock hit, central banks who really face an inflation target, (and where the price level target is just a device to reap stabilisation gains) will have an incentive to renege on their commitment. If this incentive is large enough, agents will expect the commitment to be reneged upon, and the beneficial stabilising effects of the history-dependent rule with a price level target in will not be reaped in the first place.

[31] This is of course not meant to define a spectrum along which we might locate all possible expectations formation processes. It is just meant to make more concrete some notion of 'backward-lookingness' in expectations that would weaken the benefits of (a given degree of) history-dependence.

The key question, therefore, to repeat, is how large these incentives are likely to be.[32] If the framework in which the central bank operates is such that it is sufficiently long-sighted, it will compute the present value of history dependent policies in the way that Woodford (1999) shows us and stick to them. If not, it won't. One argument is that central banks will need to establish a reputation for keeping their history-dependent promises before they will work. In which case the version of history-dependence in Reifschneider and Williams (2000)[33] that only 'turns on' when the zero bound bites is likely to be less beneficial. Since at other times this kind of history-dependence will be observationally equivalent to policies that aren't history dependent at all. Central banks that intend to stick to history-dependent promises will look no different from those that don't. To the extent that writing contracts for the central bank can provide a device that guarantees commitment more effectively than announcing a rule for the interest rate, then contractual forms of history-dependence may also be more desirable.

If history dependent policies that only turn on when the zero bound bites are beneficial (relative to those that operate all the time), and yet the private sector need to learn that the central bank would stick to its history dependent promise at the zero bound, there may be an incentive to target lower average inflation, at least initially, to induce episodes from which the private sector can learn. (Or periodically, if the private sector not only learn, but forget). In this scenario, ironically, the strength of the motivation to target positive inflation – the costs of the impairment to stabilisation policy imposed by the zero bound – would be precisely what determined the incentive to push inflation low to create these learning opportunities.

[32] This is a debate that researchers had when they discussed the material significance of the 'average inflation bias': whether central banks needed to be endowed with legislative independence to remove the incentive to behave like bankers in the celebrated Barro and Gordon (1983) paper, or could, as McCallum (1998) suggested 'just do it', or, as Woodford (1999) (and perhaps others) suggested, did in fact just do it. And the debate about the 'stabilisation bias', the incentive to renege on interest rate rules even when there is no incentive to try and raise average inflation in the economy, takes the same form. Svensson (1999) has argued that interest rate rules in general, and therefore by implication history dependent rules in particular, are "incentive incompatible", i.e. could not be committed to. Woodford takes issue with him in a comment, claiming that this belief "is tantamount to an argument that rational persons are… incapable of self-control or ethical behaviour" (p24), and cites Blinder (1998, p49) who wrote that time-inconsistency problems are a feature of many areas of economic life and are dealt with "by creating and then usually following norms of behaviour by building reputations and by remembering that there are many tomorrows. Rarely does society solve a time-inconsistency problem by rigid pre-commitment or by creating incentive-compatible schemes for decision-makers."

[33] And more recently by Hunt and Laxton (2002).

Interest rate rule "pathologies": do they bear on the choice of the inflation objective?

Some researchers have discussed the possibility that there are compelling and less benign influences on the risk of hitting the zero bound that emerge from the interaction of private sector expectations and the policy rule. Benhabib *et al* (2000, 2001), Buiter and Panigirtzoglou (1999), Bullard and Cho (2002), Christiano and Rostagno (2001), Henderson and Alstadheim (2002) have all studied what Christiano and Rostagno call 'pathologies' associated with central bank commitments to interest rate rules. These pathologies can include multiple equilibria, indeterminate or explosive equilibria. And amongst them can be equilibria dubbed a 'liquidity trap' where interest rates are zero and 'trapped' at zero.

The likelihood of the economy finding itself on one of these trajectories, and subsequently hitting the zero bound to rates, is, we might conjecture, typically not going to be affected by the choice of the average inflation rate. That has instead to do with the interaction of central bank commitments to a particular type of policy rule and private sector expectations.[34] These studies point to there being many equilibria, some appealing, stable, determinate, some not. They raise questions about what would determine which of the many possible equilibria a central bank might find itself in to begin with. There are questions too about what might cause the economy to switch from one equilibrium to another, and what the dynamics of the economy might look like in transition. But choosing high rather than low inflation does not seem likely to serve the role of a beneficial equilibrium selection device, nor to influence the chance of the economy moving from one to another.

A reasonable assumption, therefore is that studies of interest rate pathologies do not tell us anything about the cost of a given inflation rate in terms of inflation and output variability, but tell us instead about the risk of hitting the zero bound at *any* inflation rate when the

[34] I say 'typically', here, since Bullard and Cho (2002) is an exception. In their world temporary low inflation states are brought about by periodic clusters of shocks convincing the private sector that the central bank has lowered its inflation target. Since the central bank moves its target in part in line with what the private sector expects (perhaps because of a desire to avoid the output fluctuations that would come with expectational errors), the target then does indeed shift down, and the process is, for a while, self-reinforcing. In these circumstances, choosing a higher inflation rate would indeed reduce the chance of a temporary low inflation state brought about in this way forcing interest rates against the zero bound.

central bank commits to a particular types of interest rate policy.[35] They suggest, therefore, that there is a component of the risk of hitting the zero bound for which choosing high inflation would not be any sort of reliable protection. More inflation may be neither a necessary nor a sufficient remedy.

These analyses of interest rate rules do serve to illustrate, however, that the mapping between the distribution of disturbances and the distribution of interest rates will not be as trivial as in the linear, static case we started out with. But in economies with these unattractive pathologies the mapping (however complex or discontinuous) between the distribution of shocks and interest rates is likely to be preserved as we move around the mean interest/inflation rate up or down. So, for example, it should therefore not undermine the statements we have already made about how the costs of inflation reduction vary with the variance of the distribution of shocks.

Pathologies: mathematical curiosa or real diseases?

Some have questioned whether the 'pathologies' associated with interest rate rules have any economic significance at all. McCallum, since he advocates a rational expectations solution method that allows the economist to rule out equilibria of the sort discussed above, thinks them to be little more than a mathematical curioso.[3637] His criterion involves conjecturing solutions that involve the minimum number of what he calls the 'relevant' state variables (MSV), and of course imagining that private agents do the same. The authors in the pathology literature implicitly find this solution elimination criterion 'arbitary' (otherwise they wouldn't list more than one solution); McCallum (2002) finds doing anything else equally so.

Evans and Honkapohja (1999, 2001) advocate an alternative method for selecting amongst multiple solutions that involves examining which of the multiple solutions would be converged on in an economy where agents learned the coefficients in the model: this is not always the MSV case. McCallum concedes this, but argues that all economically plausible (or in his words 'well formulated') models are indeed cases where the MSV solution would be converged on by agents who learned in the way Evans and Honkapohja

[35] McCallum, for example, notes: "if one is inclined to doubt the stabilising properties of Taylor rules, or interest-instrument rules for inflation targeting, then this doubt should logically exist without any regard to ZLB considerations." (p901).
[36] As did the anonymous referee of this paper.
[37] See McCallum (2000) for his application of this point with respect to the literature on the zero bound trap, and McCallum (2002) for a full exposition of his position on the debate about appropriate criterion for eliminating equilibria when there are multiple such solutions.

illustrate. So arbitary it might be, but it is a short-cut to selecting a learnable solution, and one that means that there are no economically meaningful 'perils' associated with interest rate rules.

Whether the real world is likely to be infected by the 'pathologies' that infect special cases of metaphors meant to describe it (RE models above) of course depends on what agents actually do (to form expectations), not whether an equilibrium is learnable under very specific models of learning.[38] Resolving that debate is the subject of ongoing and likely inconclusive research program. Resolving the debate by inspecting economic outcomes would be just as uninformative. There can be multiple equilibria that might without an economy ever moving from one to the other.

One type of interest rate rule pathology that does bear on the choice of the inflation target is the "instability" to which Reifschneider and Wiliams (2000) draw our attention. They observe that there is a "extreme" shocks can push the FRB/US model into a deflationary spirals (p942). Higher inflation rates would reduce the risk of such extreme shocks inducing a spiral like this. This observation tells us that the choice of the inflation target will be influenced by the width of the region within which the model can be restabilised once interest rates have hit the zero bound. If immobilising interest rates for even short periods of time - or with respect to even very small desired cuts in rates - results in unstable oscillations policymakers will choose a higher inflation target than if the dynamics are such that the system has more tolerance of constant rates.

The parameter space in Reifschneider and Williams (2000) is such that it takes a large shock to tip the economy into such a state. But we must surely be uncertain about the 'shock tolerence' of the unknown parameter space in the real economy facing policymakers. This is a key uncertainty in our knowledge about how the distribution of shock in the economy (which we of course also don't know) would translate into costs of low inflation.

History-dependent rules and deflationary spirals

These circumstances highlight an important feature of the mechanics of the signalling benefits of history-dependent policies that it is worth returning to. History-dependent policies work to mitigate either the chance of hitting the zero bound in the first place, or

[38] My reading of Buiter and Panigirtzoglou in a 2002 revision of their 1999 paper is that they appear to sympathise with this view.

the length of time interest rates are held there (and the accumulated deviation from desired rates suffered while at the bound) provided the shock experienced is not so large or protracted as to push the economy into a deflationary spiral (or a 'liquidity trap'). In such a spiral, history dependent commitments are ineffective. The commitment to keep rates lower at some point in the future when a tightening would be warranted does not affect future inflation expectations, because those expectations are formed in the knowledge that the economy is beyond stabilisation. So the signalling inherent in these policies is a useful device for improving stabilisation performance, but it is not a device for escaping from this form of zero bound trap. This is why the proposals of Krugman (1999) have been criticised. He proposed that the solution to Japan's problem was to make a credible announcement of future inflation. The leverage over the economy in normal times through history dependent policies is via making a credible commitment to higher future inflation: it is credible because the private sector expects the central bank to have a lever to generate that inflation (the nominal interest rate will still work). The circumstances that Krugman's Japan finds itself in are such that that (conventional, interest rate) lever no longer exists (although others might, of course, as this paper aims to explore).

Interest rate 'pathologies' and credibility

The conclusion about the benefits of history-dependence resting on the credibility of the rule also applies to what we make of the analysis of some of the undesirable properties or 'pathologies' of interest rate rules. My view of this family of studies – the Reifschneider and William/Hunt and Laxton/Cozier and Lavoie/ Black *et al* pieces – is that it give us some very specific information about the risks of hitting the zero bound. It tells us something about the risks of hitting the zero bound when central banks are credibly committed to pursuing certain interest rate rules in a forward looking model and for some assumed distribution of shocks. However, if the zero bound were to bite, or threaten to, there are grounds for thinking that policy could and would be expected to deviate from the interest rate policies assumed in these studies, and that therefore the risks of hitting the zero bound are overstated.

Consider the following scenario. Policymakers follow some simple interest rate rule. They commit to doing so. The private sector believes them, up to the point where they think it is still in the central bank's interest. And up to a point, it *is* rational to stick with the rule: central banks get some leverage over long rates by sticking to their commitments. But in some circumstances they will break that commitment. For example, if there is a large shock, one large enough that threatened to put the economy in

Reifschneider and Williams' (2000) "region of instability", or a shock that threatened to send the economy on one of the 'pathological' trajectories in the other studies, a rational private sector agent would likely re-evaluate the costs and benefits of the central bank following such a rule and rationally foresee that it will follow some other kind of policy. (If there is another kind of policy).

One reading of these studies is that they tell us about the dynamics of an economy where the central bank commits to and is judged by the private sector as likely to follow policies it has no interest in following.[39] We could construct a model of an exchange rate peg, for example, whereby we studied how, under some circumstances, there was a risk that the central bank not only exhausted its foreign exchange reserves defending the peg, but the government subsequently bankrupted the economy by raising taxes continuously to fund an ongoing and hopeless defence, right to the point where all economy activity ceased. But in doing so we would be identifying the "perils" of a policy that no central bank or government would or could follow, nor would ever be expected to follow. And so with the perils of interest rate rules.

If we can argue convincingly that the equilibrium dynamics of the economy in reality (under 'discretion', or under commitments that will be believed to the point where it is rational to stick to them) are likely to be the same, or at least similar to those under commitment, then we can take estimates of the 'risk' of hitting and/or being trapped at the zero bound at face value. But to do this we would need to believe that there was no alternative policy available to the central bank in the face of a disturbance that threatened to send the economy onto a disastrous path. (Where an alternative policy would bring with it both a cost of being seen to break a previously held promise and some stabilisation benefit). In the example of the exchange rate peg, Governments have a viable alternative, (to dump the peg early). and are expected to follow it, and so the self-destruct scenario is not very informative. So to in the interest rate case. And this does not mean we need to posit an effective alternative to using interest rates to stabilise the economy (although I will indeed discuss the alternatives to interest rate stabilisation in later sections of this paper): setting interest rates according to some other procedure would do. [40]

[39] This is a comment I conjecture applies just as much to the literature on 'perils', (Christiano and Rostagno (2001), Benhabib *et al* (2001), Buiter and Panigirtzoglou (1999) etc), as it does to the literature on the risks of hitting the zero bound and entering a deflationary spiral. But since those papers arguably do not bear on the cost of inflation reduction, the narrative focuses on the studies that do.

[40] Christiano and Rostagno (2001) illustrate just such an alternative – hinted at in Sims' (2000) comments on Reifschneider and Williams – to avoid the 'perils' and 'pathologies' identified in their and other studies, but in a subtly different context. They propose that the central bank could

One factor that might make a pathological scenario plausible is the speed with which the economy heads to the Reifschneider and Williams (2000) 'region of instability', relative to the time it would take for the consequences of sticking to the current rule to become apparent, and for an alternative plan to be put into action. If such trajectories are 'fast', then we can take them seriously. If they are 'slow' enough for policymakers to make sense of them, then we need not.

A more constructive way of interpreting the results of studies in the vein of Reifschneider and Williams (2000) and others is that they tell us about the benefits of actual regimes, which do not embody commitments to any particular policy rule and provide therefore a positive explanation (although not the only explanation) for central banks' reluctance to make such commitments.[41]

None of this is really a criticism of the family of studies mentioned here. Rather it is a word of caution about what we should make of the results. The authors have to posit a rule of some sorts for interest rates. And they posit one that has been shown to both provide a reasonable empirical description of ex post movements in official interest rates and to provide a reasonable approximation to optimal rules in normal times. But herein lies the limit of these studies. Had normal times involved shocks that risked tipping the economy into a zero-rate trap, the empirical content of the Taylor like rules would have broken down temporarily. And the approximation to optimal policy (under discretion or

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commit to an interest rate rule, but also commit to deviate from it should the money supply breach some pre-announced bounds. However, the argument here is that no such commitment would be needed. Central banks would in fact not be expected to follow the interest rate rule in the first place. The commitment to the money growth exemption from the Taylor rule is surely superfluous. Alstadheim and Henderson (2002) consider an asymmetric policy rule that commits the central bank to reducing interest rates in response to a 'negative' shock by more than in response to a 'positive' shock. And Hunt and Laxton (2002) and of course Reifschneider and Williams (2000) study alternative interest rate procedures from the Taylor rule that they use to compute the risks of hitting the zero bound. These are alternatives that are studied under 'commitment'. They are therefore subject to the same observation I make about Christiano and Rostagno: namely, that the point (for our inquiry) is not that there is an alternative *commitment*, but that since there is an alternative policy to the plain vanilla Taylor rule, discretionary policy will follow it, and be expected to follow it. But, nevertheless, these simulations serve to illustrate that there *are* alternatives to the rigid interest rate rules, whether they are options to be committed to or 'just done'. All of these alternatives are shown to yield benefits over their benchmark, more Taylor-like competitors. Bryant (2000) too discusses how a central bank could announce that it would depart from conventional interest rate rules if the conjuncture justified it.

[41] Other arguments for not committing to 'rules' for setting interest rates have been made in public by central banks. That, for example, rules could not summarise the complex array of information that policymakers want to take into account when setting interest rates. Or that it may not be practical to commit to any procedure for setting rates in the presence of continual structural change. For an example from the Bank of England, see Nikolov *et al* (2002).

commitment) of such rules likewise must likewise become worse and worse the more telling is the zero bound constraint.

The economy and the risks of hitting the zero bound: inflation persistence

So far I have discussed how features of the policy rule affect the mapping from the distribution of disturbances to the distribution of desired interest rates. Equally important will be structural features of the economy that propagate shocks into variations of things that policy would like to stabilise (inflation, output) and thereby feed into the variance of desired nominal interest rates for a given variance of the shocks hitting the economy.

Other things equal, the more swift and strong is the transmission of policy changes into inflation and output, the smaller are the risks of hitting the zero bound at a given inflation rate, since the smaller and less sustained are implied variations in desired interest rates. Moreover, the more strong and swift is the transmission mechanism, the larger the benefits to committing to history-dependent rules. At this point I could digress to review innumerable literatures on various components of the transmission mechanism. One example to pick out here is the degree of inflation persistence.[42] When inflation is not sticky, the policymaker can credibly commit to inducing large variations in future inflation for a given change in interest rates, and therefore generate significant movements in real rates for a given change in nominal rates. Wolman (1998, 2000) makes just this observation, and this feature of his model informs his optimism about the risks of hitting the zero bound at low inflation.[43]

On the other hand, if the factors that mean that the transmission of monetary shocks into inflation and output is strong also mean that the propagation of other shocks into inflation

[42] Specifically, the degree of inflation persistence embedded in structural features of aggregate supply, not the autocorrelation of inflation itself, which will depend on the regime. Though of course it's possible that nominal rigidities that give rise to inflation persistence are themselves a function of steady state inflation. Higher inflation could lead to less persistence and hence to more powerful expectational effects from credible policy commitments.

[43] Hunt and Laxton (2002) make the same point, arguing that if inflation is more persistent in the Euro area than in the US, then, other things equal, that would support targeting a higher inflation rate in the Euro area than the US. However, we would be completely mistaken to infer from this that the Euro area inflation objective should be higher *than it already is*. That conclusion would depend on evaluating the relative social costs of inflation, and inflation and output variability, as I have already described. For that reason, there is nothing in the Hunt-Laxton study that can support the view that the ECB should increase its definition of price stability. On the contrary, we could just as well use it to argue that the Fed should lower its implicit inflation objective to something below the ECB's.

and output is strong, the variance of desired interest rates will be larger, and the costs of a given inflation rate larger too.

There is nothing special about structural inflation persistence that warrants us picking that out: were there space to do justice to it, I could digress at this point to review innumerable literatures on various components of the transmission mechanism.[44]

Linear rational expectations models in the face of a non-linearity

There is one final, technical caveat, but an important one, to bear in mind when trying to draw policy conclusions from estimates of the risk of hitting the zero bound. These models are solved (and generate series for expectations) conditioning on the linearity of the model, but are simulated in response to shocks with the zero bound constraint binding. Ideally, they would be solved under the assumption that the private sector would factor in the chance that it might bind. The lower the inflation target, and the lower the equilibrium nominal interest rate, and therefore the more likely the zero bound constraint is going to bind for a given distribution of shocks, the more inaccurate is a model solution conditioned on the notion that it will never bind. So the closer to the origin, the less well measured are the points in Chart 1. Reifschneider and Williams (2000) and Orphanides and Weiland (1998) attempt to correct for the bias that this introduces, but can do so only in an ad-hoc way. Klaeffling and Lopez (2002) use non-linear solution methods and are therefore immune from this problem. The other studies are subject to this criticism and make no adjustment.

Absent any adjustment, the probabilities of hitting the zero bound are probably too low. Before a shock hits, expectations of future interest rates will be based on distributions that assume a symmetric response to shocks; they will therefore be putting too much weight on interest rate cuts, relative to the agent that correctly anticipates the zero bound. This itself will imply a monetary stimulus that would not be there in reality, and imply a commensurately lower probability of hitting the zero bound in the first place.

[44] Instead, see the many papers reviewed by Angeloni *et al* (2001).

4 Gesell money, or the carry tax

Thus far we have discussed the zero bound as though it were a binding constraint, and as if there were no alternative to moving interest rates to stabilise output and inflation. Sections 4-10 discuss other policies that it has been suggested central banks can follow.

Recall that the zero bound on short term interest rates on Government debt comes about because investors can always hold cash, which pays a guaranteed zero return. Any mechanism that seeks to lower the return to cash below zero would therefore lower the zero floor to interest rates. Goodfriend (2000) and Buiter and Panigirtzoglou (1999) propose mechanisms to lower the returns to holding cash.[45] These proposals amount to levying a tax on cash, and, with all taxes, their efficacy depends on the feasibility of enforcement. Cash is anonymously held and there is no incentive for an anonymous bearer to present his cash liabilities for the levy.

Buiter and Panigirtzolou (1999) describe a scheme where the legal tender status of notes would be conditional on bearers presenting them periodically to be periodically re-issued, or stamped or clipped. Buiter and Panigirtzoglou and Goodfriend (2000) discuss taxing cash reserves held by clearing banks at the central bank. This second proposal seems the most plausible, since central banks arguably already tax banks in the way they regulate interactions with the central bank for settlement purposes (e.g. by compelling them to deposit with the central bank interest-free) and so the significance of crossing the zero bound is not great.

Either way, the tax could be manipulated to make room for interest rate cuts below zero either permanently, or when implied desired nominal rates are (or look likely to be) negative. Permanent measures would familiarise the authorities and the private sector with the system and the phenomenon of negative rates, but would carry with them larger social costs: just as it is wasteful to tax cash with inflation, so would it be to tax it directly, assuming that cash itself is a socially productive thing. A one percentage point carry tax would be equivalent to increasing inflation by one per cent. A variable or a temporary tax on money that fluctuated precisely to equal the desired level of (negative)

[45] The intellectual pedigree of this idea is traced by Goodfriend (2000) in a helpful footnote on page 1008 of his paper. He refers us to Keynes (1936, chapter 17, p 234 and 23 pp 353-358); Dahlberg (1938, chapters 7 and 8) and Hart (1948, chapter 20, pp 443-47). Both Buiter and Panigirtzoglou (1999) and Goodfriend point out that Keynes credits Gesell with the original idea.

interest rates would not interfere with portfolio decisions (the returns on cash and money would be equal, just as they are at the Friedman rule when nominal interest rates are zero).

It seems unlikely that taxes could be moved in perfect synchronicity with the desired negative rate on bonds. (If this was a possibility, then *negative* taxes – or money subsidies– could surely be used to equalise returns on cash and bonds even at positive interest rates, eliminating the (shoe leather) costs of inflation at a stroke!) A more plausible alternative would be to lower the interest rate floor by some discrete amount, ahead of a recession, and by enough to provide 'room for' some anticipated interest rate cut below the old zero floor. To the extent that this is the case, then regardless of whether the tax is a constant or temporarily invoked but constant when levied, the tax would generate an expected stream of social costs.

The costs and benefit analysis of a permanently lower floor or of planning in advance to lower the floor for some periods, is very similar to the cost-benefit analysis of raising the inflation target.[46] The costs are the shoe-leather costs of inflation in each case: the benefits are those of avoiding the floor to rates.[47] To figure out the socially optimal tax on money of this sort, we still have to compute the rate of transformation of a unit of inflation reduction into inflation and output variability, and the rate at which society prefers to substitute between them, even if by lowering the zero floor via the money tax we are positing that we can shift all of the curves in 'inflation space' (and achieve higher welfare).

To repeat, the shoe-leather costs that would come with a money tax come from not being able to move that tax in synchronisation with the negative interest rate. Taxes adjusted precisely to match the desired negative rate would present no wedge between the costs of holding money or bonds. So the more synchronous is the tax with the desired interest rate, the better in welfare terms it is compared to levying the tax by aiming for higher inflation.

A policy of temporary money taxes to lower the interest rate floor is, in modern times, untested.[48] Although inflation and 'money taxes' are perfect substitutes in principle, in practice, therefore, the returns to increasing inflation are better understood than the

[46] Of course, when the time arrives such that circumstances generate a need for a lower floor to interest rates, raising the steady state inflation target is not a feasible short-term policy option.
[47] Taxing money directly, rather than through inflation, differs to the extent that there are 'unit of account', 'menu' or relative price variability, or imperfect tax indexation type costs associated with positive inflation.
[48] Buiter and Panigirtzoglou (1999) point out that Gesell-like schemes had been tried, for reasons not connected with the zero bound, in Alberta in Canada, and in Austria in the 1930s.

benefits of money taxes. We typically advise risk averse policymakers to invest less in policies that are uncertain, holding mean returns constant. This is a theme treated more explicitly in the literature on using monetary policy to exploit portfolio balance effects,[49] which I will discuss below.

5 Money 'rains', real balances

Another option for policy is to engage in money 'rains'.[50] In open market operations, the central bank trades money for short-term debt. At zero interest rates, money and debt become perfect substitutes. Open market operations will change the composition of private sector portfolios, but will not affect private sector wealth. When interest rates are positive, offering individuals more real balances gives them something they still value for reasons other than their usefulness for storage. But at zero interest rates, swapping money for bonds does nothing for them.

The central bank could instead give money to the private sector without taking debt in exchange. Some call this a money 'rain'.[51] A money rain will increase wealth and boost consumption and aggregate demand, temporarily raise equilibrium real rates (lowering actual real rates relative to equilibrium) and increase expected inflation, lowering real rates and boosting aggregate demand via this route too.

There are several points of debate about the usefulness of such a measure: some practical, some theoretical.

Practical objections (raised by Goodfriend (2000) and Bryant (2000)) centre on whether money transfers that did not generate other costs would be administratively feasible. My own view is that modern financial economies with welfare states already have systems that could implement transfers. Most individuals have bank accounts. Those that do not are likely to be in regular receipt of benefit payments. Both involve automated systems that could surely, at some feasible cost, or rather some cost that is comparable to the alternatives available be used to distribute money.

A more significant difficulty is that money transfers would have to be designed so as not to interfere with initial wealth distributions (supposing that the fiscal authority had already

[49] Formalised by, for example, Orphanides and Weiland (1999).
[50] See Goodfriend (2000), Clouse *et al* (2002), Wolman (1998).
[51] Equivalent to one of Friedman's 'helicopter drops'!

sorted out redistributive policy as best it could via conventional taxes and benefits). Approximate information on the distribution of wealth would be available from information collected in the course of levying many types of wealth-related tax (capital gains, interest income, property, inheritance taxes, for example). But this approximation would undoubtedly mean that the money rain would generate redistributive effects (and, compounding this, be expected to). The key question is how costly the approximation would be relative to the social costs of not stabilising the economy, and relative to other policy options at the zero bound.

The closest substitute to monetary transfers would be for the central bank to print money to finance tax cuts. Governments that engage in ongoing spending could have that spending financed by central bank money rather than taxes. Goodfriend (2000) and Bryant (2000) both argue that monetised tax cuts would be more practical. My own view is that both would involve financial exchanges via the same route (bank accounts or benefit offices) and are therefore close substitutes. The distortionary implications of literal money transfers or monetised tax cuts are likely to be very similar. Both require the same information about initial wealth holdings, and to the extent that that information is imperfect, both policies will involve allocative costs.

A second question is how strong the aggregate wealth effects of money transfers would be. Money transfers that were not to be repeated would be spent only to the extent that private sector agents are credit constrained or not perfectly forward-looking: else consumers would consume only the annuitised value of the addition to permanent income.

Goodfriend (2000) debates further how, in his words, "a central bank must be prepared to reverse monetary injections after the economy recovers in order to maintain price stability" (p1026). He rightly points out that any transfer that agents expect to be reversed at some point (by whatever means) would have no wealth-stimulating effects on a private sector that faced no credit constraints. But in general, the costs and benefits of reversing the money transfer, vis a vis the likely threat to 'price stability' depend on the circumstances at hand. For example, one scenario is that a central bank that, in the course of experiencing a shock that pushes nominal interest rates to zero, has undershot either a price level or an inflation target, and will therefore be looking for ways to generate both expected and actual inflation, (expected inflation to lower real interest rates and boost aggregate demand, and actual inflation to keep to its target) *in order to meet its price stability objective*. For a central bank in this situation, a money transfer could help and not threaten the credibility of the target.

Promising to reverse a monetised tax cut in these circumstances would be counter-productive, and, if the private sector understands the authorities objective, perhaps not even credible. Note too that if the money rain brought about a larger increase in the price level than was thought consistent with the inflation objective, the central bank has got the option of raising nominal interest rates too. Reversing the monetary injection might not be necessary, nor even sufficient.

A caveat here is that money rains may have a second effect, aside from the wealth effect, by increasing liquidity in the economy [Goodfriend (2000)]. This effect is described in more detail in the next section, since it underpins a proposal for the central bank to buy illiquid bonds, and stimulate the economy that way. At the risk of pre-empting that discussion, adding money to the average agent's portfolio gives them more assets that they can use to borrow against for the purposes of avoiding external finance premia. This effect will not be so wholly undone as the wealth effect of the money rain if the rain is to be reversed: the provision of liquidity even for a temporary time provides a service that is useful. It relaxes credit constraints for the duration. An analogy would be if the central bank were to give out cars to the private sector, and promise to take them back in the future. There would be little wealth effect from the car loan. But while the private sector had extra cars, they could, if they wanted, make extra journeys, which they might value.[52] But readers will find this paragraph more comprehensible after they have read the next section.

However, a private sector that either saw a central bank rain money, or understood that it was prepared and clearly administratively capable of raining money on the private sector when interest rates hit the zero bound might suspect that it would rain money on them at other times too. In this sense Goodfriend (2000) has a point in that he identifies that the facility to engage in and reputation for engaging in money rains would threaten the credibility of *future* policy. Unfortunately, committing to reversing the money rain in the future, either in good times, or while interest rates are zero, would undo some of the benefits of the money rain itself.[53]

[52] A money rain that was not reversed would probably still generate a stronger liquidity effect than one that was. A ten year loan of cash to the private sector relieves credit constraints for ten years, but without perfect certainty that some other form of collatoral would come along in ten years, or the need for borrowing would have passed, a ten year loan is still a poor substitute for an infinite period loan.

[53] Although as I have already said, and just as with other 'fiscal' policies discussed later, if credit constraints are severe, a money rain that was accompanied by an announcement that it would be reversed in good times might still boost aggregate demand.

Money rains work by increasing the value of real assets, albeit temporarily. But it is worth noting two things here. First, this mechanism is different from the 'real balance effect' identified by Ireland (2001), McCallum (2000) and Nelson (2001), and invoked by Meltzer (1999), and probably others too. As Woodford (1999) notes, *that* real balance effect is that at positive interest rates, when interest rates are lowered, and the new equilibrium involves the private sector having agreed to swap bonds for increases in real balances, it gains something with transactions-facilitating benefits that it still values and is therefore better off, and aggregate demand increases as a result. But at zero interest rates, interest rates *are* zero precisely because the transactions-cost-reducing benefits of real balances have been exhausted. So any further bonds-for-money trades that the central bank does leave it no better off. Bonds and money are just identical means of storing wealth at zero interest rates. Increases in real balances at this point that are offset through open market operations leave the private sector no wealthier than it was before. It is therefore not correct to believe that the real balance effect allows for conventional open-market-operations monetary policy to stimulate the economy.[54]

Second, it is worth pointing out that if the economy experiences deflation, real balances will increase in the way intended in a money rain automatically. As the price level falls, nominal balances of money and outstanding nominal bonds will become worth more in real terms: consumers and firms will experience increases in wealth, and aggregate demand may rise as a result.[55] How strong this automatic stabiliser is unclear. As an aside, I quote Sims (2000), who remarks that "*real balance effects can be important to guaranteeing stability, even if they are seldom or never important over the course of ordinary business cycle fluctuations"* (p969). He implies that the past, when there might not have been a deflationary spiral, may therefore not be a good guide to the future importance of channels like this. We do have empirical evidence of real balance effects at work in normal times, but, as we have observed already, that effect will contain the real balance effect described here, and the effect of increasing consumers' wealth via adding to their store of transactions improving real balances. That channel won't be working at the zero bound, as we have observed, so we must presume that the real balance effect would be weaker than that picked up in studies like that of Ireland (2001).

[54] Ireland (2001) has explored how robust these statements are to allowing for models with positive population growth.
[55] This is the 'real balance effect' identified with Haberler (1946), Pantinkin, (1965) Pigou, (1941) and de Skitovsky (1941).

Short term debt rains

A related option is for the central bank to 'rain' down short-term debt on the private sector. At zero interest rates, the private sector will be indifferent between a money and a debt rain. A debt rain that will be made good by future taxation will have a 'wealth effect' like a money rain to the extent, of course, that agents either ignore those future taxes or feel that they will not fall on them. It will also have a similar 'liquidity effect' to the money rain (which will obtain even if agents factor in expected future taxes needed to repay the debt) since short term debt, like money, will be more liquid than the representative asset already on the private sector's balance sheet. A debt rain that is to be made good by printing money in the future ought to be a close substitute for a policy that gets money directly into the hands of the private sector today: to repeat, money and short term bonds are perfect substitutes at zero interest rates.

6 Monetary policy and the portfolio balance channel[56]

Some, [for example Meltzer (1999a,b), Friedman and Schwartz (1982) and Goodfriend (2000)][57] reject the notion that the current and expected future setting of risk-free interest rates is a necessary and sufficient description of the monetary stance of the central bank.[58] On these grounds they therefore reject the notion that the monetary authorities are

[56]This section relies heavily on Goodfriend (2000).

[57] This from Meltzer, (1999): "They claim that the lower bound was in effect during the 1930s, so monetary policy was inflexible for part of that decade. For this claim to be true, the short term interest rate must be the principal or only means by which monetary actions are transmitted from the central bank, through the market, to the economy. As my old friend Karl Brunner often said: we know this is false. Monetary actions are effective and powerful… where there is no money market… relative prices respond to monetary impulses in countries without central banks, and without money markets. There is more to the transmission process than the models recognise." (p5). And this, (also cited in Nelson (2000,p15): "Monetary policy works by changing relative prices. There are many, many such prices. Some economists erroneously believe… monetary policy works only by changing a single short-term interest rate." See also this quote from Friedman and Schwartz, (1982), cited in Nelson (2000,p15): "Keynsians regard a change in the quantity of money as reflecting in the first instance 'the' interest rate, interpreted as a market interest rate on a fairly narrow class of financial liabilities… We insist that a far wider range of marketable assets and interest rates must be taken into account… [We] interpret the transmission mechanism in terms of relative price adjustment over a broad area rather than in terms of narrowly defined interest rates."(p57,58).

[58] Meltzer makes two arguments. The first is that there is a "real balance effect" of the kind investigated by McCallum (2000), Ireland (2001) and Nelson (2001). The second is that money, govt debt and private sector assets are all imperfect substitutes and that open market operations can affect their relative prices. This second argument is what we focus on here. The real balance effect of the first kind, as we have already discussed in the previous section, does *not* provide policymakers with leverage over the economy at zero interest rates.

impotent at the zero bound simply because interest rates cannot fall now, and therefore will not be expected to fall in the future.

Goodfriend (2000) argues that the central bank can increase the volume of 'broad liquidity services' in the economy by conducting open market operations that exchange money for long-term bonds. An asset that offers broad liquidity is something that enables its holder to "minimise one's exposure to the external finance premium in the sense of Bernanke and Gertler (1995)" (p1019). As the quantity of broad liquidity in the economy rises, so the cost of finance falls.[59][60] Open market operations in short term bonds involve trading assets that serve just as well as devices for avoiding external finance premia. Both money and short-term bills or bonds can be borrowed against, since they are both default-risk-free and easily verifiable as such. But trades of money for some long-term bonds can increase liquidity. Liquidity in bond markets is highly discontinuous and concentrated in particular (e.g. 10 year) instruments. Bonds that are not traded in such large volumes will be less liquid than the cash the central bank offers to trade them for. So the central bank can increase the volume of liquidity services available in the economy in this way.

Other things equal, the private sector as a whole will try to rid itself of this excess liquidity (it was chosen optimally, for the conditions that prevailed before the open market operation). But it will be unable to do so in aggregate. The effect of trying will be to bid up asset prices (reduce yields) in less liquid assets and durable and even non-durable goods.

Central banks could of course increase the amount of this form of 'broad liquidity' available in the economy by purchasing not just long term government bonds, but any private sector asset, and perhaps any foreign-currency denominated asset that was likewise less liquid than the cash offered in exchange. And to recall from the previous section, the broad liquidity exploited here by these money for long bond swaps would also be at work

[59] I can do no better than quote Goodfriend (2000) at this point: "when the stock of outside bonds is small and the marginal implicit liquidity services yield is high, the explicit premium on equity relative to bonds is large, because the implicit marginal liquidity yield on bonds is large. As the per capita inventory of bond holdings increases, individuals are better protected against having to smooth consumption by paying large transactions costs to sell other assets. The required explicit bond return rises as the marginal implicit liquidity services yield falls, that is, the explicit equity premium falls."(p1021).

if the central bank were instead to engage in a 'money rain' of the sort we have already described.[61]

Note that the portfolio rebalancing will very likely result in an increase in the price level. This in turn would burn off the increase in nominal broad liquidity that the central bank wrought in the first place. On the other hand, to the extent that portfolio rebalancing does increase the price level, and is anticipated to do so, the increase in expected inflation will reduce real interest rates and stimulate real spending through this route too.

Policies of this sort are clearly open to central banks conducting open market operations at *any* interest rate, not just at zero interest rates. To the extent that cash and even very short term bonds and bills do not have identical liquidity characteristics, central banks may in fact be operating through this channel unavoidably at all times. The difference between normal operations in short-term markets and the policies that Goodfriend and others advocate at zero interest rates must surely be one of degree. In principle, some clue as to the effectiveness of the policy could be uncovered in data from regimes at positive rates. In practice, however, portfolio balance effects are likely to be highly non-linear, and only manifest or and exploitable when the central bank deals in very large quantities (near zero interest rates) or in very imperfect substitutes for its cash.[62]

The most obvious side-effect of this kind of policy (discussed by Goodfriend (2000) and others) is the consequence for fiscal policy of having less than perfectly liquid, risky assets on the central bank balance sheet. Central banks buying either long dated government bonds or private sector assets expose themselves to capital (or even default) risk. Whether or not losses are realised, the central bank takes on risk by engaging in these activities, which is an economically costly activity. In forward looking models we would expect that the effect of market interventions like this would be muted by the effect on aggregate demand of future taxes to make up capital losses, or of the ongoing costs of insuring against them. In fact, it would seem to me that the risk of a loss is quite high. And, perhaps even the inevitable consequence of the outcome sought for monetary policy.

[61] Finally, note that the central bank could conduct open market operations by swapping short-term debt for the illiquid long term debt. Money and bonds are perfect substitutes at zero interest rates, of course, and therefore could be used interchangeably in an operation like this.

[62] Less optimistically, the more these effects are operating in normal times, the more contaminated will our surmises about the performance of 'interest rate policies' be contaminated by portfolio balance transmission effects. The comparison in such a world would be between an 'interest rate plus small portfolio balance effect' at positive interest rates, and a 'portfolio balance effect only' policy at the zero bound.

If the stabilisation works, the economy will return at some point to a situation where interest rates are higher and bond prices therefore lower across the board.[63]

There must be doubts too about how stable the patterns of liquidity differences between assets that the central bank exploits would be once the private sector understands what the central bank is trying to achieve. For example, suppose that to some degree, the liquidity concentration in certain government bonds is not related to 'fundamentals', (the correspondence of the asset maturity with the maturity characteristics of liabilities of investors?…) but is due instead to the fact simply that because everyone thinks everyone else wants to deal in those bonds, everyone does. Equilibria like this will be self-reinforcing. The marginal market maker is forced to deal in those bonds because the fixed costs of dealing in other bonds will force it to charge higher bid-ask spreads for those trades, which in turn discourage marginal investors from trading in them, and so on.

However, the announcement that the central bank will systematically deal in non-standard illiquid bonds will immediately make such a bond more liquid. Before, the non-standard bond would have been held on the expectation that it could be sold in a market with a few private sector participants. Now the non-standard bond can be sold in a market that, in the event of the economy hitting a zero bound, will be contain a central bank willing to buy them: and precisely at a time when the prices of bonds as a whole are likely to be high (because the nominal interest rate component of the price is low) which is precisely the time investors are likely to want to sell.

In practice, the private sector must expect that the chance of hitting the zero bound is pretty low. And so the chance of having a central bank to deal with on the other side of the market for the non standard bonds is also low. So a 'fundamentals based' expectation of the change in the liquidity of that market, due simply to the expected participation of the central bank, might be small. Moreover, the central bank could sell back not the illiquid bonds it bought in the first place, but more liquid shorter-term debt: this would reduce the expected 'fundamental' change in liquidity arising from a systematic policy of

[63] Goodfriend, in addition, worries that "if the public thinks that the central bank is unwilling to take losses on its long bonds, then the central bank's… policy will lack credibility" (p1027). I am less sure that there is a problem central banks can do anything about. My surmise is that there would be no difference between the expectations of future policy, and of the future net worth of the public sector between a central bank that engaged in long bond purchases but did not want to take capital losses, and a central bank that engaged in these purchases but was prepared to accept them. Both would have little choice but to take those losses. And central bank purchases, whatever announcements accompanied them, would prompt a rational private sector to expect them. The only alternative is for the central bank to sell back the bonds when the price is high again. But that would conflict with the objectives of stabilisation policy that would prevail at the time.

this sort even further. But if the liquidity concentrations are due in large measure to the kinds of self-reinforcing, expectational mechanisms described above, then a small shift in the 'fundamentals' could induce a significant shift in the patterns of liquidity concentration. This would not make a liquidity injection impossible, but it would make it more difficult to pull off repeatedly, or pull off with predictable affects.

If there are special characteristics of assets – either government bonds or private sector assets– that the central bank can reliably exploit then it is important to note too that the efficacy of policy will depend not only on current open market operations but expected future operations too. The effect of increasing broad liquidity today will be less if it is expected that the central bank will reverse any large-scale purchase in the future. (And at some point, it surely must reverse these purchases, otherwise its balance sheet will continue expanding indefinitely.) But this is no different from the limit on the effectiveness of interest rate policy in normal times, which the private sector knows will be reversed.

Intervening in public and private sector asset markets[64] will likely risk inducing a host of microeconomic distortions. Any policy that interferes with the informativeness of relative asset prices would be socially wasteful. Private sector purchases would risk either moral hazard, or bring with them the burden of devising procedures to avoid it.

Aside from microeconomic distortions, if there are portfolio balance effects coming from the imperfect substitutability amongst public and private sector assets, any intervention by the central bank will disrupt and frustrate private sector attempts to arrive at optimal portfolios with respect to their own liabilities and risks. And the private sector will be worse off as a result.[65] The usefulness of this channel relies on there being imperfect substitutability amongst assets. Without it, government purchases would be useless, dwarfed by the infinite supply of near perfect substitutes for whatever it buys. But the more imperfectly substitutable for others are the assets the central bank buys, the more the private sector suffers from the intervention.

[64] And here I lump together all such assets, including making direct loans to private sector companies.

[65] If there are two goods, apples and oranges, and they are imperfect substitutes, and in fixed supply, then not only will government intervention by buying up apples change the relative price of apples, it will also reduce welfare possibilities achievable with a given income. So too with exploiting portfolio balance effects. Buying up a large enough fraction of a particular asset or class of assets to affect their price will reduce the amount of hedging that is achievable for a given income.

But these distortions must be compared to the welfare consequences of not intervening. The motivation for active monetary policy in the first place comes, presumably, from the lack of cheap enough forms of insurance against business cycle fluctuations, or the inequitable access to insurance of this kind.

A final comment about this kind of policy is familiar from thinking of the other options at the zero bound. Since what Goodfriend calls 'quantitative policy' is somewhat untested, the returns to this kind of policy are uncertain. The key uncertainty is the elasticity of the schedule of asset prices to central bank purchases, and how stable this elasticity would be over time. As we have noted already: the more uncertain a policy, the less a risk-averse policymaker should rely on it in its contingency planning.[66] (The problem is even worse to the extent that we don't know how uncertain the returns are.[67] But this issue I will return to in section 10.) A central bank already trapped at the zero bound will not be deterred by the uncertainty surrounding the effects of a liquidity injection of this sort. But a central bank planning in advance how to substitute between higher inflation and relying on liquidity injections would invest less in this strategy and more in inflation, other things equal.

Some – for example Meltzer (1999) – have inferred from historical experience that quantitative policy is both effective and exploitable. Meltzer makes, in my view, inferences which more cautious logic would avoid. He and others observe that in the United States, following the Great Depression, despite interest rates being at or near zero for the duration, aggregate demand and inflation stabilised. This argument then goes on to infer that there must therefore have been advantageous, systematic, non-interest-rate stabilisation at work (and therefore available to policy-makers today). This observation is consistent with the Fed having usefully exploited a portfolio balance effect (or having conducted some other policy). But it is also consistent with them having been entirely helpless, or having made matters worse by doing whatever they did.

By way of illustration, recall the results of Hunt and Laxton (2002). They observe that the probability of entering a deflationary spiral is very much smaller than the probability of interest rates reaching and staying at the zero bound. They illustrate therefore that the

[66] Orphanides and Weiland (1998) present a model with a portfolio balance effect in that incorporates the extra uncertainty surrounding the use of this kind of 'quantitative' monetary policy at the zero bound, in the same way as did Brainard (1967) in the case of only one policy instrument.
[67] Of course strictly speaking, we don't know how uncertain the returns to any policy are, but our knowledge about the portfolio balance channel would seem to be even less well developed than our understanding of other aspects of the transmission mechanism.

economy may experience periods where, although stabilisation policy is impotent, and nominal rates are at the zero bound, eventually the economy recovers without the help of the central bank. The experience of the 1930s may not provide the comfort it is intended to. Quite the opposite. That experience could suggest that even eventually self-correcting recessions could be devastating in the mean time.[68]

The evidence of Hanes (2002) is evidence in favour of one leg of Meltzer's hypothesis. Hanes finds that positive shocks to the supply of reserves lowered 3-5 year yields on Treasuries during the 1934-39 period, when short term rates were at or near the zero bound. But this evidence is not enough. We would need to establish further that the reduction in long term rates was, first, the successful consequence of an intended monetary loosening, and second, that it contributed significantly to the subsequent economic recovery, (rather than perhaps being simply a consequence of it).[69]

Goodfriend argues that quantitative policy is not "logically harder" than interest rate policy. This is true, in the sense that the story he tells about how the central bank injects liquidity into the economy is no more mysterious than the stories we tell normally about how interest rate policy works. However, this begs the question as to why interest rate policy is the option so many central banks have chosen as their instrument for normal times. Is the reason that the fiscal worries about quantitative policy are so compelling that an otherwise adequate substitute for interest rate policy is *never* worth exploiting away from the zero bound? This seems unlikely. Surely there must be something "harder" about this policy. Either that or central banks should be doing more of it regardless of whether they are at the zero bound or risk hitting it.

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[68] We could make a related comment on Meltzer's inference that there is something that monetary authorities do in countries where there are no money markets that suggests there is something monetary authorities could do in countries where there are money markets but where they are stuck at the zero bound (in the quote cited in footnote 39). Monetary authorities in these countries may well do something useful that could be mimicked by other central banks. Or they may equally well be doing something that is worse than doing nothing.

[69] Hanes himself makes it clear that he does not consider his empirical study one that evaluates a Meltzer-type argument of this kind (in footnote 1 on page 5 of his paper, he says "a related but distinct question, which I do not address in this paper, is whether a central bank can boost real activity through channels other than a decrease in interest rates on liquid debt"), so readers should be clear that I am arguing against an interpretation of his work that Hanes himself does not put on it. Hanes in fact advances a separate argument. In normal times, when interest rates are positive, banks worried about interest rate risk can purchase short-dated assets and still earn positive interest. However, when short-dated interest rates are zero, this option is not available to them, so they may seek instead to buy longer-dated assets, taking into account the interest rate risk that goes with them. This would generate a downward sloping demand for those assets that the central bank could exploit.

7 Exchange rate intervention

Some [for example, Metlzer (1999), Svensson (2000) and McCallum (2000)] have suggested that central banks could intervene in foreign exchange markets to bring about an exchange rate devaluation and stimulate aggregate demand and inflation and increase inflation expectations, even when the nominal interest rate is at the zero floor.

There are two classes of policy envisaged. McCallum (2000) envisages that the central bank have a time-varing exchange rate target, (in the same way that under normal conditions it used a time-varying interest rate target) to stimulate the economy. Svensson (2001) envisages a one-off devaluation and thereafter a defence of an exchange rate peg, until such time as the economy is lifted out of the zero bound trap. But the efficacy of both policies relies on central banks either actually exploiting or credibly promising to exploit a portfolio-balance channel in foreign exchange.

Svensson's (2001) proposal is as follows. The central bank announces a devaluation of the nominal exchange rate such that the real exchange rate is below equilibrium (which is possible when prices are sticky). It announces a commitment to peg the exchange rate at the lower level. On top of this the central bank announces a rising target path for the price-level.[70] The central bank should commit to a peg for the nominal exchange rate that corresponds to the difference between the price level target path, and expected foreign inflation. (So, if the two are equal, then they commit to an exchange rate peg.) The first effect is for short term nominal rates to rise above the zero floor: this has to happen to compensate investors for any expected nominal depreciation of the exchange rate.[71] The deflationary effect of rising short term rates is offset by three factors. First, an expected long run real appreciation (which must obtain if the real exchange rate is pushed below equilibrium) will be accompanied by a fall in long-term real interest rates. Second, the fall in the exchange rate will boost foreign demand for domestic output (which, since the

[70] The central bank announces a rising path for the price level in preference to a positive inflation target to eliminate the potential costs that some saw with the Krugman proposal, namely, that by announcing a commitment to increase inflation, it might be difficult to convince the private sector that it would not at some future date announce a further increase in the inflation target, or renounce inflation control altogether. These concerns were expressed by, amongst others, the Bank of Japan.
[71] Svensson has the exchange rate determined in part, but not only by uncovered interest parity. Provided the exchange rate peg is credible, ex post the exchange rate will have appeared to move in line with uncovered interest parity. If the peg had come under attack and the central bank had been involved in a defence, via exploiting portfolio balance effects in foreign exchange, UIP would, after the event, appear to have been violated.

output gap is negative at the start can be supplied). Third, expected inflation will increase. With the nominal exchange rate pegged, inflation faster than foreign inflation will be associated with the real appreciation. The central bank announces it will follow this policy until the price level target is met. After which, the exchange rate peg will be abandoned, and the central bank will adopt a more conventional monetary policy.

A large literature has discussed the efficacy of exchange rate targeting via foreign exchange intervention, though the focus there is typically on the difficulty of sustaining exchange rate targets that are meant to anchor an otherwise inflationary currency rather than the reverse (are, in other words, 'too high'). Many of the potential problems associated with using the home-asset portfolio-balance effect – its uncertainty, instability, especially once exploited – we can carry over to our study of foreign-exchange based policies. We can profitably concentrate on the Svensson proposal here, and I do so noting that a number of potential problems with his policy have been exposited by Svensson himself.[72]

One obvious problem, remarked on by many, is that these policies clearly rely on the cooperation of foreign monetary authorities. The exposition above takes the actions of foreign authorities as given. The efficacy of intervention is going to depend on the trade-weighted objectives of other monetary authorities. If the trade weighted policy objectives are the same as the home country, and the trade weighted shocks (and therefore desired monetary stabilisation) are perfectly negatively correlated, then a devaluation will suit everyone. If not, it won't. In other words, if other countries are looking for a relative monetary contraction they will accept the exchange rate appreciation sought by the home country's intervention. However, if other countries are looking for a contraction, it is likely that a devaluation would occur anyway through normal channels as expectations of movements of future foreign rates worked through. But in the more likely case that these conditions do not hold, other countries may 'fight' using their own monetary instrument; or be expected to fight; or 'fight' passively using other automatic fiscal stabilisers, or be expected to do so. All of which would undo the stabilising effects of the peg, and or be expected to do so!

Alternatively, pessimism about the reactions of foreign monetary authorities might be overdone. The short term costs of a temporary monetary contraction in their economies associated with an appreciation of their currencies may be more than offset by the

[72] See his 2001 paper. Finicelli *et al* (2002) also evaluate the Svensson proposal. Some of the points made here draw on these two papers.

discounted benefits associated with lifting a major trading partner out of the liquidity trap, and eventually boosting that economy's demand for the foreign economies' exports. The studies of the forces that will bring about monetary policy coordination rather than competition typically study stationary economies. The cost-benefit analysis of a foreign country competing against a devaluation (by loosening policy at home) in times when neither country is threatened with a deflationary spiral may not be that informative about the likelihood of competition when one country faces just such a situation.

Svensson addresses the most compelling problem in his own analysis. It relates to the effectiveness of the promise to defend the peg, and, in turn, to the nature of the portfolio balance channel itself.

A central bank that is prepared to print unbounded quantities of money to buy foreign currency will force other sellers of the home currency to exchange at the rate the central bank desires. Central banks trying to push *up* the exchange rate have limited foreign exchange reserves to use to buy home currency, and therefore cannot credibly commit to buying unlimited quantities. Central banks trying to push a currency *down* have 'reserves' limited only by the capacity of the currency printing presses multiplied by (discretionary) currency denominations![73] If the central bank can credibly promise to print unlimited quantities of home currency to defend the peg, then, in equilibrium, it may not have to purchase anything it all, or only very small quantities of currency. If, however, printing unlimited quantities of the home currency are likely to conflict with, rather than support central bank objectives, then this promise will not be credible. And a likely equilibrium will be that the market pushes the central bank to print currency up to the point where it is not optimal to do it any more, and the exchange rate peg fails.[74]

Svensson argues that a crucial comparison will be where this limit is, relative to the point at which portfolio balance effects – where massive purchases of foreign assets, because of the imperfect substitutability of those foreign assets relative to currency movement adjusted home assets, bid up their relative price – begin to bite. Provided the central bank can print currency and buy foreign assets without harming its interests beyond the point

[73] This from Meltzer (1999): "Suppose, now, with a short term interest at zero, the Bank of Japan announces that it wants the dollar exchange rate to fall by 50 per cent and that it is prepared to print yen to buy dollars until that occurs. Is there any doubt that the yen would depreciate or that the depreciation would affect spending, output and prices in Japan?" (p4).
[74] The mechanism here would no doubt have 'self-fulfilling' properties of the sort discussed in the literature that developed to explain how commitments to keep nominal exchange rates 'high' failed, begun by Krugman (1979) and evolving through the work of Obstfeld (1996) and others.

where portfolio balance effects begin to manifest themselves, then the peg could be defendable. Otherwise, it won't be.

The point at which printing money to defend the peg becomes harmful and therefore, *ex ante*, not credible, is going to be related to the price stability objectives held by the central bank (or even more diffuse aims that we might express in words like 'currency integrity', or 'maintaining a reliable means of exchange'). A central bank entirely unconcerned with the potential costs of infinite volumes of paper currency outstanding relative to the supply of goods (or at least believed to be entirely unconcerned) will be able to commit to those unlimited currency issues. Central banks who either are not indifferent to these costs, or are thought not to be by the private sector will not be able to make such promises.[75] Surely all central banks fall into this latter category.

Arguably, there is a contradiction between the price-level target component of the Svensson policy proposal, and the implicit promise to debase the currency (or nearly so) to defend the currency peg. If the price level leg of the strategy is believed, then the exchange rate leg may not be. Yet if the exchange rate leg of the target is believed, it may be because the price-level objectives of the central bank are not credible, and won't be. (Though at least in this case, the expected inflation will bring with it a short-term benefit).

The Svensson proposal (like most monetary policies) relies on expectational channels to generate the stimulus needed to lift the economy out of the zero bound trap. In this case: the expected fall in long real rates that accompanies the real appreciation and the expected inflation. The less credible is the policy in the first place, or the more backward-looking are expectations, (and the more, therefore, that expectations of the future are based on the event that the economy stays trapped at the zero bound), the weaker these effects will be, and perhaps the larger the exchange rate devaluation needed in the first place.

Suppose this prediction is correct. Suppose too that we combine it with a second speculation, that the larger the exchange rate devaluation needed, the more likely it is to prompt a counterproductive response from the foreign monetary authorities. In this case the efficacy of the expectational channel may well dictate whether the policy is feasible in the first place or not.

[75] Printing currency to the point where portfolio balance effects bite may involve interferences with foreign monetary policy beyond the effect imposed by the exchange rate peg. Massive purchases of foreign government assets could, for instance push up prices and reduce rates on those assets: this could, however, offset the contractionary effect on the foreign economy brought about by the exchange rate devaluation, and, therefore, be an advantage.

Finally, and rather obviously, as Svensson and others who have commented on his proposal have noted, the usefulness of the foreign exchange portfolio-balance type policies hinges on the degree of openness of the economy. This was cited as some as a reason to be sceptical that it would be a feasible policy option for Japan;[76] and the same logic would apply to the US and the Euro area, where trade forms a similar percentage of GDP.

8 Options and signalling

Tinsley (1999) suggested another way for the central bank to reduce rates further out along the term structure. He proposed that the central bank sell options to the private sector that would, should future short rates turn out higher than whatever is stipulated in the option, lead the central bank to incur financial losses. Long interest rates may be higher than (zero) short interest rates either because the market puts some weight on the hypothesis that the economy will lift itself with or without the help of the central bank out of the liquidity trap such that at some point a monetary contraction is warranted, or because of uncertainty about future rates. This in turn may constrain aggregate demand undesirably. Writing options that embody a financial commitment to zero rates (for example) could, the argument goes, lower long rates, and therefore lower real interest rates and boost aggregate demand. The private sector would consider that the central bank would want to avoid penalising itself and therefore consider it more likely that interest rates would not rise; this same effect would reduce the private sector's uncertainty about future rates. Both the first and second moment effects of selling the options would lower long rates.

The policy was suggested as a self-standing action by central banks, but in principle selling options of this sort could be a device to bolster the credibility of all policies we have discussed so far that benefit from being able to commit to future values of the interest rates; for example, the type of 'constant' history-dependence advocated by Woodford (1999) and Reifschneider and Williams (2000); or the history-dependence that 'turns on' when rates hit the zero bound suggested by Reifschneider and Williams (2000).

[76] Indeed, others [McKinnon and Ono (2000)] suggested that political economy pressures from the United States lay behind the 'high' value for the yen and, therefore, contributed to the problem Japan found itself in the first place.

But my own view is that these kinds of options are likely to be at best, wholly ineffective, and at worst, ineffective and costly. Suppose agents are rational and forward looking. And that the economic situation is such that any increase in short rates over the foreseeable future is likely to be harmful to the interest of the central bank, (e.g. if it is in the interests of the central bank to commit to history-dependence), no such increase would be expected, and long rates will be low without writing options. Alternatively, suppose that economic circumstances were expected to be such that an increase in rates was warranted in the future. In which case the welfare benefits of increasing rates at that time would dwarf all but the most enormous financial penalties levied on the public sector. If the penalties were not large enough, the private sector would understand that and the writing of options would have no effect on expected future short rates.

For the same reason, such options may have no discernable effect on the uncertainty component of long rates. The distribution of possible future short rates would depend on the distribution of shocks hitting the economy over the future, and central bank responses to those shocks. Only extremely large financial penalties would make it rational for a central bank to factor them in when deciding the optimal setting of interest rates, and since the private sector will expect this, the risk of future interest rates rises will not be affected. To the extent that expectations are not as model-consistent as the world described above, the motivation for options trades diminishes anyway.

Indeed, long rates could even increase. If the penalties embedded in the options were very large, it is conceivable that there would be a range where long rates increased, as uncertainty about the central bank balance sheet increased, or increased later on, as speculation about whether or not the central bank would stick to its promised grew more intense.

9 'Fiscal policy'

An obvious alternative to interest rate stabilisation at the zero floor to rates is for the government to manipulate conventional fiscal (spending and taxation) tools to boost aggregate demand. Reifschneider and Williams (2000) conduct their experiments assuming fiscal stabilisation policy is as active as it has been historically in the US. It is plausible that there might be more active fiscal policies than the one they study which lower the risk of hitting the zero bound without bringing with them extra costs.[77]

[77] Klaeffling and Lopez (2002) solve for optimal policy when fiscal stabilisation is a substitute for monetary policy. They therefore envisage a fiscal policy that would indeed be more active than a

Our discussion of fiscal stabilisation necessarily focuses on how good a substitute fiscal policy is likely to be for monetary policy, when interest rates are held at zero.[7879]

First, a familiar argument is that moving tax and spending instruments is a slow and imprecise business, so much so that it makes fiscal policy a very poor substitute for monetary policy: one of the reasons that objectives currently assigned to central banks *are* assigned to central banks. Many capital and current spending liabilities do not lend themselves to high frequency variations (health, education, defence….).

So-called 'automatic stabilisers'- like spending on unemployment related benefits and income, expenditure and profit taxes - could be amplified, *ex ante*, to provide an immediate stimulus that did not require any administrative or policy change.

But the authorities would need to offset the benefits of any stimulus that fiscal policy could provide against the costs of tax and expenditure variations. The distortions that come from predictable tax liabilities are less than those that come from uncertain ones.[80] Amplifying automatic stabilisers would involve increasing distortions and reducing welfare.[81] Any welfare-enhancing effects of government current or capital spending could be eroded by inducing (extra) pro-cyclicality in that spending. There is nothing to say that the optimal spending plans for transport or health provision infrastructure, for example, are likely to be coincident with the cycle.

Of course. fiscal stimuli injected by a government when the economy is at the zero bound to interest rates will be saved by consumers and firms who anticipate future taxes levied to pay for it and who are already on their desired consumption and investment plans. One

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policy that had been observed during a history of higher inflation rates (when the zero bound was not encountered, or encountered less frequently). Fuhrer and Madigan (1997) note how active fiscal policy improves the response of the economy to shocks when interest rates are constrained.

[78] It is worth noting for completeness that if either public consumption is a perfect substitute for private consumption in individuals' utility functions, and or public investment is a perfect substitute for private investment in firms' production functions, then fiscal stabilisation will be ineffective. A point stressed in this context by Buiter and Panigirtzoglou (1999,2001).

[79] Klaeffling and Lopez (2002), amongst others, raise this concern.

[80] More realistically, we are contemplating the welfare costs of adding to expenditure and tax uncertainty through the use of more active fiscal stabilisation, rather than comparing interfering with currently certain interventions by the government.

[81] For example, unemployment-related benefits would have to increase to provide a larger stimulus when unemployment increased. Higher unemployment benefits would mean a higher natural rate of unemployment. The rise in benefits accompanying a rise in the natural rate would involve an associated increase in average tax burdens and therefore an additional distortion from this source.

the one hand, a systematic a stabilisation rule (in the event of a zero bound) would, to the extent that stabilisation is effective, bring with it expected future inflation and a fall in real rates that reduced the necessary stabilisation needed in the first place, following the same logic as our discussion of history-dependent interest rate policies. On the other, systematising this kind of stabilisation will be less effective precisely *because* it is understood that the fiscal stimulus will be reversed at some point. It is not clear which effect would be the stronger is unclear.

Fiscal dominance, monetary policy rule-based fiscal dominance

So far we have talked about what initiatives a fiscal authority could take to stimulate the economy. It is possible that, *in extremis*, events might be taken out of the hands of the fiscal agent by the private sector. A live debate in the literature is under what circumstances, inflation may become a 'fiscal phenomenon' in the long as well as the short run.[82] 'Fiscal dominance' occurs when agents come to expect that taxes will not be levied to finance expenditures: or vice-versa, that deficit plans will, holding the price level constant, not be set to finance expenditure plans. In which case the real value of deficits is eroded by a jump in the price level to the point which equalises the present value of asset (tax) and liability (current expenditure plus interest payments plus debt redemption) streams.

Arguably, what Woodford termed 'fiscal dominance' is more likely to come about when the economy is trapped at the zero bound to interest rates than otherwise. During these times, the fiscal authority might find itself less able to reconcile streams of expenditure and taxes, and be expected by the private sector to find it harder to do so. And for two reasons. First, in a situation where the nominal rate is trapped at zero, it is possible that either the tax base might be shrinking and/or the pressure for higher government spending is likely to be higher. The political economy problems of levying extra taxes to stabilise public finances in either case are likely to be acute. (The economy is in recession, and no-one wants contractionary fiscal policy).

If the price level becomes 'fiscally' determined in this way then the economy will be hit by an actual and expected inflation. Since nominal rates are held at zero, this will bring about the monetary stabilisation the central bank was unable to provide by conventional means.

[82]See, for example, Woodford (1999), Buiter (2002) and Christiano and Fitzgerald (2000).

Could the mechanisms that give rise to fiscal dominance be exploited by a policymaker concerned about stabilisation? Would such a policy be desirable if it could? Sims (2000) appears to state that it is, when he urges that "*…policymakers understand that under some circumstances budget balancing can become bad policy.*" (p970).

A deliberately induced 'fiscal dominance' could implement a cut in real rates, but would risk arbitrary transfers of wealth either too or from those who hold existing nominal government debt. Sims seems to propose that the fiscal dominance be calibrated to rule such transfers out when he argues that a successful policy will come from "*assuring the public that deflation-generated increases in the real value of government debt will not be backed increased future real taxation."* (p969) Sims implies therefore that the government should make it clear it will plan to levy taxes to pay back debt accrued from times of rising prices. But that other real debt incurred as a result of unplanned periods of falling prices will not be factored into future tax plans.

A general 'rules-based-fiscal-dominance' in theory could announce financing shortfalls of different sizes to match the amount of stabilisation needed. Such an amount chosen could seek to trade off wealth transfers to or from existing debt holders against the stabilisation benefits thereby obtained. This kind of policy would involve overlaying the 'fiscal-dominance' with 'monetary dominance'. The promise to 'default' would be guided by underlying price and output stability objectives.

Though the idea is logically coherent, it seems to me to be far-fetched as a proposal for systematic policy.[83] Moreover, would a government that was prepared to manipulate an expectation of fiscal dominance to escape a deflationary spiral be able to re-establish conditions for monetary dominance in normal times?[84] The thought experiment is similar to that underpinning the exchange rate peg proposal that Svensson advocated. There, we are to believe that the central bank can devalue the currency by threatening to debase it, but is able to resume credible inflation-concerned policy again in normal times. Here, we need to believe that somehow the government could announce a partial default on its debt, but will be able to resume credible bookkeeping once the economy recovers.

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[84] It is possible that such a policy would also increase long-term rates. If the current 'inflation' risk premia in nominal debt factors in a small possibility of a deflation, then ruling out taxation to repay the portion of debt incurred through deflation would make the bet for the private sector, in terms of prices, one-sided.

Credibility and fiscal policy

In economies where fiscal stabilisation is effective the reliance on fiscal policy of this sort would confront policymakers with a similar set of time-consistency problems regarding inflation stabilisation that motivated governments to delegate monetary policy to an independent central bank. The problem would not be identical, (and therefore would not require an identical remedy), since those fiscal authorities that have delegated monetary policy to a central bank left themselves with a policy instrument that is a very imperfect substitute for monetary policy, for all the reasons we have suggested above.[85]

On the other hand, though fiscal stabilisation may involve credibility problems, they afflict fiscal authorities regardless of whether they are at the zero bound. It is not clear that announcing a transparent pro-cyclical fiscal stimulus in the event of a severe negative shock would measurably erode the (already imperfect) credibility of the overall government 'inflation and output stabilisation' policy (the collection of institutions that govern both fiscal and monetary policy). In fact, it may not be credible to establish fiscal rules that promise *not* to indulge in this kind of stabilisation when there is a risk of hitting the zero bound. Or at least, the more likely is the economy to hit the zero bound, the more likely agents are to expect governments to break any fiscal promises they have made that deprive them of a useful instrument.

For example, Reifschneider and Williams' simulations involve a fiscal rule that embodies the degree of activism in fiscal policy observed over the past (during which time the zero bound was not encountered). This kind of rule may not be credible if the economy either hits or risks hitting the zero bound. More active fiscal stabilisation may be desirable (it may better serve the stabilisation objectives that the government and central bank share) and, as a result, be anticipated.

Optimal mixes of monetary and fiscal stabilisation

This section digresses to consider three related propositions: (i) 'policies that are 'fiscal' should not be in the province of the central bank; (ii) policies that happen to be in the

[85] For instance, the credibility problem in monetary policy has at its heart the knowledge that agents who have to set nominal contracts before a shock arrives know that a central bank will not only have an incentive but will also have the ability to break its promise on monetary policy once contracts are set, to deflate real prices and boost output and employment. A fiscal authority which finds it either more costly or more time-consuming to change the fiscal stance in response to high frequency news on the economy will find that its promises not to move fiscal policy are more readily believed by the private sector.

province of the central bank, but are 'fiscal' should not be pursued by it; and (iii) policies that are not in the province of the central bank, and are 'fiscal' should not be used by the fiscal authority in the pursuit of objectives delegated to the central bank.

Propositions (i) to (iii) do not seem at first blush to be such a bad description of modern, developed economy regimes. And some papers, by so conspicuously avoiding discussion of fiscal policy, imply them.[86] But I am going to draw out three points that I think are clear from the original contributions to the zero bound literature.

First, propositions (i) to (iii) are problematic given that monetary and fiscal policies interact so intimately. Given this, proposing that fiscal policy substitute for monetary policy in the case of a zero bound is not so radical: relative to what happens in modern regimes in normal times, it is merely a quantitative, not a qualitative change.

To illustrate, it has been clear throughout that 'fiscal' policies have clear 'monetary' consequences, and vice versa. Beginning with the fiscal consequences of 'monetary policy':[87] taxes on cash to bring about negative nominal rates will boost central bank revenues while they are in force. Intervening in either long bond or private sector asset markets will expose the central bank balance sheet to potential (in fact highly likely) capital losses that the fiscal authority will have to underwrite, (and the private sector will expect will be underwritten) or capital gains that it will have to redistribute; writing 'Tinsley' options likewise.

And the monetary consequences of 'fiscal policy': money rains will increase prices, of course. And conventional fiscal stabilisation affects the setting of real rates for a monetary regime that is concerned about stabilising inflation. (Which is precisely why it is a potential substitute for monetary policy at the zero bound).

To repeat my first point in this section: proposing that fiscal policy substitutes for monetary policy when interest rates hit the zero bound is not so radical when we see how intimately they are mixed during normal times.

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[86] See, for example, Clouse *et al* (2000), Buiter and Panigirtzoglou (1999).

[87] Of course, monetary policy choices in normal situations, leaving aside monetary policies that we would consider only when the zero bound to nominal interest rates has become a constraint, have 'fiscal' consequences. Conventional monetary policy at positive inflation rates involves seigniorage revenues. The choice of the inflation rate will influence the natural rate of output, and clearly, therefore, outcomes that are relevant for the 'fiscal' authority. (Not only because of the usual 'costs of inflation' but because of the zero bound itself, of course).

My second point here is this: that the optimal mix of monetary and fiscal policy for a regime that never hits the zero bound is very likely to be different from the optimal mix in an economy that may, or has already hit the zero bound.

Third, the institutional arrangements that divide monetary and fiscal policies should be designed to facilitate as close an approximation to that optimal mix, placing due weight on time-consistency problems that may impair both monetary and fiscal policies when these policies are not isolated from day to day political imperatives. If the optimal mix of monetary and fiscal policy differs for an economy that is susceptible to hitting or hits the zero bound, then so will the optimal institutional framework that is needed to support them. In other words, if the zero bound calls for more fiscal policy, then institutions should reflect that fact, rather than be designed in spite of it.

Return to propositions (i) to (iii), and they now look problematic. To repeat, they were: (i) 'policies that are 'fiscal' should not be in the province of the central bank; (ii) policies that happen to be in the province of the central bank, but are 'fiscal' should not be pursued by it; and (iii) policies that are not in the province of the central bank, and are 'fiscal' should not be used by the fiscal authority in the pursuit of objectives delegated to the central bank. But, if all monetary actions open to a central bank have direct and fiscal consequences, only in a semantic sense (distinguishing between actions and known consequences) can we fulfil (i) and (ii). And if the reverse is true, that all fiscal actions have direct and predictable fiscal consequences, (iii) is likewise impossible.

10 Optimal policy when interest rates are bounded at zero

What would a close reading of the literature suggest about an optimal policy that takes account of the zero bound? A useful place to begin to take stock is the benchmark suggested by the consensus in the simulation studies of the 'risks' of hitting the zero bound at inflation rates close to those pursued by prominent central banks. The consensus, as we have observed, seems to be as follows. First, at inflation rates around the levels of those quantified by some central banks, the risk of hitting the zero bound is small. Second, the risk of hitting the zero bound and being trapped at it – of entering a 'deflationary spiral' - is very small indeed at these inflation rates. Third, this risk seems to increase a great deal as the central bank starts to pursue inflation rates that fall towards zero.

Beginning from this benchmark, there are reasons why we might think that they offer too much comfort to central banks right now: but there are also reasons why they may overstate the costs of the current regimes.

The key unknown for policymakers in choosing an inflation rate is the dispersion of desired interest rates, which in turn depends on the dispersion of the shocks hitting the economy and how the economy and the policy rule combined propagate these shocks into a distribution for desired rates. The consensus about the risks of hitting the zero bound is based on assuming that these are normal, symmetric, and, in the case of some studies, resemble those shocks seen in the past. The question is how accurate these historical distributions will be in guiding a policy choice, and how large are the consequences of making a mistake (in particular, being too optimistic about the dispersion of shocks to desired rates).

The assumptions made by the authors about the distribution of shocks (normality, symmetry, congruence with past) are as good as any other. But the problem is what to do about the possibility that these assumptions may be wrong, either too pessimistic or too optimistic. 'What policy should do about the uncertainty it faces in gauging the extent of uncertainty' is a question that those who have written on 'robust' policies have addressed. Those authors (for example, Hansen and Sargent (1999)) were read as making a comment more directly about what might be good rules for stabilising variables central banks care about (for example, but not exclusively, inflation) about a *given target*, when the distribution of shocks about that target was itself, in some well defined sense, subject to some uncertainty. But that literature focused on how the concern for robustness might influence the choice of parameters in the rule for *any* inflation (or more complex) target. In the face of the zero bound constraint, the choice of the *inflation objective itself* is an exercise that could benefit from a concern for robustness.[88] If we are uncertain about the probability of hitting the zero bound, and the difficulties that would pose for policy, we may be better off assuming that our estimates of that probability are too small, than too large (or assuming that our estimate of the dispersion of desired nominal interest rates is too narrow). This would imply choosing a higher mean inflation rate than otherwise. Suppose the mistake we make is in underestimating the variance of shocks hitting the economy. Here the costs of underestimating the downside portion of the distribution exceed those on the upside. Larger than expected upside shocks to desired interest rates can be stabilised with conventional policy. Larger shocks on the downside cannot.

The more difficult question is how much insurance it would be worth buying to reduce the risk of hitting the zero bound. Answering this involves evaluating the relative social costs of inflation versus inflation and output variability. This is firmly beyond the scope of this paper. But it is worth noting one thing: it is conceivable that central banks have already 'bought' enough by choosing the inflation rates they have. Studies that warn against choosing inflation rates below 2 per cent do so implying that the benefits in terms of lower inflation would be outweighed by the costs of extra variability. But this is an unfounded conjecture in my view. Those same studies have models that do not allow us to uncover rigorous measures of welfare. Evidence that the 'risks' of hitting the zero bound increase below 2 per cent is not by itself enough to warrant such a conjecture. All we can say is that the inflation rate should be higher, other things equal, if the zero bound is a problem. Nothing more.

[Studies that work with micro-founded models that do allow us to make statements about welfare – for example Wolman (1998, 2000) – would even suggest that inflation objectives quantified by central banks are too high, as we have already observed in section 3. But, arguably, those studies buy access to sound welfare analysis at the expense of realism. Making inferences for policy from the zero bound literature is fraught with the same trade-off as with any other macroeconomics literature in this respect.]

So much for the reasons why the literature gives us perhaps too much comfort. On the other hand, there are two clear possibilities that suggest that a simple reading of the 'risks' of hitting the zero bound as they have been computed may lead us to be too pessimistic about the welfare consequences of the current low inflation rates chosen by central banks.

First, the simulation studies necessarily do not consider many of the alternative policy options that researchers in the field have suggested are open to central banks to follow. Some studies do not consider fiscal alternatives to monetary stabilisation. Those that do consider only stabilisation as active as policy has been in the past, when more active stabilisation policies may be an option.

Again, most necessarily exclude some of the other policy options we have discussed here (money rains, taxing money, buying other assets, writing options…) They therefore exaggerate the risks of hitting the zero bound, (and the risks of a 'deflationary spiral') and the costs in terms of impaired stabilisation of remaining there.

This said, the returns to using these policies must be considered highly uncertain (including fiscal policy, where previous estimates of the efficacy of fiscal stimulus may, as we have suggested, be unreliable in novel situations like the one we are considering here). And that would make them less valuable insurance policies compared with the insurance of choosing a higher inflation rate. (It does not make them less valuable when choosing a higher inflation rate may not be an option, in other words, when the economy is already or thinks itself already trapped at the zero bound to interest rates. In this situation, however uncertain the returns may be, the authorities may have no option but to engage in unconventional policies.)

By way of qualification, there is perhaps a danger in drawing too stark a contrast between the 'known' performance of interest rate policies and 'unknown' nature of the other policy options. There are many discrepancies between the kind of rules studied in evaluations of monetary policy and the policies followed by actual central banks: policymakers themselves are reluctant to describe their policy as following a procedure as mechanical as those portrayed in the academic literature. Empirical descriptions of interest rate policies include features that are, to some degree, theoretically puzzling (like the excess autocorrelation of interest rates, or movements in discrete steps). Simulation studies therefore give us an assessment of *an* interest rate policy in a particular model, but cannot reliably taken as providing certain estimates of *interest rate policy in general* against which we can contrast entirely uncertain alternatives policy.

A second and related point is that, as we have already discussed above, the risks of hitting the zero bound and the costs of enduring periods there are calculated assuming that central banks credibly commit to policy rules which (i) none are currently credibly committed to and (ii) would not be credible under the circumstances under which they are studied (severe negative shocks). Central banks could and indeed would be expected to deviate from such rules once the circumstances they faced became clear, and perhaps indulge in more active conventional stabilisation (a larger, earlier cut in rates than warranted by the simple rules under study?) and it is conceivable that the risks as calculated are thereby overstated.

11 Conclusions and summary

To recap:

A large literature evaluating the performance of alternative interest rate rules or alternatives to interest rate based stabilisation has grown up as central banks have pursued low rates of inflation. The views expressed in this paper could be summarised in the following set of statements.

The bound to nominal interest rates is given by the value to which the marginal utility of real balances tends. The zero figure comes from thinking that the transactions benefits to holding extra real money balances eventually diminish to nothing. But the bound may be higher than zero if there are anonymity benefits to holding cash that don't diminish to zero; or lower than zero if there are either significant costs of storing or managing real balances that kick in at some point, or non-pecuniary benefits to holding the other riskless alternative, bonds.

In the absence of perfect alternatives to interest rate stabilisation, policy faces the task of choosing an inflation rate to balance the costs of inflation and output variability against the costs of inflation itself.

The consensus in the literature on the risks of hitting the zero lower bound seems to be that the risk is small down to inflation rates close to those currently pursued by central banks, but gets much larger below that. The risk of a deflationary spiral seems to be very small indeed. The distinction is important. Many shocks that will force interest rates down to the zero bound will not be large enough to tip the economy into a deflationary spiral.

A key unknown in the calculation of the risks is the shape of the distribution of shocks that hit the economy and are propagated into shocks to desired interest rates. This must temper the comfort we draw from the studies so far carried out. Optimal policy would probably argue for a choice of inflation rate that is 'robust' to making mistakes about that distribution, and point to higher inflation than otherwise.

But computing the risks of hitting the zero bound doesn't tell us about optimal policy until we evaluate the benefits of avoiding the zero bound, as against the costs of inflation.

Those central banks that have either privately or publically quantified inflation objectives may already have taken out enough insurance in this regard. (Or even too much).

Studies of the risks of hitting the zero bound (and diagnoses of 'pathologies' associated with interest rate rules) are hampered by the fact that they study commitment to rules that no central bank does, or, under the circumstances considered, could commit to. They therefore overstate the risks. Moreover, studies of the 'perils' or 'pathologies' of interest rate rules do not tell us about the risk of hitting the zero bound at some inflation rate: choosing higher inflation would not provide an insurance against these catastrophes. But to repeat, these catastrophes again come out of simulating the pursuit of interest rate policies that are not credible. They are therefore either curiosities or a positive explanation for why central banks don't commit to policies of this form.

The central bank could engage in 'money rains' or monetary financing of the fiscal deficit. On the one hand, it would be counter-productive to commit to reversing money rains ('money drains'?) in the future. But on the other, the central bank might find it hard, once it has rained money in this way, to convince the private sector that it would not rain money (in whatever form) in normal times.

'Tinsley' style options that penalise the central bank for breaking a commitment not to raise interest rates in the future are likely to be ineffective at best, and harmful at worst. Financial penalties on the central bank and the public purse would have to be enormous to persuade the private sector that it was no longer in the interest of the central bank to raise rates. It is plausible to think that long rates could even increase, rather than fall, if penalties embedded in these options were large enough.

The central bank can clearly opt to exploit portfolio balance effects in markets for longer-term government, private sector, or even foreign assets. The most persuasive argument here is Goodfriend's argument that such purchases would increase broad liquidity in the market and reduce real rates. If these effects exist, they may already be at work anyway in normal times, and would certainly be open to policymakers to exploit at any interest rate, not just zero. The drawbacks are that the effects of interventions like this are very uncertain, may be unstable, and actions like this will expose the central bank to significant fiscal losses that the private sector as a whole will have to underwrite; they may also distort price signals in the market for risk.

A related proposal advanced by Svensson is to commit to an exchange rate depreciation, underpinned by portfolio balance effects in foreign exchange, and a rising path for the price level. How effective the exchange rate peg is will depend on how much intervention the central bank would have to engage in (relative to an amount that would be consistent with stabilisation objectives) before the point at which portfolio balance effects start to kick in is reached. A central bank understood to be committed to some notion of price stability may either not have or not wish to seek the option of credibly committing to debasing its currency. McCallum's proposal for a time-varying exchange rate target is subject to an analogous set of problems.

Conventional fiscal stabilisation carries with it many familiar costs: of implying larger microeconomic distortions from stronger automatic stabilisers; of interfering with the ongoing time consistency of monetary and fiscal policy. 'Fiscal dominance' may be more likely to occur in a deflationary spiral than in normal times, but is more likely to be a consequence of policy failure, rather than an option for systematic policy. This said, the burden of pursuing monetary policy objectives is already shared out between monetary and fiscal policies, by virtue of the fact that fiscal instruments have monetary policy consequences, so a further step in the fiscal direction may not be so radical.

Commitments to history-dependence in interest rate rules can help reduce the risk of hitting the zero bound, but do not provide a means of escape from it. Whether such commitments can be credible depends on whether you think central banks can 'just do it' (as Woodford, (1999) and McCallum, (1998) clearly believe) or will be expected to be susceptible to changes of heart (as Svensson, (1999) believes). Commitments that 'turn on' when the zero bound bites (as suggested by Reifschneider and Williams (2000), and simulated by Hunt and Laxton (2002)) are likely to be less effective in so far as they don't allow the central bank to build a reputation for sticking to its history- dependent promises.

Overall, the risks of being trapped at the zero bound to interest rates are probably small, and probably overstated. But the returns to policy alternatives are decidedly uncertain as most of their proponents have recognised. Given the uncertainties around the estimates of the risk of a 'deflationary trap', as Fuhrer and Sniderman (2000, p845) put it "prevention is likely easier than cure", or, in the words of Ueda, of the Bank of Japan board: "Don't put yourself in the position of zero interest rates".[89] Alternatives to 'prevention' are of course more interesting for monetary authorities for whom prevention is too late. But how

[89] Cited by Fuhrer and Sniderman (2000, p846).

much ‘preventative’ medicine to take depends on evaluating the social preferences for inflation and output variability, relative to inflation. It’s conceivable that the inflation objectives that typify modern monetary regimes have already prescribed more than enough of this kind of medicine.

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Appendix: short summary of the main studies on the effects of the zero lower bound

Cozier and Lavoie (1994)

Calibrated model: backward looking aggregate demand; 'expectations-augmented Phillips Curve'; monetary policy rule described as "forward looking monetary policy rule with an inflation target" by Amirault and O'Reilly. Stochastic simulations.

Record that the probability of interest rates being at the zero bound is 3.5 per cent when the inflation target is 1 per cent, and 5 per cent when the inflation target is reduced to zero.

Fuhrer and Madigan (1997)

Model: backward looking aggregate demand; variant on Taylor (1980) overlapping contracts in aggregate supply (i.e no inflation persistence). Interest rate reaction functions: one Taylor type rule with interest rates responding to deviations of nominal income growth from.

Compare the impulse response of aggregate demand to IS shocks at an inflation rate of 4 per cent compared to zero. The differences between the responses are quite small for short-lived shocks, and for rules that incorporate some dependence on past values. For longer lived shocks, or for rules that involve aggressive responses, the differences are larger.

Hunt and Laxton, also reported in IMF World Economic Outlook (2002)

Simulations using IMF multi-country model 'MULTIMOD', imagining a hypothetical Japanese policymaker conducting policy with a Taylor rule. Report that the probability of hitting the zero bound is 4 per cent at 2 per cent inflation. (Slightly lower than Reifschneider and Williams, therefore). But this rises non-monotonically as inflation falls. For example, the probability of hitting the zero bound is reported to be 13 per cent at 1 per cent inflation, and 31 per cent at zero inflation. (This compares with the Taylor rule results of Reifschneider and Williams of a 14 per cent chance of hitting the zero bound at zero inflation.) Also report the probability of entering a 'deflationary spiral', the same as Reifschneider and Williams' 'region of instability'. This is 0 per cent at 2 per cent inflation, but rises to 11 per cent at zero inflation. Considers the effect of increasing the aggressiveness of the Taylor rule (increases likelihood of hitting the zero bound). And

of interventions once the zero bound is hit: committing to reversing price level target declines suffered at the zero bound (induces a faster escape); and a fiscal stimulus (also induces a faster escape); and also a Svensson style depreciation plus price level target (induces a faster escape). But the success of these policies is really given by assumption in the model, (price level / depreciation targets believed, fiscal stimulus assumed to generate extra aggregate demand…).

Orphanides and Wieland (1998)

Model: estimated Fuhrer-Moore (1995) model with overlapping contracts and a forward looking aggregate demand side (with future income terms in a consumption equation, and backward looking investment and stocks). Taylor and Henderson-Mckibbin rules. (HM rules include coefficients of 2 on lagged output and 1 on lagged inflation-target deviation). Find that effects of zero bound are negligible at inflation rates down to 2 per cent. But at targets between 0 and 1 per cent the zero bound affects inflation and output variability significantly. For example: interest rates never at zero with target inflation at 3 per cent. Interest rates at zero 30 per cent of the time with an aggressive HM rule, or 15-20 per cent of the time with a Taylor rule.

Wolman (1998)

Calibrated, optimising theoretical model embodying price rather than inflation stickiness: optimising model enables welfare comparisons of regimes to be made, unlike other studies. Price level targeting regime optimal, and neglible risk of hitting the zero bound due to the ability to credibly induce large fluctuations in future inflation.

Reifschneider and Williams (2000)

Model: FRB/US forward looking aggregate demand, inflation persistence in aggregate supply.[90] Study performance under a Taylor and a HM rule (as above). With a Taylor rule, effect of zero bound negligible down to inflation targets of 2 per cent. Effect increases markedly towards zero. For example, percentage of time interest rate bounded at zero is 5 per cent at 2 per cent inflation, but 14 per cent at zero inflation. The HM rule, which implies more aggressive responses of rates, (but lower inflation and output variability on average), implies hitting the zero bound more often: 17 per cent of the time

[90] Induced by quadratic costs of adjustment rather than Fuhrer-Moore style contracting.

at 2 per cent inflation, 31 per cent of the time at 0 per cent inflation. Cost of zero bound in all cases felt more in terms of output than inflation variability. Assume steady state real rate is 2.5 per cent.

Black, Coletti and Monnier (1999)

Bank of Canada QPM. Caibrated forward-looking aggregate demand, some sluggishness in inflation process. Inflation forecast based interest rate rule. For a level of the real rate that is 0.5 pp above that assumed in Reifschneider and Williams, they have nominal rates at the zero floor 0.9 per cent of the time at 2 per cent inflation (p325, table 3); and at 0 per cent inflation at the floor about 10 per cent of the time.

Table 1: estimates of the risk of hitting the zero lower bound

(per cent of time interest rates at zero)

	Assumed inflation objective (per cent)								
	0	**0.5.**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**
RW	14		9		5		1		<1
OW[91]	7	3	1	<1					
BCM[92]	9.6	6.3	2.8	1.4	0.9	0.7	0.4	0.1	
HL[93]	9	5	2		1				
CL[94]	4.8		2.9		1.3		0.2		0

[91] Authors own rough calculations from figure 6 on page 45 of OW 1998. They assume a value of 1 for the steady state real interest rate. I add 1.5 to make that comparable with RW, and present the Taylor rule results.

[92] Authors own calculations from BCM, taking the results they have assuming that the interest rate floor is zero (they experiment with different levels of the floor) and subtracting 1.5 from their reported inflation rates in table 3 on page 325) to get results for a real rate that is equivalent to Reifschneider and Williams. BCM assume 4 per cent real rates.

[93] Hunt and Laxton simulate the Japan block in MULTIMOD. They assume a real rate of 2.2 per cent. These figures are taken, unadjusted, from table 7 on page 26. HL describe these figures as underestimating the risk of hitting the zero bound, relative to RW, for a variety of reasons.

[94] The assumed real rate in this paper is not transparent. Figures approximate, taken from a chart with no exact numbers.

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