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Working Paper No. 11/43
June 2011

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Abstract

Given the recent experience, there is growing interest in the liquidity trap; which occurs when the nominal interest rate reaches its zero lower bound. Using the Dixit-Lambertini (2003) framework of strategic policy interaction between the Treasury and the Central Bank, we find that the optimal institutional response to the possibility of a liquidity trap has two main components. First, an optimal inflation target is given to the Central Bank. Second, the Treasury, who retains control over fiscal policy and acts as a Stackelberg leader, is given optimal output and inflation targets. This solution achieves the optimal rational expectations pre-commitment solution. This result holds true for a range of specifications about the Treasury's behavior. However, when there is the possibility of a liquidity trap, if monetary policy is delegated to an independent central bank with an optimal inflation target, but the Treasury retains discretion over fiscal policy, then the outcome can be a very poor one.

Keywords: liquidity trap, strategic monetary-fiscal interaction, optimal Taylor rules.

JEL Classification: E63, E52, E58, E61.

*We are very grateful to David Vines, Mark Gertler, Andrew Scott and Kevin Lee for useful comments. The usual disclaimers apply.

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1. Introduction

Keynes (1936) coined the term ‘liquidity trap’ to refer to a situation where the nominal interest rate has been driven down to its ‘zero lower bound’. The source of a liquidity trap, in most circumstances, is a sharp fall in aggregate demand; see Keynes (1936), Bernanke (2002). Hence, deflation typically accompanies a liquidity trap. In a liquidity trap, traditional monetary policy loses its effectiveness because nominal interest rates can be reduced no further in order to boost the interest sensitive components of aggregate demand. Hence, reliance must be placed on other, possibly more expensive, policies. Keynes (1936), in the first policy prescription for a liquidity trap, suggested the use of fiscal policy, which works through the multiplier effect to boost output and employment.

The Japanese experience since 1990 has revived great interest in the liquidity trap. Woodford (2005, p.29) discusses the near miss of the US economy from a liquidity trap in the summer of 2003. Recent policy discussions on either side of the Atlantic have expressed concerns about the nominal interest rate hitting the zero lower bound.[1]

1.1. The critical role of inflation expectations in a liquidity trap

The recent literature has largely focussed on the role of inflation expectations in a liquidity trap. The real interest rate, r, is given by $r = i - \pi^e$, where i is the nominal interest rate and π^e is expected inflation. In a liquidity trap, by definition, $i = 0$, and due to deflationary expectations, typically $\pi^e < 0$, hence, $r > 0$. To expand economic activity, the government needs to lower r.

One possible solution, suggested by Krugman (1998, 1999), is to generate positive inflationary expectations, $\pi^e > 0$, so that the real interest rate $r < 0$. This, in turn, creates a need for a credible commitment to the future level of actual inflation because after the economy has escaped from the liquidity trap it is in the interest of all parties to reduce inflation. A forward looking private sector will anticipate this and expect low future inflation. But then the real interest rate remains high, keeping the economy in a liquidity trap. The era of low inflation targets exacerbates the problem, because such targets lead to low values of π^e and, so, the real interest cannot be reduced low enough to

[1] In an article on Bloomberg.com on 6 July 2009, the Federal Reserve Bank of San Francisco President, Janet Yellen, is reported to have told reporters after a speech in San Francisco: “We have a very serious recession, we have a 9.4 percent unemployment rate... Given the recession’s severity, we should want to do more. If we were not at zero, we would be lowering the funds rate.” The Economist wrote on November 13, 2008 that: ‘Remember Japan’s zero interest rates? America is almost there too. Since October 29th, ...the “effective rate”, has averaged around 0.25%...’ The Telegraph, a national daily in Britain reported in January 2009 that the interest rate has been cut to it’s lowest level in the last 300 years to 1.5% and went on to say that: “Further cuts are expected in the next few months and the base rate may be reduced to zero this year.”

boost recovery in a liquidity trap.[2]

1.2. Some proposed solutions to a liquidity trap

The literature on the liquidity trap has considered a range of solutions, e.g., exchange rate policies such as currency depreciation, integral stabilization, a carry tax on currency, open market operations in long term bonds, price level targets, and money growth rate pegs. The surveys in Blinder (2000) and Svensson (2003) consider these policies in detail. However, these policies have important limitations[3,4]. Eggertsson (2006a,b) recommends abandonment of an independent central bank and a return to discretionary policy by a unitary monetary-fiscal authority. A debt financed fiscal expansion during a liquidity trap results, via the government budget constraint, in higher expectations of future inflation. Eggertsson shows that this solution is superior to either monetary policy alone or uncoordinated monetary and fiscal policy. However, as Eggertsson shows, even optimal discretion is inferior to the fully optimal rational expectations solution with commitment. Moreover, abandoning delegation of monetary policy to an independent central bank with a narrow mandate, in favor of a return to discretion, appears to be a retrograde step.[5]

1.3. Stylized facts

Based on several recent works on the Japanese experience[6], we outline the following three stylized facts, S1-S3.

[2] Blanchard *et al.* (2010) propose an inflation target of 4 percent in order to provide greater manoeuvrability of the nominal interest rate instrument. Our paper provides one framework within which to evaluate this proposal.

[3] Variants of the devaluation approach can be found in McCallum (2000) and Svensson (2003). There are several potential problems with the devaluation option. First, calibrated models show that the magnitude of the devaluation required to get out of the liquidity trap might be too high. Second, using the uncovered interest rate parity condition, when the domestic interest rate is zero, the expected appreciation of the home currency is fully locked-in by the foreign interest rate. Third, current devaluation will generate expectations of future appreciation of currency when the economy moves out of the liquidity trap, generating counter flows that frustrate attempts to devalue. Fourth, devaluations may bring about competitive devaluations or retaliations in the form of other barriers to trade.

[4] In a liquidity trap, zero nominal interest rates make bonds and money perfect substitutes. Hence, it might be difficult to engineer a price level increase. Furthermore, increases in money supply, suggested, for instance, in Clouse *et al.* (2003) and in Orphanides and Wieland (2000), for a long enough period that exceeds the duration of the liquidity trap, creates problems of credibility. While short term interest rates might be zero, long term interest rates might be strictly positive (this has been true of Japan during its deflationary experience). Hence, several authors such as Bernanke (2002) and Auerbach and Obstfeld (2005) have suggested open market operations in long term bonds. However, moving the long run yield curve on securities is confounded by the presence of the risk premium term whose behavior in a liquidity trap is not well known. A carry tax on money, suggested by Buiter and Panigirtzoglu (2003), works in theory but substantial practical problems of implementation are likely.

[5] Central bank independence has other benefits. For example, it shields monetary policy from political interference and allows the delegation of policy to the most competent experts etc.

[6] See, for instance, Posen (1998), Kuttner and Posen (2001), Iwamura *et al.* (2005) and Ball (2005).

S1. (Potency of fiscal policy) Fiscal policy is potent in a liquidity trap. Whenever the net fiscal stance was expansionary, it worked well and the deficit spending multipliers were significant, and large. However, the net fiscal stance was typically contractionary or neutral.[7]

S2. (Role of institutional design) The response to a liquidity trap is inadequate if the Treasury or the Central Banks are not given appropriate targets. There were no explicit inflation or output targets given to either the Treasury or to the Central Bank. So, the fiscal stance was typically contractionary, or neutral, and the monetary policy reaction was too little, too late.

S3. (Coordination between Treasury and Central Bank) Lack of coordination between the Treasury and the Central Bank hampers policy response in a liquidity trap. The Treasury and the Central Bank may disagree about an appropriate response and also differ about their respective spheres of responsibility, if not well defined. They might end up taking policy actions that are counter to each other or cancel each other out and so, on net, are not expansionary.[8]

1.4. Modelling choices

In this paper we shall make two modelling choices, which we call M1 and M2.

M1. We shall take an *ex ante* perspective in this paper. Models with an ex ante perspective recognize the possibility of a liquidity trap in the future and spell out the optimal design of institutions in order to reduce or eliminate the consequences arising from a liquidity trap. By contrast, models with an *ex post* perspective propose policy solutions, conditional on an economy having already slipped into a liquidity trap.[9]

M2. In this paper we are interested in optimal policies and their robustness. In Economics, the optimal policy must balance the marginal cost of removal of the economic bads against the marginal benefits. In the context of a liquidity trap, the optimal policy recommendation might, therefore, turn out to be one that lets the economy fall

[7] See, for instance, Posen (1998), Kuttner and Posen (2001) and Eggertsson (2006b).

[8] See, for instance, the empirical evidence in Iwamura *et al.* (2005) and Eggertsson (2006b).

[9] Papers that take an ex ante perspective include Krugman (1998), Eggertsson and Woodford (2003), Benhabib *et al.* (2002), Shin-Ichi (2003), Clouse et al. (2003), Buiter- Panigirtzoglou (2003). Papers that take an ex post perspective include Ball (2005) and Auerbach and Obstfeld (2005). Finally there are papers that touch on both *ex ante* and *ex post* issues, for instance, Orphanides and Wieland (2000), McCallum (2000), Bernanke (2002), Svensson (2003).

into a liquidity trap with some probability rather than completely eliminating the possibility of a liquidity trap.[10]

1.5. Our approach to modeling a liquidity trap

Our model of a liquidity trap takes explicit account of all the three stylized facts, S1, S2 and S3. Our perspective is *ex ante* (M1). We seek to derive the optimal strategy and study its stability (M2). We consider strategic interaction between monetary and fiscal authorities in a simple aggregate supply-aggregate demand model similar to the one in Dixit and Lambertini (2003) and Lambertini and Rovelli (2003) but extended to allow for a liquidity trap and the effect of inflationary expectations in the aggregate supply curve.

Issues of strategic policy interaction between monetary and fiscal authorities are completely ignored by the theoretical work on the liquidity trap. Typically, the only policy considered is monetary policy and so issues of strategic interaction do not arise[11]. On the other hand, when several policies are simultaneously considered, their strategic interaction is not allowed for.[12]

1.6. Some results and intuition

As pointed out above, Krugman identified the solution to a liquidity trap as creating high enough inflationary expectations. However, under discretion, promises of high inflation will not be believed. This is because, outside a liquidity trap, the correct value for the real interest rate can be achieved more cheaply with zero inflation. Therefore, if the economy turns out not to be liquidity trapped, the Treasury has an incentive to renege on its promise of high inflation. A rational forward looking private sector will anticipate this. The result is low inflation expectations, keeping the real interest rate too high in a liquidity trap. Notice that unlike the standard analysis conducted in the absence of a liquidity trap, the discretionary outcome can be suboptimal relative to the precommitment outcome because it creates *too little* inflation (Eggertsson (2006a,b) calls this the deflation bias).

We suggest an institutional solution, the *optimal delegation regime*, that achieves the optimal rational expectations precommitment solution for all parameter values in our

[10] A dental analogy might be appropriate here. Tooth decay can be prevented by extracting all the child's teeth. But, normally, the optimal policy is not to extract; tooth decay then occurs with some probability.

[11] Examples are Krugman (1998), Eggerston and Woodford (2003), Nishiyama (2003), Clouse *et al.* (2003), Buiter and Panigirtzoglou (2003), and Auerbach and Obstfeld (2005). Ball (2005) considers fiscal policy alone.

[12] Examples include (i) monetary and fiscal policy in Benhabib *et al.* (2002), Iwamura et al. (2005), and (ii) monetary and exchange rate policy in Orphanides and Wieland (2000), McCallum (2000) and Svensson (2003). Bernanke (2002) considers both monetary and fiscal policy but there is no theoretical analysis.

model. This regime has three components. First, the Treasury acts as the Stackelberg leader and the Central Bank as the follower. Second, an inflation target, π_B^*, is given to the Central Bank who has exclusive control over monetary policy. Outside a liquidity trap, where monetary policy is effective, the Treasury would rather not use the relatively more costly fiscal stabilization policy, leaving the Central Bank to perform the stabilization function. Because the Central Bank is operationally independent and its sole objective is achieving monetary stability, this type of delegation provides a commitment to the necessary inflation level, π_B^*, when the economy is not in a liquidity trap. Our third component is to give the Treasury, who retains control of fiscal policy, something like a *Taylor rule*, which penalizes deviations of output from an output target, y_T^*, and inflation from an optimal inflation target, π_T^* (we show that π_T^* can always be taken to be equal to π_B^*). This gives the Treasury the correct incentive to undertake the appropriate (but costly) fiscal stimulus in a liquidity trap. Consequently, inflation expectations are at the right level to produce the correct value for the real interest rate in a liquidity trap.

For a variety of reasons, e.g., electoral concerns, the output target of the Treasury, y_T, could differ from the optimal target, y_T^*. In this case, we find that even if the Treasury's output target, y_T, is substantially different from the optimal output target, y_T^*, this *sub-optimal delegation regime* achieves *close* to the optimal solution and is much better than discretion.

While it may appear reasonable to assign an inflation target, π_B^*, to the Central Bank, it may be asked why should the Treasury have an inflation target, π_T^*, as well as an output target, y_T^*? To address this issue, we define two further regimes: the *output nutter regime*, where the Treasury has an output target but not an inflation target; and the *reckless output nutter regime* where the Treasury has an output target but does not have an inflation target and, furthermore, does not care about the cost of fiscal policy. It turns out that so long as the Treasury follows the optimal output target, y_T^*, then delegation achieves the optimal solution even in the regimes of the output nutter and the reckless output nutter.

However, in the output nutter and the reckless output nutter regimes, the delegation regime is not robust in the following sense. If the output target of the Treasury, y_T, is different from the optimal output target, y_T^*, then performance is poor and can be much worse than under discretion. Hence, giving the Treasury an inflation target (as well as an output target), while not essential for optimality, adds to the robustness of the policy. In particular the hybrid regime where monetary policy is delegated to an independent central bank with an optimal inflation target, while the Treasury retains discretion over fiscal policy, can perform badly and much worse than had the Treasury retained *discretion* over both monetary and fiscal policy.

Furthermore, the *optimal delegation regime* achieves the optimal mix between monetary and fiscal policy as we now explain. Theoretically, society could give a sufficiently high inflation target to the Central Bank which in turn generates sufficiently high inflation expectations so that the nominal interest rate never hits its zero floor. While this policy would always avoid the liquidity trap (see modelling assumption M2 above), it is not optimal because inflation is costly. Analogously it is not optimal to give the Treasury too high an output target because if a liquidity trap occurs, it would use the costly fiscal policy excessively. The optimal solution then is to have a mix of both i.e. some inflation outside a liquidity trap and some dependence on costly fiscal policy in a liquidity trap.

The first best is achieved if one could remove the distortions that cause the liquidity trap. The second best obtains with the optimal rational expectations commitment solution. The third best is achieved with various institutional design features introduced into policy making. The fourth best obtains under discretion. It is well known that, in the absence of a liquidity trap, 'optimal institution design', such as Walsh contracts, can achieve the second best. Our suggested institutional design achieves the second best in the presence of a liquidity trap.

1.7. Relation to Dhami and al-Nowaihi (2011)

Dhami and al-Nowaihi (2011), henceforth DaN, also propose a model of a liquidity trap along the lines that are mentioned above. In this paper we extend their model along the following lines.

- E1. Here, we introduce the full set of parameter values. By contrast, DaN assign the value one to all parameters. The advantage of that special choice of parameter values is that all the details of all the proofs can be exhibited. Unfortunately, this is no more the case when the full set of parameter values is introduced, as is done here. While we can still explicitly state the assumptions and the conclusions, the details of the proofs can no longer be printed. The reason is that many of the algebraic expressions are more than one page in length each! However, the logic of the proofs here is the same as in DaN. All proofs require only elementary (though tedious) algebraic calculations. All our claims can be independently checked by a reader wishing to reconstruct the intermediate steps of the calculations or willing to use the 'check equality' command of a scientific word processor.
- E2. Here, we allow for persistence in demand shocks. By contrast, in DaN the demand shocks are uncorrelated over time.
- E3. Here, we allow for general probability distribution over the two states of the world. By contrast, in DaN the demand shocks in any period take two possible values, 1 and -1 with equal probability.

E4. Here, we show that if the Treasury follows its own private output target, y_T, rather than the optimal output target, y_T^*, then the resulting 'suboptimal delegation regime' is, nevertheless, close to the 'optimal delegation regime' and is much better than discretion. This analysis is absent in DaN.

E5. Here, we show that giving the Treasury an inflation target (as well as an output target), while not essential for optimality, adds to the robustness of the policy. In particular the hybrid regime where monetary policy is delegated to an independent central bank with an optimal inflation target, while the Treasury retains discretion over fiscal policy, can perform badly and much worse than had the Treasury retained *discretion* over both monetary and fiscal policy. This analysis is absent in DaN.

1.8. Schematic outline

The model is formulated in Section 2. Section 3 derives the *optimal rational expectations precommitment solution* which we would like to implement, using appropriate institutional design. We also briefly comment, in this section, on the *discretionary solution*. Section 5 derives the *optimal delegation solution* under a large variety of behavioral assumptions about the Treasury. For instance, the Treasury might or might not internalize society's preferences; the Treasury might or might not care about inflation or it's costs; the Treasury might or might not be given an inflation target etc. Section 6 concludes with a brief summary.

Proofs can be found in the working paper version of this paper, Dhami and al-Nowaihi (2007). There are two reasons, why we do not report the proofs here. First, the proofs are standard, and straightforward; easily at the level of graduate level problem sets in economics. Second, the expressions in the proofs are extremely long (some going well over a page), despite the fact that the final results are manageable and intuitive.

2. Model

2.1. Aggregate Demand and Aggregate Supply

We use an aggregate demand and supply framework that is similar to Ball (2005), Dixit and Lambertini (2003) and Lambertini and Rovelli (2003). The aggregate demand and aggregate supply equations are given by, respectively,

$$\text{Aggregate Demand: } y = \varphi f - \lambda \left(i - \pi^e\right) + \varepsilon, \tag{2.1}$$

$$\text{Aggregate Supply: } y = \mu \left(\pi - \pi^e\right). \tag{2.2}$$

where y is the deviation of output from the natural rate and f captures fiscal policy[13]. For example, $f > 0$ could denote a fiscal deficit (either debt financed or money financed[14]) while $f < 0$, a fiscal surplus. But f could also denote a temporary balanced budget reallocation of taxes and subsidies that has a net expansionary effect; for instance Dixit and Lambertini (2000). $i \geq 0$ is the nominal interest rate, π is the rate of inflation, π^e is expected inflation[15] and, in keeping with the modern literature on the liquidity trap, ε is a demand shock[16]. The instruments of policy are the nominal interest rate, i, and, the stabilization component of fiscal policy, f.

The parameters φ, λ, μ are all strictly positive. φ and λ are a measure of the effectiveness of fiscal and monetary policy, respectively, in influencing aggregate demand and μ indicates the degree of influence of inflation surprises on aggregate supply.

The aggregate demand equation reflects the fact that demand is increasing in the fiscal impulse, f, and decreasing in the real interest rate; it is also affected by demand shocks. The aggregate supply equation shows that deviations of output from the natural rate are caused by unexpected movements in the rate of inflation.

Equating aggregate demand and supply we get from (2.1) and (2.2), our reduced form equations for output and inflation.

$$y = \varphi f - \lambda \left(i - \pi^e \right) + \varepsilon, \tag{2.3}$$

$$\pi = \frac{1}{\mu} \left[\varphi f - \lambda i + \pi^e \left(\lambda + \mu \right) + \varepsilon \right]. \tag{2.4}$$

Hence, fiscal policy, monetary policy and inflation expectations (in the spirit of New Keynesian models) have an affect on output (and so also on unemployment) and inflation.

2.2. Specification of the demand shocks

The state contingent values of the demand shock, ε, are:

$$\text{Bad State: } \varepsilon_{-} = \rho x - (1-p)\, s \text{ (with probability } p), \tag{2.5}$$

[13] To be more precise, f is the *stabilization* component of fiscal policy (which varies over the business cycle). *Total* fiscal policy can be represented by $F = f_0 + f$, where f_0 is *fixed.*

[14] In principal, these alternative modes of finance need not be equivalent. However, in the context of a liquidity trap, Ball (2005) shows that there are no long run differences arising from these alternative modes of finance.

[15] The following formulation might appear even more plausible

$$AD : y_t = \varphi f_t - \lambda \left(i_t - \pi^e_{t+1} \right) + \epsilon_t$$

$$AS : y_t = \mu(\pi_t - \pi^e_t)$$

where $\pi^e_t = E_{t-1}\pi_t$ and $\pi^e_{t+1} = E_t\pi_{t+1}$. However, in our model, the private sector has to make its decision before the realization of the demand shock ϵ_t. Hence, in the aggregate demand curve, it has to forecast π^e_{t+1} at time $t-1$. But $E_{t-1}\pi^e_{t+1} = E_{t-1}\left(E_t\pi_{t+1}\right) = E_{t-1}\left(\pi_{t+1}\right) = E_{t-1}\left(\pi_t\right) = \pi^e_t$. While this is true in our model, it is not true more generally.

[16] Our framework can be easily extended to incorporate supply, as well as demand, shocks.

$$\text{Good State: } \varepsilon_+ = \rho x + ps \text{ (with probability } 1-p). \quad (2.6)$$

where $0 < p < 1$, $s > 0$ and $0 \leq \rho < 1$. The variable x represents the previous period's shock and so ρ is a measure of the persistence in the shock. The second component in (2.5), (2.6) shows the innovation terms. With probability p the shock takes the value ε_- and with probability $1-p$ it takes a value ε_+. Hence $E[\varepsilon] = p\epsilon_- + (1-p)\varepsilon_+ = \rho x$ and so in the absence of the persistence term, $E[\varepsilon] = 0$.[17]

In more standard but less convenient notation, $x_t = \rho x_{t-1} + z_t$, where $z_t = -(1-p)s$ with probability p and $z_t = ps$ with probability $1-p$.

Special Case: We shall also find it useful in one of the subsequent sections to consider a special case of the distribution of shocks in which $\rho = 0$, $p = 1/2$, $s = 2a$, where a is a real number. In this case, ε takes the two equally likely values, $-a$ and a.

2.3. Microfoundations

Our model is inspired by the microfounded dynamic model of monopolistic competition and staggered price setting in Dixit and Lambertini (2000, 2003). Our structural model in (2.1),(2.2) is similar to the Dixit and Lambertini model[18]. In the Dixit and Lambertini framework, unexpected movements in inflation have real effects because prices are staggered. Alternatively, a range of 'rational inattention' theories currently compete as potential explanations for the presence of the unexpected inflation term in (2.2). For instance, see Sims (2003).[19]

To simplify the dynamic *game-theoretic* analysis Dixit-Lambertini follow the tradition, established in the time-inconsistency literature[20], of abstracting from *structural* dynamic issues, notably, capital formation, the term structure of interest rates, exchange rate policy and the financing of the stabilization component of fiscal policy. Concentrating on

[17] Thus, if an economy is close to a liquidity trap, a negative shock can push the economy into it. Because of persistence, it may take the economy several periods to get out of the liquidity trap.

[18] However, our model has the following differences from the Dixit-Lambertini model. (1) We normalize the natural rate of output to zero, hence, the additive shock ϵ (in (2.1) or in (2.3)) can also be interpreted as a shock to the natural rate of output. (2) Our model has the New Keynesian feature that expected inflation, π^e, also affects actual inflation, π. (3) Our stochastic structure allows persistence. While there is no persistence in Dixit-Lambertini, they allow all parameters to be stochastic, hence, considering the possibility of non-additive shocks. (4) In our model a fiscal impulse acts on the demand side, creating greater output and inflation. However, in Dixit-Lambertini fiscal policy works on the supply side and takes the form of a subsidy to imperfectly competitive firms that increases output but reduces prices.

[19] Most dynamic structural models used in the analysis of a liquidity trap are forward looking New Keynesian models. Gertler (2003), Mankiw (2002) note dissatisfaction with this model in terms of its inability to explain persistence in the data. Recent work, for instance, Rudd and Whelan (2006), casts doubt even on the hybrid variant proposed by Gali and Gertler (1999). Of course, similar criticisms apply to the version of our model microfounded along the lines of Dixit and Lambertini (2003). Thus, it would not be unfair to say, all current macroeconomic models lack satisfactory microfoundations.

[20] See, for example, Romer (2006, chapter 10) and Walsh (2003, chapter 8).

the aggregate demand consequences of investment expenditure, but abstracting from its contribution to growth, is standard in models of the business cycle, and is a feature of all the models of the liquidity trap (as far as we know).

Eggertsson and Woodford (2003), in a structurally dynamic model of monetary policy with a financial sector and a zero lower bound on interest rates, show that the short-run interest rate (which is the instrument of policy) determines all other interest rates and exchange rates. As they clearly explain, open market operations only work to the extent that they enhance the credibility of policy. Thus, and in common with many models, we take the short-run interest rate as directly affecting aggregate demand and we abstract from open economy aspects.

We offer three arguments that mitigate not explicitly modelling the government budget constraint in the Dixit and Lambertini type models. First, we shall assign a higher welfare loss to the use of fiscal policy relative to monetary policy. The cost of using fiscal policy could include deadweight losses, costs of servicing debt and a risk premium for default. Second, in all equilibria of our model, fiscal policy is not used for stabilization purposes outside a liquidity trap. In a calibrated model of Japan, Ball (2005) shows that the combination of higher output, higher tax revenues and higher inflation outside the liquidity trap is more than adequate to finance the extra fiscal spending during the liquidity trap. Third, the liquidity trap is an extremely unusual situation with huge welfare costs in terms of loss of output, unemployment and social unrest. There is not ex-ante guarantee that the government will respect it's budget constraint, or debt obligations, in this event.

2.4. Social Preferences

Society's objective function is given by

$$U_S = -\frac{1}{2}\alpha\pi^2 - \frac{1}{2}\beta\left(y - \overline{y}\right)^2 - \frac{1}{2}\gamma f^2, \tag{2.7}$$

where α, β, γ are positive. The first term in (2.7) indicates that inflation reduces social welfare. The second term shows that departures of output from its desired level, $\overline{y}$ (note that $\overline{y}$ is the difference between desired output and the natural rate), are costly. We assume that

$$\overline{y} \geq 0, \tag{2.8}$$

which captures the fact that the natural level of output is socially suboptimal (unless $\overline{y} = 0$)[21]. The third term captures the fact that the exercise of fiscal policy is more costly

[21] The microfoundations for this in Dixit and Lambertini (2000, 2003) rest on the presence of monopolistic competition. Monopoly power in the product market reduces output below the efficient level, hence, giving policy makers an incentive to raise output. There are also a large number of other well known reasons for (2.8) but the ultimate cause, argue Alesina and Tabellini (1987), is the absence of nondiscretionary taxes. For if they were available then other market failures could be corrected.

than that of monetary policy[22]. We model this as imposing a strictly positive cost of fiscal policy, $\frac{1}{2}\gamma f^2$, but no cost of using the monetary policy[23]. The cost of using fiscal policy could include deadweight losses, as in Dixit and Lambertini (2003), costs of servicing debt and a risk premium for default.

From (2.7) we see that the first best obtains when $\pi = 0$, $f = 0$, and $y = \overline{y}$. However, from (2.1) and (2.2), it follows that this cannot be an outcome of a rational expectations equilibrium (unless $\overline{y} = 0$). On the microfoundations of such a social welfare function, see Dixit and Lambertini (2000, 2003), Rotemberg and Woodford (1999).

2.5. Preferences of the Central Bank

The monetary instrument, which is the nominal interest rate, i, is assigned to the Central Bank whose objective is to attain the inflation target, π_B, given to it by society. We formalize this by assigning the following objective function to the Central Bank:

$$U_B = -\frac{1}{2}\left(\pi - \pi_B\right)^2. \tag{2.9}$$

The optimal value of π_B will be denoted by π_B^*.

2.6. Preferences of the Treasury

The fiscal instrument, f, is controlled by the Treasury. Many possible behavioral assumptions can be made about the Treasury. We check the model's robustness with respect to a range of such alternative assumptions.

2.6.1. Baseline Preferences of the Treasury

The *baseline objective function* of the Treasury is similar to that of society (2.7) but with, possibly, different inflation and output targets:

$$U_T = -\frac{1}{2}\alpha\left(\pi - \pi_T\right)^2 - \frac{1}{2}\beta\left(y - y_T\right)^2 - \frac{1}{2}\gamma f^2, \tag{2.10}$$

where y_T, π_T are the output and inflation targets respectively of the Treasury. It is important to bear in mind the difference between the socially desirable output level, $\overline{y}$, and the Treasury's own output target, y_T. The optimal targets assigned by society to the Treasury are y_T^*, π_T^* and, in the baseline model, the Treasury *complies* with these targets,

[22]Fiscal policy is typically more cumbersome to alter, on account of the cost of changing it (balanced budget requirements, lobby groups etc.). Indeed the 'monetary policy committee' in the UK or the Fed in the USA meet on a regular basis to make decisions on the interest rate while changes to the tax rates are much less frequent.

[23]Strictly speaking, for our qualitative results to hold, we only require that fiscal policy be relatively more expensive than the (possibly strictly positive) cost of using monetary policy. Normalizing the cost of using monetary policy to zero, however, ensures greater tractability and transparency of the results.

hence, sets $y_T = y_T^*$ and $\pi_T = \pi_T^*$. Our model allows $\pi_T^* \neq \pi_B^*$, however, we shall see that $\pi_T^* = \pi_B^*$ is always feasible (and, of course, natural).

Giving the Treasury an output and an inflation target such that the Treasury feels penalized when either output or inflation depart from these targets is a form of Taylor's rule. We check to see if such a Taylor rule is optimal, in the sense that it helps achieve the *rational precommitment solution*. Some might object to the assignment of an inflation target to the Treasury. To address these issues, we consider the next two alternative specifications.

2.6.2. The Treasury as an "output nutter"

If the Treasury is not given an inflation target, we call it an *output nutter*. It continues to adopt the output target, y_T^*, assigned to it by society; its objective function is given by

$$U_T = -\frac{1}{2}\beta\left(y - y_T\right)^2 - \frac{1}{2}\gamma f^2.$$

2.6.3. The Treasury as a "reckless output nutter"

If the Treasury cares neither about inflation nor the costs of fiscal policy we call it a *reckless output nutter*. However, it immediately adopts the output target, y_T^*, assigned to it by society. Its objective function is given by

$$U_T = -\frac{1}{2}\left(y - y_T\right)^2.$$

2.6.4. The Treasury follows it's own agenda (suboptimal delegation)

In this case, the preferences of the Treasury can be represented by any of the three cases above (subsections 2.6.1 - 2.6.3, above), with one important difference. The Treasury refuses to follow the optimal output target, y_T^*, assigned to it by society. It chooses, instead, to follow it's own agenda, reflected in it's private output target, y_T.[24]

2.7. Notation

We shall write a policy variable with a subscript '+' in the good state, $\varepsilon = \varepsilon_+$. For example, i_+, f_+, denote the interest rate and the fiscal policy when $\varepsilon = \varepsilon_+$. Analogously, to denote the realization of the same variable in the state of the world when $\varepsilon = \varepsilon_-$, we use a subscript '$-$', for example, i_-, f_-.

[24] The Treasury is just an arm of the government. The literature on political economy often highlights the case $y_T \neq y_T^*$. For instance, before an election, the government might engage in opportunistic expansion.

2.8. Sequence of Moves

At the first stage, the economy designs its institutions, which assign powers of policy-making decisions to one or two independent policy makers. This is followed by the formation of inflationary expectations, π^e, and the signing of nominal wage contracts in anticipation of future inflation. Next, the demand shock, ε, is realized. In light of the actual realization of the shock, the relevant policy makers (who were chosen in the first stage) then decide on the optimal values of the policy variables, f and i. We shall also derive the optimal rational expectations solution (precommitment benchmark) in which the last stage is conducted up-front i.e. the (state contingent) policy variables f and i are announced to the economy prior to the resolution of demand uncertainty.

3. The Precommitment Solution

We begin by describing the Precommitment solution or the globally optimal solution in the class of all rational expectations solutions[25]. Since our aim is to propose an optimal delegation scheme for the Central Bank and the Treasury that achieves the Precommitment solution, our interest in the Discretionary solution is only tangential. We will only use some results from the Discretionary solution in the last section, section 5.3. Hence, we largely focus on the Precommitment solution. The sequence of moves is described below.

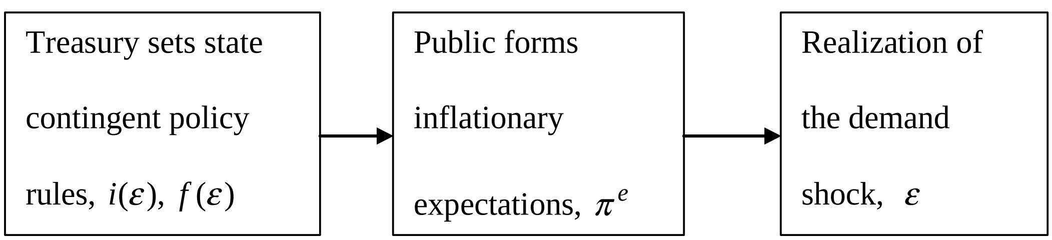

Figure 3.1: Sequence of moves for the precommitment regime

The proofs are long and cumbersome (some expressions are several pages long), but conceptually very straightforward, so we omit them. The method of solution should be quite familiar to most graduate students in economics. Simply, find state contingent rules for the policy variables, $i(\varepsilon)$, $f(\varepsilon)$, that maximize the expected value of the social welfare

[25] Strictly speaking, this is a second best solution. The first best obtains if the imperfections responsible for the liquidity trap are removed. It is variously referred to as the 'precommitment solution', the 'optimal rational expectations solution', the 'second best solution' or simply the 'optimal solution'.

(2.7) under the constraints (2.3), (2.4) and the rational expectations condition

$$\pi^e = p\pi_- + (1-p)\pi_+.$$

Depending on the realization of the shock in the previous period, x, there are three possibilities. The economy could be (a) liquidity trapped in both the good (ε_+) and the bad states (ε_-), (b) not liquidity trapped in the good state but liquidity trapped in the bad state, and (c) not liquidity trapped in either state. The main focus of this paper is on case (b), although, for completeness, we consider all three cases.

Proposition 1 *:(a) If $x < -ps\frac{\left(\alpha+\beta\mu^2\right)\left(\alpha\varphi^2+\gamma\lambda^2\right)}{\alpha\rho(\gamma\mu^2+\varphi^2(\alpha+\beta\mu^2))}$ then the economy is liquidity trapped in both states and the commitment solution is given by $i_- = i_+ = 0$,*

$$f_- = \varphi\left(\frac{\left(\alpha+\beta\mu^2\right)s\left(1-p\right)}{\gamma\mu^2+\varphi^2\left(\alpha+\beta\mu^2\right)} - \frac{\alpha\rho x}{\alpha\varphi^2+\gamma\lambda^2}\right) > 0,$$

$$f_+ = -\varphi\left(\frac{\left(\alpha+\beta\mu^2\right)sp}{\gamma\mu^2+\varphi^2\left(\alpha+\beta\mu^2\right)} + \frac{\alpha\rho x}{\alpha\varphi^2+\gamma\lambda^2}\right) > 0.$$

***(b)** If $-ps\frac{\left(\alpha+\beta\mu^2\right)\left(\alpha\varphi^2+\gamma\lambda^2\right)}{\alpha\rho(\gamma\mu^2+\varphi^2(\alpha+\beta\mu^2))} \leq x < (1-p)\frac{s}{\rho}$ then the economy is liquidity trapped in the bad state only and the commitment solution is given by $i_- = f_+ = 0$,*

$$f_- = \frac{\alpha\varphi\left(\alpha+\mu^2\beta\right)\left(\left(1-p\right)s-\rho x\right)}{\left(\alpha+\beta\mu^2\right)\left(\alpha\varphi^2+\gamma\lambda^2 p\right)+\alpha\gamma\mu^2\left(1-p\right)} > 0,$$

$$i_+ = \frac{\left(\gamma\lambda^2+\alpha\varphi^2\right)\left(\alpha+\beta\mu^2\right)sp + \left(\beta\varphi^2\mu^2+\gamma\mu^2+\alpha\varphi^2\right)\alpha\rho x}{\lambda\left(\left(\alpha+\beta\mu^2\right)\left(\alpha\varphi^2+\gamma\lambda^2 p\right)+\alpha\gamma\mu^2\left(1-p\right)\right)} \geq 0.$$

***(c)** If $x \geq (1-p)\frac{s}{\rho}$ then the economy is liquidity trapped in neither state and the commitment solution is given by $f_- = f_+ = 0$,*

$$i_- = \frac{\rho x - (1-p)s}{\lambda} \geq 0,$$

$$i_+ = \frac{\rho x + ps}{\lambda} > i_- \geq 0.$$

Proposition 1 illustrates the evolution of the economy over time. Suppose that the economy is liquidity trapped in period t. How does it get out of a liquidity trap? Proposition 1(b), (c), give the conditions required on how big the shocks must be in period t so that in period $t+1$ the economy is not liquidity trapped in at least in one state of the world[26].

[26] This might not be a bad descriptor of the actual occurrence of a liquidity trap given the deep reservations expressed about the efficacy of most macroeconomic policies; see Blinder (2000) for an excellent survey.

From Proposition 1(a), note that when the economy is liquidity trapped, monetary policy is completely ineffective in the good and the bad states, so $i_- = i_+ = 0$. Hence, the government must commit to using expensive fiscal policy in the two states, $f_- > 0$, $f_+ > 0$, in order to 'lean against the wind'. By contrast, when the economy is liquidity trapped in the bad state and not liquidity trapped in the good state (Proposition 1b) then $i_- = f_+ = 0$. In this case, the costly fiscal policy is not used outside a liquidity trap[27], while monetary policy is ineffective in a liquidity trap. When the economy is not liquidity trapped in either state (Proposition 1c) then there is no need at all to use the costly fiscal policy; monetary policy suffices in both states.

It might be useful to consider the optimal rational expectations solution in a special case to build more intuition. We formally define the special case.

Definition 1 : *(Special Case) In this special case, (1) $\alpha = \beta = 1$ and $\gamma = 2$ in the society's objective function (2.7), (2) $\varphi = \lambda = \mu = 1$ in the aggregate demand and supply curves (2.1), (2.2) and (3) the noise term ε takes two possible values $-a$, a with equal probability, so $\rho = 0$, $p = 1/2$, $s = 2a$, see section 2.2.*

We state the result of this special case in Corollary 1. The proof can be found in DaN.

Corollary 1 : *Consider the special case in Definition 1. The optimal state-contingent rational expectations precommitment solution is given in Table 3.2. The expected utility in*

	State of the world		
	$\varepsilon = -a < 0$	$\varepsilon = a > 0$	$\varepsilon^e = -0.5a + 0.5a = 0$
Interest rate	$i_- = 0$	$i_+ = 6a/5$	$i^e = 3a/5$
Fiscal policy	$f_- = 2a/5$	$f_+ = 0$	$f^e = a/5$
Output	$y_- = -a/5$	$y_+ = a/5$	$y^e = 0$
Inflation	$\pi_- = a/5$	$\pi_+ = 3a/5$	$\pi^e = 2a/5$
Real interest rate	$i_- - \pi^e = -2a/5$	$i_+ - \pi^e = 4a/5$	$i^e - \pi^e = a/5$

Figure 3.2: The Precommitment solution in a special case

the precommitment regime is given by $E\left[U_S^{Opt}\right] = -\frac{1}{5}a^2 - \frac{1}{2}\overline{y}$. Furthermore, $\left(\frac{\partial U_S}{\partial i}\right)_{Opt} < 0$ when $\epsilon = -a$ and $\left(\frac{\partial U_S}{\partial i}\right)_{Opt} = 0$ when $\epsilon = a$.

From Corollary 1, note that $\left(\frac{\partial U_S}{\partial i}\right)_{Opt} < 0$ when $\epsilon = -a$. Hence, the economy is always liquidity trapped when $\epsilon = -a$. In this case, monetary policy is not effective, $i_- = 0$.

[27] Recall that f refers only to the stabilization component of fiscal policy, hence, $f_+ = 0$ is consistent with a strictly positive level of government expenditure on other items such as redistribution etc.

Hence, the government must commit to using the expensive fiscal policy, $f_- = \frac{2}{5}a$, in order to 'lean against the wind'. By contrast, when $\epsilon = a$, monetary policy is effective, $i_+ = \frac{6}{5}a$, and the government has no need for the expensive fiscal instrument, $f_+ = 0$.

Also note that output is below the natural rate (which is normalized to zero) in the liquidity trap but above it otherwise. On average, it equals the natural rate (recall that y measures the deviation of output from the natural rate). Inflation is positive in both states of the world. The real interest rate is negative[28] in the liquidity trap but positive otherwise and on average.

Recall that in this special case, the shocks take the two possible values, $-a$ and a and $Var(\epsilon) = a^2$. On average, ceteris paribus., inflation, interest rates and the fiscal instrument of the government will display greater variability in economies where demand shocks have a greater variance and precommitment is possible. Furthermore, the magnitude of policy instruments employed in the two states of the world, $f_- = \frac{2}{5}a$ and $i_+ = \frac{6}{5}a$, are increasing in the size of the shock. This is not surprising as each of these policies fulfills a stabilization role and a larger shock elicits a greater effort in "leaning against the wind".

The solution is independent of $\overline{y}$, society's desired output relative to the natural rate. As in time consistency models, in the absence of the liquidity trap, this occurs, because, even if society has a high $\overline{y}$, the precommitment technology allows it to counter expectations of ex-post surprise inflation (designed to push output towards the high target).

The magnitude of social welfare in this regime depends negatively on the variance of shocks hitting the economy, a^2, and also on the output target of society, $\overline{y}$.

Finally, note that the values of i_+, i_-, f_+, f_- of the instruments are optimal *ex-ante*. However, after the realization of the shock, $\varepsilon = -a$ or $\varepsilon = a$, the *ex-post* optimal values of i, f will, in general, be different from these. Thus, for successful implementation, this optimal rational expectations solution needs a precommitment technology.

Our focus is on the implementation of the rational precommitment solution by appropriate institutional design. So, we shall not dwell too much on the comparative statics results.

4. Discretion

The full set of results under Discretion can be found in Appendix-B of Dhami and al-Nowaihi (2007). Denote by EU^{Disc}, the expected welfare level under discretion; we only make use of it in one place, in Section 5.3, below.

[28] We conjecture that the combination of rigid wages-prices and a flexible nominal interest rate has the effect that the real interest rate, $i - \pi^e$, overshoots so as to equilibrate the economy.

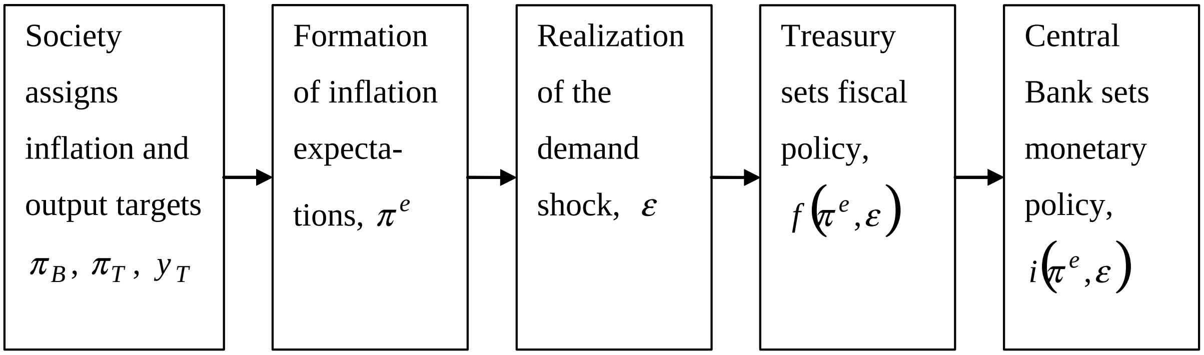

Figure 5.1: Sequence of moves in the optimal delegation regime

5. Institutions and Delegation

We now ask if the precommitment rational expectations solution can be implemented by an appropriate design of institutions. As outlined above, in Section 2.6, one could propose several plausible models of the Treasury's behavior. We now examine the possibility of implementation in each of these alternative models.

5.1. The Optimal Delegation Regime: The baseline model

The preferences of the Treasury in the baseline model are described in section 2.6.1, above. The Treasury's objective function is this case is given by

$$U_T = -\frac{1}{2}\alpha\left(\pi - \pi_T\right)^2 - \frac{1}{2}\beta\left(y - y_T\right)^2 - \frac{1}{2}\gamma f^2. \tag{5.1}$$

Note that the parameters α, β, γ are the same as in society's welfare function given in (2.7). We now consider the various subcases.

5.1.1. The inflation targets of the Treasury and the Central Bank are distinct

Denote the optimal inflation target of the Central Bank by π_B^* and the optimal output and inflation targets of the Treasury by y_T^* and π_T^* respectively.

Under optimal delegation, the game has five stages, shown in Figure 5.1. The Treasury acts as the Stackelberg leader with an output target, y_T, and an inflation target π_T. The Central Bank is the follower with an inflation target π_B. The Central Bank sets monetary policy, taking the fiscal policy, set by the Treasury, as given. The Treasury sets fiscal policy, taking into account the anticipated response of the Central Bank.

We solve the game backwards. First we obtain the Central Bank's reaction function $i = i\left(\pi_B, \pi^e, f, \varepsilon\right)$ by maximizing U_B, given in (2.9). Second, we find the Treasury's reaction function $f = f\left(y_T, \pi_T, \pi^e, \varepsilon\right)$ by maximizing U_T, given in (5.1). This allows us to derive output and inflation as functions of $y_T, \pi_T, \pi_{B,} \pi^e, \varepsilon$. Third, we determine π^e, assuming rational expectations on the part of the private sector. Fourth, we find the expected social welfare, EU_S, as a function of y_T, π_T, π_B, which we maximize to find the optimal values of $y_T, , \pi_T, \pi_B$ which are denoted by y_T^*, π_T^*, π_B^*.

We assume that, in this baseline case, the Treasury and the Central Bank adopt their respective optimal inflation targets, π_T^*, π_B^*, and that the Treasury fully complies with the optimal output target, y_T^*. Section 5.2, below, explores the possibility that the Treasury might not care for inflation and/ or be unwilling to follow the optimal output target, y_T^*, because it has its own output target, y_T. For ease of reference, these concepts are summarized in the following definition.

Definition 2 *: $\overline{y}$ is the output level preferred by society (0 is the inflation level preferred by society, see (2.7)). y_T and π_T are output and inflation targets for the Treasury. π_B is the inflation target for the Central Bank. y_T^*, π_T^* and π_B^* are the values of y_T, π_T and π_B that maximize expected social welfare, EU_S, subject to the constraints of the model, where U_S is given by (2.7). In section 5.2, below, we allow the Treasury to adopt an output target, y_T, different from y_T^*, consistent with its own agenda and also allow π_T to differ from π_B.*

Proposition 2, below, states the results under optimal delegation. As in Proposition 1, the magnitude of the demand shock in the previous period, x, gives rise to three subcases, although we are primarily interested in Case (b).

Proposition 2 *: **(a)** Under the condition of Proposition 1(a), give the Central Bank any inflation target, π_B^*, that satisfies $\pi_B^* > \gamma\left(\frac{\mu sp}{\beta\varphi^2\mu^2+\alpha\varphi^2+\gamma\mu^2} + \frac{\lambda\rho(-x)}{\alpha\varphi^2+\gamma\lambda^2}\right)$ and give the Treasury any output and inflation target pair (y_T, π_T) that satisfy*

$$y_T(\pi_T) = k - \frac{\alpha}{\beta\mu}\pi_T \tag{5.2}$$

where $k = \alpha\frac{(\lambda+\mu)\gamma\rho(-x)}{\beta\mu\left(\alpha\varphi^2+\lambda^2\gamma\right)}$. Then the solution under optimal delegation is the same as under precommitment, and given by Proposition 1(a).

***(b)** Under the conditions of Proposition 1(b), give the Central Bank the inflation target*

$$\pi_B^* = \frac{\gamma\left(\beta\mu^2\lambda + \alpha(\lambda+\mu)\right)\left(s(1-p) - \rho x\right)p}{\left(\alpha+\mu^2\beta\right)\left(\alpha\varphi^2+\gamma\lambda^2 p\right) + \gamma\mu^2\alpha(1-p)} > 0, \tag{5.3}$$

and give the Treasury any output and inflation target pair (y_T, π_T) that satisfies

$$y_T(\pi_T) = K - \frac{\alpha}{\beta\mu}\pi_T \tag{5.4}$$

where $K = \frac{\alpha\gamma p}{\mu\beta}\frac{(\lambda+\mu)\left(\alpha+\mu^2\beta\right)(\varepsilon(1-p)-\rho x)}{(\alpha+\beta\mu^2)\left(\alpha\varphi^2+\gamma\lambda^2 p\right)+\gamma\mu^2\alpha(1-p)}$, *is a constant that depends on the exogenous parameters of the model. Then the solution under optimal delegation is the same as under precommitment and is given by Proposition 1(b). Furthermore, in the good state, the Central Bank hits it's inflation target i.e.* $\pi_+ = \pi_B^*$.

(c) *Under the condition of Proposition 1(c), give the Central Bank the inflation target* $\pi_B^* = 0$. *Then, for any output and inflation target pair* (y_T, π_T) *for the Treasury, the solution under optimal delegation is the same as under commitment and is given by Proposition 1(c). Furthermore, the Central Bank hits it's inflation target in the good and the bad states i.e.* $\pi_+ = \pi_- = \pi_B^* = 0$.

If the economy is not liquidity trapped in any state of the world, then, we are in the standard textbook case where delegation to an independent Central Bank achieves the precommitment solution. Proposition 2(c) deals with this case.

Our main case of interest, however, is when the economy is liquidity trapped in the bad state only; this is stated in Proposition 2(b). Here, the inflation target of the Central Bank is uniquely determined while the Treasury's target pair y_T, π_T can be chosen from a *menu of contracts* that satisfy (5.4). To explain the indeterminacy of y_T and π_T, in (5.4), note that the Treasury has *two* targets, y_T and π_T, but just *one* instrument, f. Hence, the best it can hope for is to hit just one of these targets or, more generally, a linear combination of them. Maximizing society's expected welfare yields the optimal linear combination of y_T and π_T. This is given by (5.2) in the case of Proposition 2(a) and (5.4) in the case of Proposition 2(b). The negative slope signifies that a high output bias is needed to compensate a low inflation target for the Treasury.

So why does the optimal delegation regime perform so well? The inflation target given to the Central Bank provides a commitment to the necessary inflation level when the economy is not in a liquidity trap. This affects the (ex-ante) inflation expectations, which also apply to the (ex-post) liquidity trap, ensuring the correct value for the real interest rate in a liquidity trap. Furthermore, inflationary expectations are also influenced correctly by the output and inflation targets given to the Treasury that provide it with the incentive to use the appropriate level of fiscal policy in a liquidity trap. Such an institutional regime achieves the optimal balance between fiscal and monetary policy by neither having to rely too much on costly inflation outside the liquidity trap, nor relying too much on costly fiscal policy in a liquidity trap.

5.1.2. The inflation targets of the Treasury and the Central Bank are identical

What if instead of $\pi_T \neq \pi_B$, the inflation targets of the Treasury and the Central Bank are identical i.e. $\pi_T = \pi_B$? As we have hinted above, we find this to be the more natural

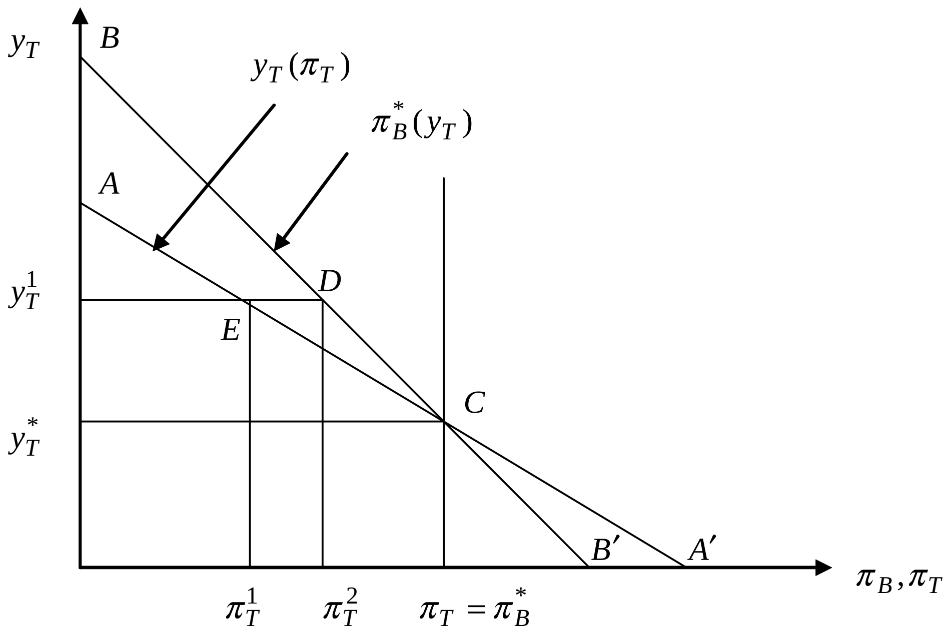

Figure 5.2: **Output and inflation targets under the optimal and suboptimal delegation regimes.**

of the two cases. Corollary 2 describes the results when the economy is liquidity trapped in the bad state only.

Corollary 2 : *Under the conditions of Proposition 1(b), if the Treasury is also given the same inflation target as the Central Bank i.e.* $\pi_T = \pi_B^*$*, and the optimal output target for the Treasury is*

$$y_T^* = \alpha\gamma p\mu^2 \frac{s(1-p) - \rho x}{(\alpha + \beta\mu^2)\left(\alpha\varphi^2 + \gamma\lambda^2 p\right) + \gamma\mu^2\alpha(1-p)} > 0. \tag{5.5}$$

then the Treasury attains this target in the good state i.e. $y_+ = y_T^*$*. Furthermore, the solution under optimal delegation is the same as under precommitment and is given by Proposition 1(b).*

In Figure 5.2, the downward sloping line AA' is a graph of $y_T(\pi_T)$ defined in (5.2) or (5.4). The vertical line positioned at π_B^* reflects the inflation target for the Central Bank given in (5.3). Ignore the downward sloping line BB' for the moment.

When the Treasury has baseline preferences, Proposition 2 and Corollary 2 show that the *optimal delegation regime* can achieve the *optimal precommitment solution* in the following two cases,

1. *The Treasury and the Central Bank can be given the same inflation target*
   Figure 5.2 shows that the optimal delegation solution is given by point C, where $\pi_B = \pi_T = \pi_B^*$ (given in (5.3)) and $y_T = y_T^*$ (given in (5.5)).

2. *The Treasury and the Central Bank are given distinct inflation targets*
   Figure 5.2 shows one possible menu of targets that achieves the optimal precommitment solution. The Central Bank is given the uniquely determined inflation target, i.e., $\pi_B = \pi_B^*$ (see (5.3)). The Treasury is given any output, inflation target along the line AA, for instance, corresponding to point E, i.e., $(y_T, \pi_T) = (y_T^1, \pi_T^1)$.

We also state, for future reference, the result in the special case when the conditions in Definition 1 hold and the inflation targets of the Treasury and the Central Bank are identical.

Proposition 3 *: Assume that the conditions in Definition 1 hold and the inflation targets of the Treasury and the Central Bank are identical. Monetary policy is delegated to an independent Central Bank with inflation target $\pi_B^* = \frac{3}{5}a$. Fiscal policy is retained by the Treasury with output target $y_T^* = \frac{1}{5}a$. The Treasury acts as the Stackelberg leader. Then, the optimal rational expectations (precommitment) solution (see Proposition 1) is achieved. Society's expected utility in the optimal delegation regime is given by $E\left[U_S^{OD}\right] = -\frac{1}{5}a^2 - \frac{1}{2}\overline{y}$. The economy is liquidity trapped only in the bad state. Inflation and output targets are achieved in the good state but not in the bad state.[29] It follows that in the optimal delegation regime, any menu of choices of (y_T, π_T) such that the following hold*

$$y_T\left(\pi_B^*\right) = \frac{7}{2}a - \frac{11}{2}\pi_B^* \tag{5.6}$$

achieve the optimal rational expectations solution.

(5.6) provides one example of what the expressions in (5.2), (5.4) look like, in the special case of Definition 1.

5.2. What happens if the Treasury does not have an inflation target?

Here we consider two alternative regimes. In both of these cases, the Central Bank is given an inflation target π_B, i.e., has the objective function given in (2.9) but the Treasury is not given an inflation target. We consider the two cases when the Treasury is an *output nutter* and a *reckless output nutter*, described in sections 2.6.2, 2.6.3. We find that these regimes are able to achieve the precommitment solution.

[29] As stressed by Eggertsson and Woodford (2003), failure to meet the inflation target in the liquidity trap does not signify failure of policy. A similar remark can be made with respect to the output target.

Proposition 4 : *Unless the economy is liquidity trapped in both states of the world, if the Treasury can be assigned an optimal output target y_T^* and the Central Bank is assigned an optimal inflation target, π_B^*, then the outcome in the "output nutter" and the "reckless output nutter" cases is identical to the precommitment regime.*

However, if the Treasury does not adopt the optimal output target, y_T^*, preferring instead to follow it's own agenda, captured in it's private output target, y_T, then the outcome can be very poor, and much worse than the outcome under discretion, as we shall see in section 5.3.

5.3. Suboptimal Delegation: Treasury follows its own agenda ($y_T \neq y_T^*$)

We now consider the case where the Treasury does not adopt the optimal output target as described in section 2.6.4 above. We call this regime '*suboptimal delegation*'. The output target y_T now represents the Treasury's own agenda and it refuses to accept the optimal output target, y_T^*, assigned to it by society. The objective function of the Treasury is given in (5.1). For pedagogical simplicity, we stick here to the more natural case where the inflation targets of the Treasury and the Central Bank are equal i.e. $\pi_B = \pi_T$.

Let $\pi_B^*(y_T)$ maximize society's expected welfare, given the output target, y_T, of the Treasury. The expression for $y_T(\pi_B^*)$ is too unwieldy, so consider the special case in Definition 1 as our motivation device, for the moment.[30] We know from Proposition 3, equation (5.6), that in this case, the menu of choices (y_T, π_T) satisfy

$$y_T(\pi_B^*) = \frac{7}{2}a - \frac{11}{2}\pi_B^*.$$

In Figure 5.2, the line BB' is a sketch of (the inverse of) $\pi_B^*(y_T)$. Any point on the line BB' gives the optimal inflation target for the Central Bank, $\pi_B^*(y_T)$, conditional on the Treasury's private, but not necessarily optimal, output target, y_T, which is steeper than the schedule $y_T(\pi_T)$ plotted as line AA'.

Suppose that the Treasury's output target is given by $y_T = y_T^1$. Then, at one possible suboptimal equilibrium $\pi_B = \pi_T = \pi_T^2$ while $y_T = y_T^1$ i.e. the Treasury's target pair is shown by the point D. Because point D is off the line AA, which plots the optimal menu of contracts for the Treasury, it is interesting to ask how well does the suboptimal delegation regime fare, relative to the optimal precommitment solution? Simulations, below, show that the performance of the *suboptimal delegation regime*, when the Treasury's baseline preferences are as in (5.1), is 'near optimal' and much better than *discretion*.

[30] Recall that this implies that $\alpha = \beta = \gamma = 1$; $\varphi = \lambda = \mu = 1$; $\rho = 0$, $p = 1/2$, $s = 2a$.

5.3.1. Simulation results

While we have considered the special case of Definition 1 to graphically motivate the problem above, here, we perform simulations for the completely general case. Denote the expected social welfare level under suboptimal delegation by EU_S^{SD}. The state contingent values of the policy variables in this case run into several pages, so we confine ourselves to reporting a representative sample of simulation results. Towards this end we define the following variables.

$q = EU_S^{Opt}/EU_S^{SD}$ is the expected welfare level under the optimal solution relative to the expected welfare under suboptimal delegation. Note that $0 < q \leq 1$ and $q = 1$ when $y_T = y_T^*$ (see Proposition 2).

$\omega = EU_S^{Disc}/EU_S^{SD}$ is the ratio of the expected welfare under discretion relative to that under suboptimal delegation. Note that $\omega > 0$ because the numerator and denominator are both negative.

$Q = \frac{EU_S^{SD} - EU_S^{Disc}}{EU_S^{Opt} - EU_S^{Disc}}$ is the ratio of the welfare loss under suboptimal delegation relative to that under the optimal solution when each is expressed as a difference from the expected welfare level under discretion. Hence, relative to the discretionary solution as a benchmark, this is the proportional loss to society in moving from the optimal solution to the suboptimal delegation solution. Note that $Q = 1$ for $y_T = y_T^*$ (see Proposition 2).

$o = \overline{y}/y_T^*$ is the output target of society relative to the optimal output target given to the Treasury.

$t = y_T/y_T^*$ is the output target of the Treasury relative to the optimal output target given to it.

The feasible set of parameters belongs to a ten dimensional set. We give below simulations for a representative sample of parameters in Tables 1, 2 below. Tables 4 through 6 in Appendix-C of Dhami and al-Nowaihi (2007) give further simulation results to support our assertions. To simplify results, we focus on cases where the output targets of the Treasury and society coincide i.e. $y_T = \overline{y}$ (and so $o = t$) and the inflation targets of the Treasury and the Central Bank also coincide i.e. $\pi_T = \pi_B$.

The main results of the simulations can be summarized as follows.

Proposition 5 *: Even if the private agenda of the Treasury, i.e. y_T, is substantially different from the optimal output target, y_T^*, the expected welfare level under the suboptimal delegation solution is very close to the optimal precommitment solution i.e. q is very close to 1. Suppose that we start with the minimal institutional framework of the discretionary regime. Then, moving to the institutional regime of suboptimal delegation recovers, for all parameter values that we have investigated, a very large percentage of the benefit that might accrue if one could move to the optimal solution, i.e., Q is typically very close to* 1.

Table 1: $p = \frac{1}{2}, y_T = \overline{y} = s, x = 0$

α	φ	λ	β	γ	μ	q	ω	Q	$o = t$	$\pi_B^*(y_T)$
$\frac{10}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	0.999 9	1.007	0.9844	404.4	$0.045s$
$\frac{10}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{10}{10}$	0.993 6	1.039	0.858 9	6.422	$0.146s$
$\frac{10}{10}$	$\frac{10}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	0.999 9	1.270	0.999 5	602.6	$0.178s$
$\frac{10}{10}$	$\frac{10}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{10}{10}$	0.992 1	1.451	0.982 8	8.6	$0.216s$
$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	0.9989	1.067	0.984 4	44.42	$0.406s$
$\frac{10}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	1.000 0	3.931	1.000 0	8.006	$2.497s$
$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{10}{10}$	0.999 9	1.006	0.985 1	2.048	$0.585\,s$
$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{10}{10}$	0.987 3	1.039	0.752 1	2.84	$0.371s$

In Table 1, the economy is liquidity trapped in the bad state only. Even if the output target of the Treasury is up to 602.2 times higher than the optimal output target (i.e. $o = t = 602.2$), q and Q are still very close to 1. Tables 4-6, in Dhami and al-Nowaihi (2007), confirm these results for other parameter values. In Table 2, below, constructed under the conditions of Proposition 2(a), the economy is liquidity trapped in both states and there is a very high level of persistence in the demand shocks.

Table 2: $p = \frac{1}{50}, y_T = \overline{y} = ps, x = -(1-p)s, \rho = \frac{9}{10}$

p	α	φ	λ	β	γ	μ	ω	π_B^*
$\frac{1}{50}$	$\frac{10}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	1.039 7	$0.174\,45s$
$\frac{1}{50}$	$\frac{10}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{10}{10}$	2.468 0	$0.958\,59s$
$\frac{1}{50}$	$\frac{10}{10}$	$\frac{10}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	2.421 5	$0.484\,9s$
$\frac{1}{50}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	1.480 5	$1.601\,6s$

From Table 2, the social loss in the discretionary regime is, in some cases, twice that under suboptimal delegation.

Table 3 gives a sample of results for the "output nutter" case, when the Treasury does not follow the output target, y_T^*, assigned to it by society. Unlike the suboptimal delegation case discussed above, the outcome here can be very bad, even worse than discretion.

Table 3: Treasury is an "output nutter" $\left(p = \frac{1}{50}, y_T = \overline{y} = s \neq y_T^*, x = 0\right)$

p	φ	λ	β	γ	μ	q	Q
$\frac{1}{50}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	.08 584 9	−33829
$\frac{1}{50}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	0.957 78	0.382 82
$\frac{1}{50}$	$\frac{10}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	0.202 25	−3821.0
$\frac{1}{50}$	$\frac{10}{10}$	$\frac{10}{10}$	$\frac{1}{10}$	$\frac{10}{10}$	$\frac{10}{10}$	0.959 11	0.280 7

In this case, Q can take extreme negative values i.e. the output nutter regime turns out to be much worse than discretion; we summarize this result in the Proposition below.

Proposition 6 *: If the Treasury is not assigned the optimal output target, y_T^*, then the performance of the "output nutter" and the "reckless output nutter" regimes can be very adverse and, possibly, much worse than the discretionary regime. In particular, if monetary policy is delegated to an independent central bank, with an optimal inflation target, while the Treasury retains discretion over fiscal policy, then the outcome can be poor and much worse than had the Treasury retained discretion over both monetary and fiscal policy.*

Proposition 6 indicates the serious consequences that can arise if the Treasury/government does not have the appropriate inflation or output targets even if it follows society's most preferred output target (note $y_T = \overline{y}$ in Table 3).

5.4. Summary

Proposition 2 and Corollary 2 establish that the *optimal delegation regime* (where the Bank has an optimal inflation target and the Treasury has optimal output and inflation targets) achieves the precommitment solution for all parameter values. Proposition 5 shows that performance of the *suboptimal delegation regime* (similar to the *optimal delegation regime*, except that the Treasury has its own output target) is near optimal, and much better than *discretion*, even when the Treasury deviates considerably from the optimal output target. Proposition 4 establishes that the *output nutter* and the *reckless output nutter* regimes (in both cases, the Bank and Treasury are given optimal inflation and output targets, respectively, but the Treasury is not given an inflation target) also achieve the precommitment solution. However, Proposition 6 shows that the latter two regimes, unlike the *suboptimal delegation* regime, perform poorly, and can be much worse than *discretion*, if the Treasury deviates from the optimal output target.

Thus, although giving the Treasury an inflation target as well as an output target is not necessary for optimality, it is necessary to achieve robustness. In particular, a hybrid system, where monetary policy is delegated to an independent central bank with an inflation target, but where the Treasury retains discretion over fiscal policy, can perform poorly and much worse than had the Treasury retained discretion over both monetary and fiscal policy.

6. Conclusions

The role of fiscal policy in theoretical models of the liquidity trap has not been adequately stressed despite this being Keynes's (1936) original solution to the problem. This is puzzling in light of the empirical evidence from Posen (1998), Kuttner and Posen (2001) which suggests that fiscal policy, when used in Japan, has been potent. The simulation exercises of Ball (2005) show that fiscal transfers equal to 6.6 percent of GDP could have ended

Japan's output slump. There have been other suggestions in the literature, without a full theoretical model, that advocate fiscal policy in a liquidity trap. Bernanke (2002) recommends a broad based tax cut while Gertler (2003) recommends transitory fiscal policy. We consider fiscal policy and monetary policy, explicitly, in a Dixit and Lambertini (2003) framework when there is the possibility of a liquidity trap.

The theoretical literature has considered aspects of our *optimal delegation regime*, that achieves the precommitment solution. For instance, inflation targets have been suggested in Krugman (1998), Nishiyama (2003), and Iwamura et al. (2005). Other variants of monetary policy commitment have also been considered. Benhabib Schmitt-Grohe and Uribe (2002) consider a commitment to switch from an interest rate rule to a money growth rate peg in a liquidity trap. Eggertsson and Woodford (2003) propose a commitment to adjust nominal interest rates to achieve a time varying price level target. Bernanke (2002) suggests a commitment to a buffer zone for the inflation rate. Svensson (2003) advocates a price level target (as part of a larger set of policies). However, none of these models allow for the possibility of strategic interaction between monetary and fiscal authorities nor jointly derive the optimal set of targets and instruments of the two policy making authorities.

Eggertsson (2006a, 2006b) studies the liquidity trap within a new Keynesian stochastic general equilibrium model with a government budget constraint and explicit microfoundations. Eggertsson recommends abandonment of an independent central bank and a return to discretionary policy by a unitary monetary-fiscal authority. A debt financed fiscal expansion during a liquidity trap results, via the government budget constraint, in higher expectations of future inflation. Eggertsson shows that this solution is superior to either monetary policy alone or uncoordinated monetary and fiscal policy. However, as Eggertsson shows, even optimal discretion is inferior to the fully optimal rational expectations solution with commitment. Moreover, abandoning delegation of monetary policy to an independent central bank with a narrow mandate, in favor of a return to discretion, appears to be a retrograde step.

Dixit and Lambertini (2003) and Lambertini and Rovelli (2003) consider strategic interaction between fiscal and monetary authorities, but in the absence of a liquidity trap. Lambertini and Rovelli (2003) show that the equilibrium with the fiscal authority acting as leader is superior to the Nash equilibrium. Dixit and Lambertini (2003) show that this regime can achieve the optimal precommitment rational expectations solution.

One of the important lessons of our paper is that an optimally derived target for one policy maker that ignores the incentives and constraints facing the other policy maker can lead to extremely poor outcomes; see Proposition 6. The intuition is that if there were no liquidity trap, and the Treasury had its own agenda[31], then it would undermine the Central Bank's monetary commitment. However, appropriate delegation of policy to the Treasury, far from undermining monetary commitment, gives it an incentive to engage in an 'appropriate' fiscal stimulus in a liquidity trap, where the independent Central Bank is ineffective. This is in line with the case when there is no liquidity trap considered by Dixit and Lambertini (2003, p1523, point 4): "Commitment achieves the second best only if it can be extended to both monetary and fiscal policy".

Furthermore, the *optimal delegation regime* achieves the optimal mix between monetary and fiscal policy as we now explain. Theoretically, society could give a sufficiently high inflation target to the Central Bank which in turn generates sufficiently high inflation expectations so that the nominal interest rate never hits its zero floor. While this policy would always avoid the liquidity trap, it is not optimal because inflation is costly. Analogously it is not optimal to give the Treasury too high an output target because if a liquidity trap occurs, it would use the costly fiscal policy excessively. The optimal solution then is to have a mix of both i.e. some inflation outside a liquidity trap and some dependence on costly fiscal policy in a liquidity trap.

References

[1] Alesina, A. and Tabellini, G. (1987) "Rules and discretion with non-coordinated monetary and fiscal policies" Economic Inquiry : 619-630.

[2] Auerbach, A.J. and Obstfeld, Maurice (2005) "The case for open market operations in a liquidity trap" American Economic Review, 2005, 95: 110-137

[3] Ball, L. (2005) "Fiscal remedies for Japan's slump", NBER Working Paper 11374.

[4] Benhabib, J. Schmitt-Grohe, S. and Uribe, M. (2002) "Avoiding liquidity traps", Journal of Political Economy, 110:535-563.

[5] Bernanke, Ben S. (2002) "Deflation: Making sure that it does not happen here" speech on November 21, Federal Reserve Board.

[6] Blanchard, O., Dell'Ariccia, G., and Mauro, P. (2010) Rethinking macroeconomic policy, IMF Staff Position Note, SPN/10/03.

[7] Blinder, A. (2000) "Monetary policy at the zero lower bound: Balancing the risks" Journal of Money Credit and Banking, 32: 1093-99.

[31] In Dixit and Lambertini (2003) the Treasury never has its own agenda and fully internalizes society's social welfare function.

[8] Buiter, W. H. and Panigirtzoglou, N. (2003) Overcoming the zero bound on nominal interest rates with negative interest on currency: Gesell's solution" The Economic Journal, 113: 723–746.

[9] Clouse, J., Henderson, D., Orphanides, A., Small, D., and Tinsley, P. (2003) "Monetary policy when the nominal short term interest rate is zero," Topics in Macroeconomics, www.bepress.com.

[10] Dhami, S. and al-Nowaihi (2011) Strategic Monetary and Fiscal Policy Interaction and Optimal Institutional Design when there is the Possibility of a Zero Lower Bound on Interest rate, forthcoming in Oxford Economic Papers.

[11] Dhami, S. and al-Nowaihi, A. (2007) "Alice through the looking glass: Strategic monetary and fiscal interaction in a liquidity trap" University of Leicester Discussion Paper in Economics 07/15.

[12] Dixit, A. and Lambertini, L. (2003) "Interactions of commitment and discretion in monetary and fiscal policies" American Economic Review, 93: 1522-1542.

[13] Dixit, A. and Lambertini, L. (2000) "Fiscal discretion destroys monetary commitment" mimeo., Princeton University.

[14] Eggertsson, G. (2006a) "The deflationary bias and committing to being irresponsible" Journal of Money, Credit and Banking, Vol. 38. No. 2.

[15] Eggertsson, G. (2006b) "Fiscal multipliers and policy coordination" Federal Reserve Bank of New York, Staff Report no. 241.

[16] Eggertsson, G. and Woodford, M. (2003) "The zero bound on interest rates and optimal monetary policy" Brookings Papers On Economic Activity, 1: 139-211.

[17] Gali, J. and Gertler, M. (1999) "Inflation dynamics: A structural econometric analysis," Journal of Monetary Economics, 44: 195-222.

[18] Gertler, M. (2003) "Comments on: The zero lower bound on interest rates and optimal monetary policy" Paper prepared for the Brookings Panel on Economic Activity, 1:219-227.

[19] Iwamura, M., Kudo, T. and Watanabe, T. (2005) "Monetary and fiscal policy in a liquidity trap: The Japanese experience 1999-2004", NBER Working Paper No. W11151. Available at SSRN: http://ssrn.com/abstract=669450.

[20] Keynes, M (1936) The general theory of employment, interest and money (Macmillan: London)

[21] Krugman, P. (1999) “Thinking about the liquidity trap”, mimeo., http://web.mit.edu/Krugman/www/trioshrt.html.

[22] Krugman, P. (1998) “Its baaack! Japan’s slump and the return of the liquidity trap” Brookings Papers on Economic Activity, 2: 137-187.

[23] Kuttner, K. N. and Posen, A. (2001). The Great Recession: Lessons for Macroeconomic Policy from Japan," Brookings Papers on Economic Activity, 2001: 93-185.

[24] Lambertini, L. and Rovelli, R. (2003) “Monetary and fiscal policy coordination and macroeconomic stabilization: A theoretical analysis” Available at SSRN: http://ssrn.com/abstract=380322 or DOI: 10.2139/ssrn.380322.

[25] Mankiw, N. G. (2001) “The Inexorable And Mysterious Trade-off Between Inflation And Unemployment,” Economic Journal, 111:45-61.

[26] McCallum, Bennett T. (2000) “Theoretical analysis regarding a zero lower bound on nominal interest rates” Journal of Money Credit and Banking, 32: 870-904.

[27] Nishiyama, Shin-Ichi (2003) “Inflation target as a buffer against liquidity trap” Institute for Monetary and Economic Studies, Discussion Paper No. 2003-E-8.

[28] Orphanides, A. and Wieland, V. (2002) “Efficient monetary policy design near price stability” Journal of the Japanese and International Economies, 14: 327-365.

[29] Rogoff, K. (1985) “The optimal commitment to an intermediate monetary target” Quarterly Journal of Economics, 100(4), 1169-1189.

[30] Romer, D. (2006) “Advanced Macroeconomics” 3rd edition, McGraw-Hill/Irwin.

[31] Rotemberg and Woodford (1999) “Interest rate rules in an estimated sticky price model” in Monetary Policy Rules. in John B. Taylor, ed., Monetary Policy Rules, University of Chicago Press, 57-126.

[32] Ruud, J. and Whelan, K. (2006) “Can rational expectations sticky-price models explain inflation dynamics?” American Economic Review, 96: 303-320.

[33] Posen, A. S. (1998) Restoring Japan’s Economic Growth, Institute for International Economics, Washington DC.

[34] Sims, C.A. (2003) "Implications of rational inattention" Journal of Monetary Economics, 50, 665-690.

[35] Svensson, Lars E. O. (2003) "Escaping from a liquidity trap and deflation: The foolproof way and others", Journal of Economic Perspectives, 17: 145-166.

[36] Walsh, C.E. (2003) "Monetary Theory and Policy' 2nd edition, The MIT Press.

[37] Woodford, M. (2005) "Central bank communication and policy effectiveness" Presented at the Federal Reserve Bank of Kansas City Symposium, "The Greenspan Era: Lessons for the Future" Jackson Hole, Wyoming, 25-27 August 2005.