Nominal Targeting in an Economy with Government Debt*

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Abstract

The fiscal policy environment central banks operate in can be radically different with respect to debt levels, maturity structures and whether or not fiscal adjustments are spending- or tax-based. Despite this, most analyses of monetary policy delegation schemes typically ignore the behavior of the fiscal policy maker. This paper investigates whether delegating either nominal income or price level targets to a monetary authority yields social gains in an economy with government debt, where the fiscal policymaker, acting strategically, may support or undermine the policies of the central bank. We argue that the fiscal environment plays an important role in determining the performance of monetary policy. The gains to price level targeting typically found in the literature can be overturned at empirically relevant debt-to-GDP ratios, when debt stabilization is achieved through spending cuts. In contrast these gains are retained if the fiscal authorities utilize taxes to respond to shocks and stabilize debt.

Key Words: Monetary and Fiscal Policy Interactions, Price Level Targeting, Nominal Income Targeting, Discretionary Policy

JEL References: E31, E52, E58, E61, C61

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1 Introduction

Advanced economies differ considerably with regard to their sovereign debt levels and the maturity of that debt. In 2015, for example, government net debt was about 25 percent of GDP in Switzerland but 113.5 percent in Italy. The average term to maturity of Sweden's public debt was five years, whereas that of the UK was 14.5 years (Source: IMF, 2016). Sims (2013) has stressed that the effectiveness of monetary policy is influenced by fiscal policy, and that both the level and maturity of debt play a key role in determining inflation. Nevertheless, the literature concerned with optimal delegation of monetary policy largely abstracts from such differences in the fiscal position. The current paper argues that the fiscal position should be considered a central determinant of an optimal monetary delegation scheme. Countries operating within different fiscal environments may require different forms of monetary delegation.

This paper builds a New Keynesian business cycle model augmented with fiscal policy, that is subject to both inflationary cost-push shocks and technology shocks. In the standard New Keynesian model without a meaningful fiscal policy, optimal monetary policy under commitment – i.e. time-inconsistent policy where the policy maker is known to keep policy promises – possesses two important properties. First, it produces the lowest possible welfare loss, thanks to the policy maker's ability to manipulate the expectations of the private sector through the policy commitments it makes. Second, following a shock, it manipulates expectations in this beneficial way by committing to stabilize not only inflation, but also the price level itself. Instead, a benevolent central bank which is unable to precommit to such a plan and which has to act in a sequential and time consistent manner, known as discretionary policy, creates an additional loss: a welfare-reducing 'stabilization bias', see Currie and Levine (1993) and Svensson (1997). Two prominent proposals to improve welfare outcomes under discretion are to give the central bank a mandate for price level targeting (Vestin, 2006) or nominal GDP targeting (Jensen and McCallum, 2002). The rationale is that such mandates would lead the discretionary central bank to act in a way that induces a history dependence to policy making, through the adoption of price level control, which is similar to the one arising under commitment. The current paper examines the effectiveness of these two targeting regimes, albeit in the context of a richer fiscal environment.

Specifically, we assume that fiscal policy has to finance welfare-relevant government consumption and government debt through distortionary income taxes. Assuming that fiscal policy, as well as monetary policy, acts under discretion and is bound by existing debt levels and a given debt maturity structure, we ask what the welfare gains would be from providing the monetary authority with either a price level or nominal GDP target. We find that the answer to this question depends crucially on whether the fiscal policy maker can adjust taxes, or has to adjust spending to pay the debt. When the fiscal authority has access to taxation, both delegation schemes perform well, while when the only available fiscal instrument is government spending the effectiveness of each delegation scheme depends, differently in each case, on the level and maturity of government debt. It is, in fact, possible, when fiscal adjustment is conducted solely through government spending, for the delegation scheme to worsen outcomes relative to discretion, even though such nominal targets have been shown to dramatically improve welfare outcomes in the context of monetary economies.

The reason for this is as follows. In an economy with meaningful fiscal policy and with access to taxation as an instrument (in combination with the monetary instrument), the joint monetary and fiscal policy under commitment can deal effectively with both technology and cost-push shocks without generating significant unwanted inflation. As a result, although the optimal commitment policy does not perfectly control the price level, the extent of price level drift is small. Under discretion, the presence of nominal government debt gives rise to a substantial 'debt stabilization bias', which depends upon both the level and maturity of government debt (Leeper and Leith, 2016) as policy makers face the temptation to inflate away any shock-induced fluctuations in debt. Economic agents anticipate this and inflation expectations (and inflation itself) rise until the temptation is removed. This implies a far larger amount of price level drift under discretion. Delegating a nominal income or, more effectively, price-level target to the monetary authority, can improve on this significantly, with welfare gains amounting, under our calibration, to around 0.53% of steady-state consumption that the consumer would be willing to give up to move from the actual regime to the steady-state allocation in the case of a relatively high debt economy like Italy.

In contrast, without access to taxation as a fiscal instrument the policy makers' ability to stabilize the economy in the face of cost-push shocks under commitment is more limited. Therefore, under the optimal commitment policy there is far less price level control, particularly in the short run, as surprise inflation becomes a useful tool in stabilizing debt. The corresponding incremental welfare loss under discretion is smaller, but the two forms of nominal target can actually make outcomes worse. Essentially, the discipline imposed by price level control can be counter-productive since the first-best policy under commitment features a non-trivial degree of price level drift. For example, with high debt levels a price level target can undermine the use of a short burst of surprise inflation which would otherwise facilitate the stabilization of debt following a shock. Therefore, the welfare loss in Italy, for example, would increase by 0.16% of steady-state consumption, although it would be improved by 0.16% in a low debt economy like Sweden if these countries were to adopt a price-level target. At the same time, a nominal income target moderates the initial movements in bond prices when debt is of longer maturity, thereby reducing the policy makers' ability to reduce the initial impact of the shock on debt and forcing them to rely on costly changes in government spending to stabilize debt in the longer-term. This gives rise to a welfare gain of between 0.03%-0.06% of steady-state consumption across all economies in our sample of 11 representative advanced economies.

The fact that our results depend on the choice of fiscal instrument is of practical relevance, since Alesina and Ardagna (2010) find that the composition of fiscal consolidation packages varies over time and across economies with major consolidations in OECD economies between 1970 and 2007 being three times as likely to be tax, rather than spending, based. However, the IMF (2012) suggest, more recently, that the nine major fiscal consolidations being implemented at the time were all predominately spending based, as policy makers no longer appear able to implement significant tax increases. The results in the current paper suggest this may have negative welfare consequences.

While rich in some dimensions, our analysis deliberately abstracts from analyzing the transmission mechanism of monetary and fiscal policy in the presence of the zero lower bound (ZLB), debt management policies, and the transition from one steady-state debt level to another. Instead, we take a range of combinations of debt level and maturity as given, and ask how the impact such changes in the fiscal environment have on the policy transmission mechanism affects the desirability of alternative monetary policy delegation schemes.

The paper is organized as follows. Next, we review the related literature, which further pinpoints the contribution of this paper. In the following section we outline the model. Section 3 defines all policy scenarios of interest and Section 4 describes the calibration. Section 5 presents the analysis of all cases we consider, for each of the fiscal instruments. In Section 6 we apply our results to a representative sample of 11 advanced economies. Section 7 concludes.

Related Literature. Despite the potential welfare gains from commitment, there is little evidence either from formal econometric estimation of policy making behavior (Chen, Kirsanova, and Leith (2013b) and Chen, Kirsanova, and Leith (2013a)), or from policy discussions emanating from central banks, that policy making is conducted under commitment, particularly when such policies imply a deliberate offsetting deviation from an inflation target following shocks. In light of this, there have been calls to adopt alternative monetary policy delegation schemes as an alternative means of reducing the welfare loss under discretion with particular emphasis on price-level targeting (Vestin, 2006) and nominal income growth targeting (Jensen and McCallum, 2002). These calls have been given renewed vigor in the light of the recent financial crisis and the attendant difficulties of implementing monetary policy when interest rates are constrained by the zero lower bound (ZLB). For example Eggertsson and Woodford (2003) and Woodford (2012) advocate a policy of nominal income targeting as a way of influencing inflation expectations such that the economy would be lifted off of the ZLB. However, such analyses take place in models where there is an absence of meaningful monetary and fiscal policy interactions.

In New Keynesian models which do consider monetary and fiscal policy interactions the results are striking. The optimal Ramsey policy implies a random walk in steady-state debt following shocks (see, for example, Benigno and Woodford (2003), and Schmitt-Grohe and Uribe (2007)). In an application of Barro's (1979) tax smoothing result, a shock with negative fiscal consequences results in an adjustment of fiscal variables to sustain the higher level of debt that emerges, but there is no attempt to return debt to its pre-shock level. This is due to the fact that the optimal policy precisely balances the short-run costs of fiscal adjustment in a sticky-price model against the long-run gains of a lower steady state level of debt. Unlike the standard New Keynesian model without fiscal policy, this policy will not imply perfect control of the price level following shocks, as there is some use of surprise inflation to stabilize debt (see Sims (2013), and Leeper and Leith (2016)).[1] Since the delegation schemes we explore in this paper re-instate price level control, the desirability of adopting such schemes will, in turn, hinge on the extent to which optimal policy would deviate from price level control which will depend on the size and maturity structure of the debt stock and on the nature of the shocks and available fiscal instruments.

When the policy maker cannot commit to behave in this way, the resultant time-consistent policy is radically different. Leith and Wren-Lewis (2013) show that the debt stock will be returned to its steady state value following shocks. The commitment policy is inherently time-inconsistent as the policy maker commits to raise taxes and/or reduce spending to service a permanently higher debt stock. In doing so the policy maker faces a temptation to induce inflation surprises to reduce debt and its associated fiscal costs. In the absence of an ability to commit, economic agents anticipate this temptation, raising expectations of (and actual) inflation. The policy maker can only avoid this endogenous inflationary bias problem by returning debt to steady-

[1] The surprise inflation has a twofold benefit for fiscal stabilization through a direct impact on the real value of debt, as well as expanding the tax base.

state. The discretionary policy mix employed to achieve this depends crucially on the level of debt. At low debt levels, fiscal instruments are typically employed to stabilize debt and monetary policy behaves as usual in controlling aggregate demand to stabilize inflation, while at higher levels of debt, the implicit policy assignment is reversed and monetary policy acts to stabilize debt (through monetary policy's impact on debt service costs and the tax base), while distortionary taxes are adjusted to moderate the higher inflation such monetary accommodation would otherwise imply. However much of this analysis assumes government debt is of one quarter's maturity. Leeper and Leith (2016) and Leeper, Leith, and Liu (2016) show that the interactions between monetary and fiscal policy also depend crucially on the maturity structure of the outstanding stock of government debt. Given that the presence of government debt and its maturity can have such a significant impact on the conduct of monetary policy when the two policy makers are acting cooperatively, but are unable to commit it is important to ask, as we do in this paper, (i) how fiscal policy influences the conduct of an independent central bank when the two policy makers interact strategically rather than cooperatively, and (ii) how such interactions affect the design of monetary policy delegation schemes which hope to achieve outcomes closer to those obtained under commitment.

2 The Model

We consider the now-mainstream New Keynesian policy model modified to take account of the effects of fiscal policy, see, for example, Woodford (2003) and Benigno and Woodford (2003). It is a closed economy model with two policy makers, the fiscal and monetary authorities. Fiscal policy is assumed to support monetary policy in the stabilization of the economy around the non-stochastic steady state. The policy makers may act cooperatively or non-cooperatively.

2.1 Consumers

The economy is populated by a unit-continuum of infinitely-lived households. The representative consumer maximizes the following objective function

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} + \varpi \frac{G_t^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \delta \frac{N_t^{1+\frac{1}{\psi}}}{1+\frac{1}{\psi}} \right), \tag{1}$$

where C_t, G_t and N_t are a consumption aggregate, a public goods aggregate and labor supply, respectively.[2] Goods are combined via a Dixit and Stiglitz (1977) technology to produce

[2] We focus on cashless limit following Woodford (1998).

aggregate level variables. Private and public consumption goods aggregates are defined as $C_t = \left(\int_0^1 C_t^{\frac{\epsilon_t - 1}{\epsilon_t}}(z)dz\right)^{\frac{\epsilon_t}{\epsilon_t - 1}}$ and $G_t = \left(\int_0^1 G_t^{\frac{\epsilon_t - 1}{\epsilon_t}}(z)dz\right)^{\frac{\epsilon_t}{\epsilon_t - 1}}$ with an elasticity of substitution between goods of different varieties, $C_t(j)$ and $G_t(j)$ given by stationary stochastic process ϵ_t with support $(0, \infty)$ and mean $\epsilon > 1$. The time variation in the elasticity of substitution will translate into time variation in the mark-up, a cost-push shock. Parameter $\psi \geqslant 0$ measures the Frisch elasticity of labor supply, σ is the intertemporal elasticity of substitution, $\beta \in (0, 1)$ is the households' discount factor, $\delta > 0$ and $\varpi > 0$ are preference parameters.

Optimization of expenditure across individual goods implies the households' demand function for a differentiated good z, $C_t(z) = \left(\frac{p_t(z)}{P_t}\right)^{-\epsilon_t} C_t$ with an associated aggregate price level of $P_t = \left(\int_0^1 p_t^{1-\epsilon_t}(z)dz\right)^{\frac{1}{1-\epsilon_t}}$.

The budget constraint at time t is given by:

$$P_t C_t + P_t^S B_t^S + P_t^M B_t^M \leq B_{t-1}^S + \left(1 + \rho P_t^M\right) B_{t-1}^M + (1 - \Upsilon_t)(W_t N_t + \Psi_t) - T_t,$$

where $P_t C_t = \int_0^1 p_t(z) C_t(z) dz$ is nominal consumption, W_t the nominal wage rate, T_t are lump-sum taxes, Υ_t is a tax on nominal income. The household's period-t income includes: wage income from providing labor services to goods producing firms, $W_t N_t$, profits from monopolistically competitive firms $\Psi_t = \int_0^1 \Psi t(z) dz$, both of which are taxed at rate Υ_t, and payments on the portfolio of assets B_t^S and B_t^M. The household also pays a lump sum tax, T_t, which is used to finance a steady-state production subsidy.[3]

Households hold two forms of government bond. The first is one-period debt, B_t^S, which has a price equal to the inverse of the gross nominal interest rate, $P_t^S = \frac{1}{1+i_t}$. The second type of bond is actually a portfolio of many bonds which, following Woodford (2001) pay a declining coupon of ρ^j, $j+1$ periods after being issued, where $0 < \rho < \beta^{-1}$. The duration of the bond is $\frac{1}{1-\beta\rho}$, which means that ρ can be varied to capture changes in the maturity structure of debt. We only need to price a single one of these longer-term maturity bonds, since any existing bond issued j periods ago is worth ρ^j of new bonds.[4]

Household wealth in period t can be written as

$$D_t = \left(1 + \rho P_t^M\right) B_{t-1}^M + B_{t-1}^S$$

[3]These lump sum taxes are not available for stabilization purposes as re-introducing Ricardian Equivalence would render the policy problem trivial - see Section 5.1 for a discussion.

[4]See also Leeper and Leith (2016).

and we require the following transversality condition to hold

$$\lim_{T\to\infty} \mathbb{E}_t \frac{1}{R_{t,T}} \frac{D_T}{P_T} = 0$$

where $R_{t,T} = \prod_{s=t}^{T-1} \left(\frac{(1+\rho P_{s+1}^M)}{P_s^M} \frac{P_s}{P_{s+1}} \right)$ for $T > 1$ and $R_{t,t} = 1$.

The resultant optimization yields a labor supply condition

$$\frac{W_t}{P_t} = \frac{\delta N_t^{\frac{1}{\psi}}}{(1-\tau_t) C_t^{-\frac{1}{\sigma}}}, \tag{2}$$

the consumption Euler equation

$$\frac{1}{1+i_t} = \beta \mathbb{E}_t \frac{C_{t+1}^{-\frac{1}{\sigma}}}{\Pi_{t+1} C_t^{-\frac{1}{\sigma}}}, \tag{3}$$

and bond pricing equation

$$P_t^M = \beta \mathbb{E}_t \frac{C_{t+1}^{-\frac{1}{\sigma}}}{\Pi_{t+1} C_t^{-\frac{1}{\sigma}}} \left(1 + \rho P_{t+1}^M\right), \tag{4}$$

where we define gross inflation as $\Pi_t \equiv \frac{P_t}{P_{t-1}}$.

2.2 Firms

Firms set their prices subject to a Calvo (1983) price rigidity. The firm's optimization problem is standard[5]: a firm i chooses prices to maximize profits

$$\mathbb{E}_t \sum_{s=t}^{\infty} Q_{t,s} \left(Y_s(i)\, p_s(i) - \frac{1}{\mu^w} W_s N_s(i) \right),$$

where $Q_{t,s} = \beta^{s-t} \left(\frac{C_s}{C_t}\right)^{-1/\sigma} \frac{P_t}{P_s}$ is the household's stochastic discount factor and μ^w a time-invariant employment subsidy which can be used to eliminate the steady-state distortion associated with monopolistic competition and distortionary income taxes. The firm faces three constraints when choosing prices: (i) the available production technology

$$Y_t(i) = Z_t N_t(i),$$

[5]See Appendix A for more details. Here and elsewhere we refer to the Online Appendix.

where Z_t is an exogenous stochastic technology process, (ii) a downward sloping demand curve implied by individual goods being imperfect substitutes in consumption,

$$Y_t(i) = Y_t \left(\frac{p_t(i)}{P_t} \right)^{-\epsilon_t},$$

where $Y_t = \left(\int_0^1 Y_t^{\frac{\epsilon_t - 1}{\epsilon_t}}(i) di \right)^{\frac{\epsilon_t}{\epsilon_t - 1}}$, and (iii) the fact that in any period the firm is only able to change prices with probability $1 - \alpha$.

Profit maximization implies the following first order conditions to determine $p_t(i)$:

$$\begin{aligned} 0 &= \mathbb{E}_t \sum_{s=t}^{\infty} (\alpha\beta)^{s-t} Y_s \left((\epsilon_s - 1) C_s^{-\frac{1}{\sigma}} \left(\frac{p_t(i)}{P_s} \right)^{1-\epsilon_s} \right. \\ &\quad \left. - \frac{\delta \epsilon_s}{\mu^w Z_s (1 - \Upsilon_s)} \left(\frac{Y_s}{Z_s} \right)^{\frac{1}{\psi}} \left(\frac{p_t(i)}{P_s} \right)^{-\left(1 + \frac{1}{\psi}\right)\epsilon_s} \right) \end{aligned} \tag{5}$$

and the aggregation over individual prices yields

$$\left(\frac{p_t}{P_t} \right)^{1-\epsilon_t} = \frac{1 - \alpha \Pi_t^{\epsilon_t - 1}}{1 - \alpha}. \tag{6}$$

Price dispersion $\Delta_t \equiv \int_0^1 \left(\frac{p_t(i)}{P_t} \right)^{-\epsilon_t} di$ evolves according to

$$\Delta_t = (1 - \alpha) \left(\frac{1 - \alpha \Pi_t^{\epsilon_t - 1}}{1 - \alpha} \right)^{\frac{\epsilon_t}{\epsilon_t - 1}} + \alpha \Pi_t^{\epsilon_t} \Delta_{t-1}. \tag{7}$$

2.3 Fiscal Constraint

The government buys goods (G_t), taxes income (at tax rate Υ_t), raises lump-sum taxes, T_t, pays an employment subsidy S_t, and issues long and short-term nominal debt B_t^M and B_t^S. The government budget constraint can be written as:

$$P_t^M B_t^M = \left(1 + \rho P_t^M\right) B_{t-1}^M + P_t G_t - \Upsilon_t P_t Y_t - T_t + S_t, \tag{8}$$

where we assumed that the aggregate stock of one-period bonds is in zero net supply, $B_t^S = 0$. The employment subsidy is $S_t = \left(1 - \frac{1}{\mu^w}\right) W_t N_t$.

We assume that lump-sum taxes T_t are used solely to finance the employment subsidy S_t so their net effect is zero, $T_t = S_t$.[6] For analytical convenience we introduce $B_t = B_t^M / P_t$, so that

[6] In Section 5.1 we do allow the policy maker to utilize lump-sum taxes to satisfy its budget constraint, but solely as a means of identifying how government spending and distortionary tax rates would be employed to offset shocks without the need to simultaneously achieve fiscal solvency. This helps explain the relative efficacy of the two types of fiscal instrument in subsequent policy exercises where the need to stabilize debt is re-introduced.

equation (8) becomes

$$P_t^M B_t = \left(1 + \rho P_t^M\right) \frac{B_{t-1}}{\Pi_t} + G_t - \Upsilon_t Y_t. \tag{9}$$

2.4 Market Clearing and Evolution of the Economy

Aggregation of the private and public sector budget constraints results in the aggregate resource constraint

$$Y_t = C_t + G_t, \tag{10}$$

which can replace one of either of the individual budget constraints. While the aggregate production technology is given by

$$Y_t = N_t \frac{Z_t}{\Delta_t}. \tag{11}$$

The allocation $\{C_t, P_t^M, \Pi_t, \Delta_t, B_t, Y_t, N_t\}_{t=0}^{\infty}$ given policy $\{i_t, G_t, \Upsilon_t\}$ and shock processes $\{Z_t, \epsilon_t\}$ is the private sector equilibrium if it satisfies the system of first order conditions (3)- (7) and (9)-(11).

2.5 The Model in Gap Form

In order to tractably solve the model in the presence of potential strategic interactions between the monetary and fiscal policy makers we recast the policy problem in a linear quadratic (LQ) form. In doing so we employ the device of a steady-state employment subsidy which ensures that the deterministic steady state is efficient. This allows us to generate a valid LQ approximation to the underlying policy problem across all the types of policy we consider.[7]

In maximizing social welfare (1) subject to the technology and resource constraint, the social planner would ensure the following allocation was applied

$$\begin{aligned} \varpi G_t^{*-\frac{1}{\sigma}} &= C_t^{*-\frac{1}{\sigma}}, \\ C_t^{*-\frac{1}{\sigma}} Z_t^{\frac{1}{\psi}+1} &= \delta Y_t^{*\frac{1}{\psi}}, \end{aligned}$$

where the superscript * is used to denote the efficient equilibrium.

[7] If we did not adopt an efficient steady-state then the second order approximation to social welfare would include linear terms which would both prevent us calculating a valid second-order approximation to welfare using a linearized model and would also introduce an inflation bias to our policy problem. Eliminating the level bias allows us to focus on the stabilization bias.

We can contrast this allocation to the decentralized equilibrium that would be achieved under flexible prices

$$\frac{1}{\mu} = \frac{1}{Z_t^{\frac{1}{\psi}+1} \mu^w (1-\Upsilon_t)} \frac{\delta Y_t^{\frac{1}{\psi}}}{C_t^{-\frac{1}{\sigma}}},$$

where $\mu = \frac{\epsilon}{\epsilon - 1}$. We choose the steady state subsidy such that $\mu^w = \frac{\mu}{1-\Upsilon}$ and adopt the steady state government spending rule $\frac{G}{Y} = (\varpi^{-\sigma}+1)^{-1}$, so that the steady state level of output is identical to the optimal level of output in the efficient steady state that would be chosen by the social planner, $Y = Y^* = \delta^{-\frac{\sigma\psi}{\sigma+\psi}} (1+\varpi^{\sigma})^{\frac{\psi}{\sigma+\psi}}$.

In the various experiments we conduct below we focus on the implications of varying both the debt to output ratio and the maturity of that debt stock. Variations in these variables will not alter the underlying steady state values for consumption, output and labor supply, as the steady state subsidy will adjust to changes in the tax rate needed to support an alternative debt to output ratio, cet. par. to ensure that these variables remain at their efficient levels in steady state. Therefore, our focus is not on transitioning from one distortionary debt level to another. Instead, different assumptions about the steady state level of debt and its maturity will significantly impact on the policy transmission mechanism implying quite different gains to alternative delegation schemes in the face of shocks.

We rewrite the linearized model as[8]

$$c_t = \mathbb{E}_t c_{t+1} - \sigma (i_t - \mathbb{E}_t \pi_{t+1}), \quad (12)$$

$$p_t^M = -i_t + \beta\rho \mathbb{E}_t p_{t+1}^M, \quad (13)$$

$$\pi_t = \hat{\upsilon}_t + \frac{\kappa\psi}{\epsilon+\psi}\left(\frac{\Upsilon}{1-\Upsilon}\tau_t + \frac{1}{\psi}y_t + \frac{1}{\sigma}c_t\right) + \beta\mathbb{E}_t\pi_{t+1}, \quad (14)$$

$$\tilde{B}_t = -(1-\rho)\frac{B}{Y}p_t^M + \frac{1}{\beta}\tilde{B}_{t-1} - \frac{1}{\beta}\frac{B}{Y}\pi_t + \frac{(1-\beta\rho)}{\beta}\left((1-\theta)g_t - \Upsilon y_t - \Upsilon\tau_t\right) + \hat{\zeta}_t, \quad (15)$$

$$y_t = \theta c_t + (1-\theta) g_t, \quad (16)$$

where we use lower case variables to denote 'gap' variables, where the gap is the difference between linearized actual level and the efficient level of the variable i.e. $x_t = \hat{X}_t - \hat{X}_t^*$.[9] Parameter $\kappa = (1-\alpha)(1-\alpha\beta)/\alpha$ and $\theta = C/Y$ is the steady state consumption to output share.

The model is subject to two shocks: the cost-push shock $\hat{\upsilon}_t = -\frac{\kappa\psi}{\epsilon+\psi}\frac{1}{\epsilon-1}\hat{\epsilon}_t$, and a shock $\hat{\zeta}_t$ which measures the fiscal consequences of technology shocks

$$\hat{\zeta}_t = -\frac{B}{Y}\left(\frac{1-\beta}{\beta}\sigma + \frac{(1-\rho)(1-\rho_z)}{1-\beta\rho\rho_z}\right)\frac{\psi+1}{\sigma+\psi}\hat{Z}_t, \quad (17)$$

[8] Full details of the linearization of the model are given in Appendix B.

[9] The only exception for this notation rule is taxes. Here $\tau_t = \hat{\Upsilon}_t$.

where technology and cost push shocks follow AR(1) processes

$$\begin{aligned}\hat{Z}_t &= \rho_z \hat{Z}_{t-1} + \sigma_z \eta_{z,t}, \qquad |\rho_z| < 1, \qquad \eta_{z,t} \sim N(0,1) \\ \hat{\upsilon}_t &= \rho_\upsilon \hat{\upsilon}_{t-1} + \sigma_\upsilon \eta_{\upsilon,t}, \qquad |\rho_\upsilon| < 1, \qquad \eta_{\upsilon,t} \sim N(0,1)\end{aligned}$$

with parameters ρ_z, σ_z and $\rho_\upsilon, \sigma_\upsilon$, respectively.

The 'efficient' values of bond prices are those that are consistent with the efficient allocation that would be implemented by a benevolent social planner, see Appendix C:

$$\begin{aligned}\hat{\imath}_t^* &= \frac{1}{\sigma}\hat{C}_{t+1}^* - \frac{1}{\sigma}\hat{C}_t^* = -\frac{\psi+1}{\sigma+\psi}(1-\rho_z)\hat{Z}_t, \\ \hat{P}_t^{M*} &= \frac{\psi+1}{\sigma+\psi}\frac{(1-\rho_z)}{(1-\beta\rho\rho_z)}\hat{Z}_t, \\ \hat{Y}_t^* &= \frac{\psi+1}{\sigma+\psi}\sigma\hat{Z}_t, \\ \hat{G}_t^* &= \frac{\psi+1}{\sigma+\psi}\sigma\hat{Z}_t, \\ \hat{C}_t^* &= \frac{\psi+1}{\sigma+\psi}\sigma\hat{Z}_t, \\ \hat{\Upsilon}_t^* &= 0.\end{aligned}$$

It is straightforward to demonstrate that a quadratic approximation to households' utility can be written as[10]

$$W_t = -\frac{1}{2}\delta Y^{\frac{1}{\psi}+1}\sum_{s=t}^{\infty}\beta^{s-t}\left(\frac{\theta}{\sigma}c_s^2 + \frac{1-\theta}{\sigma}g_s^2 + \frac{1}{\psi}y_s^2 + \frac{\epsilon}{\kappa}\pi_s^2\right) + tip + O(2), \tag{18}$$

where *tip* denotes 'terms independent of policy' and *O(2)* captures terms of order higher than two in the approximation of social welfare. Since government spending is defined in gap terms, we are implicitly measuring the movements of the instrument away from its efficient level in a sticky-price economy. The terms in real variables contained in the objective function reflect the costs of deviating from the optimal trade-off between consumption and labor supply in household utility, while inflation is costly as it induces a distribution of prices across firms which leads to inefficiencies in the pattern of household consumption of different goods and in the distribution of labor supply across firms.

3 Policy

There are two independent policy makers: the monetary and the fiscal authority. The monetary authority controls the short-term interest rate i_t while the fiscal authority controls spending g_t,

[10] See Appendix C.

which is defined in gap form and/or the income tax rate τ_t.

3.1 Policy Problems

The social loss is approximated by the following quadratic criterion

$$\mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} U_s^S, \tag{19}$$

where

$$U_s^S = \pi_s^2 + \frac{\theta\kappa}{\sigma\epsilon} c_s^2 + \frac{\kappa}{\psi\epsilon} y_s^2 + \frac{(1-\theta)\,\kappa}{\sigma\epsilon} g_s^2.$$

The fiscal authority adopts this objective function, while the monetary authority either does the same or seeks to minimize a delegated loss function containing a price level or nominal income target.

Prior to considering strategic interactions between policy makers, as a benchmark, we compute the stabilization bias (Svensson, 1997) arising in our economy when the two policy makers are benevolent and share the same policy objective (19), but cannot commit. We then seek to explore the benefits of assigning the monetary authority a different set of policy objectives in an attempt to improve social welfare. This section explains this starting point for our investigation and then details the two delegation regimes.

3.1.1 The Starting Point: Benevolent Regimes and the Stabilization Bias

The effectiveness of a delegation scheme is usually measured by how well it reduces the welfare costs of shocks relative to the case of time-consistent discretion. It is hoped that delegation will achieve gains relative to the case where policy is time-consistent, since this is subject to a stabilization bias (Svensson, 1997), where the latter is an intrinsic feature of dynamic discretionary policy in many rational expectations models. The best stabilization outcome is achieved when both policy makers jointly minimize the social loss (19) under commitment (C), where the dynamic path of policy instruments $\{i_s, g_s \text{ and/or } \hat{\tau}_s\}_{s=t}^{\infty}$ is chosen in the initial moment t. Specifically, the optimization problem under commitment is

$$L_t^C = \min_{\{i_s, \mathcal{F}_s\}_{s=t}^{\infty}} \mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} U_s^S,$$

subject to the system of constraints (12)-(16). Here and below i_t is period-t instrument of the monetary policy maker, while $\mathcal{F}_t$ is the set of fiscal policy instruments and takes the values of

$\{g_t\}$, or $\{\tau_t\}$, or $\{g_t, \tau_t\}$ depending on policy scenario of interest. This regime yields the minimum conditional loss, which we denote L_t^C and use as a benchmark.

In contrast, the discretionary optimization problem is sequential. Under discretion (D), in every period the policy makers only choose the current level of instruments. The private sector knows that the policy makers will re-optimize and sets expectations accordingly.[11] The policy maker, therefore, solves the following Bellman equation

$$V_t = \min_{i_t, \mathcal{F}_t} \left(U_t^S + \beta \mathbb{E}_t V_{t+1} \right)$$

subject to the system of constraints (12)-(16). Here V_t is the value function. The joint optimization of social welfare under discretion generates a higher welfare loss relative to commitment – the stabilization bias – because the 'average' volatility of welfare-relevant variables under discretion exceeds the volatility under commitment. This is due to the fact that under discretion the policy maker cannot make credible promises about how they will behave in the future. The inability to do so means they cannot exploit the expectational benefits such promises can achieve. We denote $L_t^D > L_t^C$ the loss under discretion conditional on initial conditions.[12]

The two delegation schemes which we describe next are designed to improve the welfare loss under discretion, but have typically only been considered in contexts where there is no meaningful interaction between monetary and fiscal policy. We focus on two regimes which invoke a form of price level control for the monetary policy maker, specifically price level and nominal income targeting.

3.1.2 Delegation: Monetary Price Level Targeting

The first regime we consider is monetary price-level targeting (MPLT). This regime has been thoroughly investigated in models without fiscal policy, where it generally yields a substantial reduction in the welfare costs of shocks relative to discretion, effectively removing much of the original stabilization bias, and would perfectly mimic the commitment solution were our model to exclude fiscal policy and assume all shocks are i.i.d. (see Vestin, 2006). In a model with fiscal policy, however, this regime allows us to evaluate the welfare implications of price stability in an environment with debt accumulation, where non-cooperative fiscal policy can potentially

[11] A detailed treatment of commitment and discretion can be found in, for example, Currie and Levine (1993).

[12] We focus on conditional rather than unconditional welfare, as we rely on the theoretical result that commitment always dominates discretion in terms of conditional welfare so the problem of designing a delegation scheme to attempt to reduce the stabilization bias is well defined. In welfare evaluations we assume that economy starts in the deterministic steady state.

augment or offset the actions of the monetary policy maker. Following standard applications of a price-level target (Svensson, 1997; Vestin, 2006), we solve the following problem

$$\Phi_p = \arg\min_{\Phi_p \geq 0} L^{MPLT}\left(\Phi_p\right)$$

where $L^{MPLT}\left(\Phi_p\right)$ is the conditional loss generated by the non-cooperative discretionary optimization problem:

$$\text{Monetary policy maker solves:} \quad V_t^M = \min_{i_t}\left(U_t^{MPLT}\left(\Phi_p\right) + \beta \mathbb{E}_t V_{t+1}^M\right)$$

$$\text{Fiscal policy maker solves:} \quad V_t^F = \min_{\mathcal{F}_t}\left(U_t^S + \beta \mathbb{E}_t V_{t+1}^F\right)$$

subject to the system of constraints (12)-(16) and with the delegated monetary policy objective

$$U_t^{MPLT}\left(\Phi_p\right) = p_t^2 + \Phi_p\left(\frac{\theta\kappa}{\sigma\epsilon}c_t^2 + \frac{\kappa}{\psi\epsilon}y_t^2 + \frac{(1-\theta)\kappa}{\sigma\epsilon}g_t^2\right).$$

In comparison with the flow social objective U_t^S, the flow monetary objective U_t^{MPLT} replaces the term in inflation with a term in the price level. In delegating this target to the monetary authority, the weight on real variables is chosen by searching for the value which minimizes the expected social losses that would emerge as a result of the equilibrium outcomes observed under the time consistent strategic interactions between the monetary and fiscal authorities. The parameter Φ_p is chosen in a time invariant way, based on the conditional loss achieved under the non-cooperative regime. By choosing Φ_p to maximize society's welfare under delegation, it allows the delegation schemes to perform as well as possible given their structure.

3.1.3 Delegation: Monetary Nominal Income Targeting

The second regime we consider is that of monetary nominal income targeting (MNIT). This regime has recently attracted a lot of attention – as we discuss in the Introduction – and it has nominal output as a target. Similar to the MPLT, we solve

$$\Phi_n = \arg\min_{\Phi_n \geq 0} L^{MNIT}\left(\Phi_n\right)$$

where $L^{MNIT}\left(\Phi_n\right)$ is the conditional loss generated by the non-cooperative discretionary optimization problem:

$$\text{Monetary policy maker solves:} \quad V_t^M = \min_{i_t}\left(U_t^{MNIT}\left(\Phi_n\right) + \beta \mathbb{E}_t V_{t+1}^M\right)$$

$$\text{Fiscal policy maker solves:} \quad V_t^F = \min_{\mathcal{F}_t}\left(U_t^S + \beta \mathbb{E}_t V_{t+1}^F\right)$$

subject to the system of constraints (12)-(16) and with the monetary objective given by,

$$U_t^{MNIT}(\Phi_n) = \left(p_t + \hat{Y}_t\right)^2 + \Phi_n \left(\frac{\theta\kappa}{\sigma\epsilon} c_t^2 + \frac{\kappa}{\psi\epsilon} y_t^2 + \frac{(1-\theta)\kappa}{\sigma\epsilon} g_t^2\right).$$

Note that the $\hat{Y}_t$ measures the percentage deviation of output from steady state and not the gap between output and its natural level, y_t, since most calls for nominal income targeting focus on targeting nominal output rather than the output gap.

3.2 Timing

The timing of events in this model is conventional: at the beginning of every period t the state variables, debt $\tilde{B}_{t-1}$ and the price level p_{t-1}, are known and the cost-push and technology shocks, $\hat{v}_t$ and $\hat{Z}_t$, respectively, realize and are observed by all economic agents, the policy makers and the private sector. Knowing the state realization, and anticipating the private sector's reaction – as described by households' and firms' first order conditions – the policy makers choose the interest rate and fiscal policy instruments. Then, the private sector chooses consumption and prices at the end of the period.[13] The equilibrium responses π_t, c_t and policy instruments i_t, $\mathcal{F}_t$ result in a new level of states $\tilde{B}_t$ and p_t by the beginning of the next period, $t + 1$.

There are two policy makers: the central bank and the fiscal authority which stabilize the economy following shocks. Policymakers act cooperatively if they share common objectives, although this may be under discretion or commitment depending on whether or not they are able to make credible promises about their future policies. Policymakers are assumed to act strategically, rather than cooperatively, if their objectives differ. If they do not cooperate, they could make decisions either simultaneously without taking each others' actions into account, or they can observe and anticipate each others' policy decisions, as one of the authorities may have intraperiod leadership. An intraperiod leader knows the policy objectives – and therefore the reaction function – of the follower and takes this into account when choosing its policy, by treating the follower's reaction function as a constraint in its optimization.

In this paper we assume the regime of fiscal leadership throughout, such that the fiscal authority acts as an intra-period leader. Fiscal leadership is consistent with the empirical evidence, as monetary policy objectives are much more transparent and the subsequent monetary policy reaction is anticipated by the fiscal policymaker. It should be stressed that Fiscal Leadership is not the same as Fiscal Dominance and we are not assuming that the central bank is forced to accommodate the actions of the fiscal authority. It is simply that, for example, the fiscal

[13] This timing is standard in the literature on dynamic monetary policy, see e.g. Clarida, Galí, and Gertler (1999).

authority may anticipate that the central bank will react to, say, a fiscal stimulus by attempting to stabilize any inflation that it generates.

In what follows we, therefore, assume that the fiscal authority minimizes the social welfare loss with flow U_t^S and moves first, after the state is observed at the beginning of each period. The monetary authority minimizes the delegated objective with flow cost U_t^{MPLT} or U_t^{MNIT} and moves after the fiscal policymaker but before the private sector takes its decisions at the end of each period.

When all policymakers share the common objective with flow U_t^S, the order of moves is inconsequential. However, in what follows, it is more intuitive to assume that the order of moves under cooperation is the same as under non-cooperation with a delegated monetary policy objective such that the only policy change is the introduction of a delegated objective function for the monetary authority without any change in the timing of moves.

4 Calibration and Numerical Solution

4.1 Calibration

This model is highly stylized and involves relatively few parameters. Calibration of $\beta = 0.99$ and $\alpha = 0.75$ corresponds to the most frequently estimated values of the steady state annual interest rate of 4% and the average frequency of price changes of one year. We calibrate the Frisch elasticity of labour supply $\psi = 3.0$, consistent with the macro-evidence of Peterman (2012) based on empirical work which matches volatilities of aggregate worked hours and of wages. We calibrate the intertemporal elasticity as $\sigma = 0.5$, based on evidence in Hall (1988), Campbell and Mankiw (1989) and Attanasio and Weber (1993, 1995). The elasticity of substitution between goods, ϵ, is set to 11 based on evidence in Chari et al. (2000) and corresponds to a 10% mark up. The share of government consumption in output is assumed to be, 25% such that $1 - \theta = 0.25$, consistently with Gali (1994) and Leith and Wren-Lewis (2013). Given our assumption of an efficient steady state fiscal spending rule we obtain the corresponding parameter $\varpi = \left(\frac{1-\theta}{\theta}\right)^{\frac{1}{\sigma}}$ in the household utility function. Due to the use of the employment subsidy, the deterministic steady state is efficient and the steady-state value of welfare relevant variables like private and public consumption, output and labor supply will be invariant to the calibrated debt to output ratio and its maturity. We conduct a robustness exercise which explores alternative calibrations of these key parameters in online Appendix F.

The remainder of the fiscal side of the model is calibrated as follows. Figure 1 plots a range

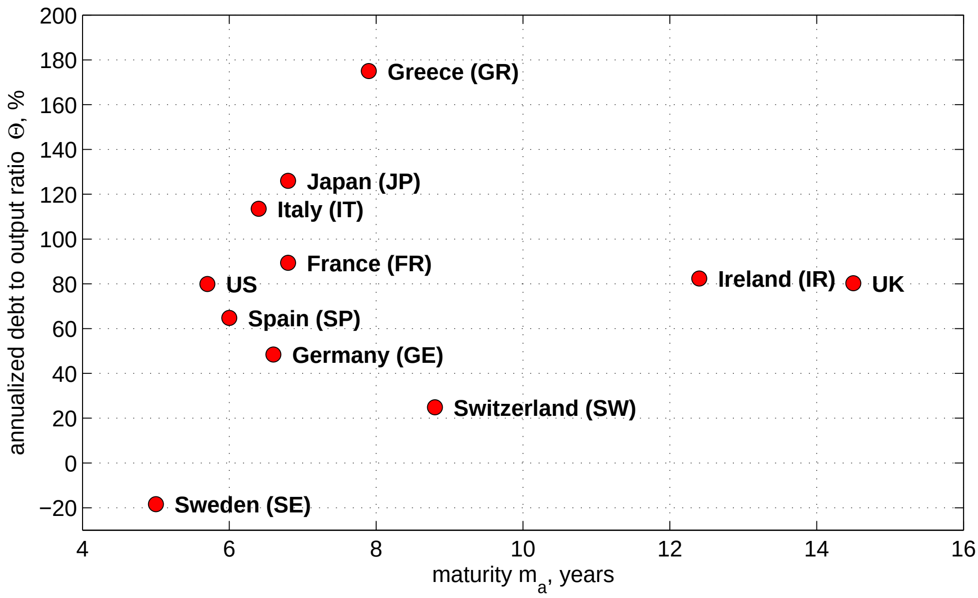

Figure 1: Debt and maturity for selected countries

of debt to output ratios and average debt maturities for a representative sample of advanced countries. These define the range of debt and maturities that we consider across our various policy exercises. The geometrically declining debt maturity structure implies the average maturity of debt is given by $m = \frac{1}{1-\beta\rho}$, and we consider a range of annualized maturities $m_a = \frac{1}{4}m$ between one and eight years. Calibration of m gives us $\rho = \frac{1}{\beta} - \frac{1}{\beta m}$. Similarly, we consider range of annualized debt to output ratios, $\Theta = \frac{BP^M}{4Y}$, lying between 0 and 160% of annualized output. For a specific case, the debt to output ratio which prevails in the economy in absence of shocks is $\chi = 4\Theta/P^M = \frac{(\tau+\theta-1)(1-\beta\rho)}{1-\beta}$, which ties down the steady-state tax rate as $\tau = \frac{\chi(1-\beta)}{(1-\beta\rho)} + 1 - \theta$, given the steady state share of of government consumption in output $1-\theta$. Note that this calibration approach assumes that we study a variety of economies, which differ with respect to their debt maturities and their steady state levels of taxes and debt to output ratios. If such an economy is hit by a shock, the variables will eventually converge to their steady state values. The steady state debt to output ratio, therefore, works as an implicit debt target for policy makers who choose the steady state level of taxes consistently with the debt to output ratio. This approach contrasts with an alternative interpretation where the currently observed difference in debt to output ratios is seen as a temporary deviation from a steady state which is the same for all countries.

We calibrate the technology shock as an AR(1) process $\hat{Z}_t = \rho_z \hat{Z}_{t-1} + \varepsilon_{zt}$ with $\rho_z = 0.95$

and $\sigma(\varepsilon_{zt}) = 0.008$. This is broadly in line with the values used in Canzoneri et al. (2006) $(\rho_z, \sigma(\varepsilon_{zt})) = (0.92, 0.0090))$, Ireland (2004) $(\rho_z, \sigma(\varepsilon_{zt})) = (1.00, 0.0109))$ and those used in Schmitt-Grohe and Uribe (2007) $(\rho_z, \sigma(\varepsilon_{zt})) = (0.86, 0.0064))$.[14] Among these three studies, only Ireland (2004) uses a cost-push shock, which is AR(1) with a standard deviation of 0.0044. Smets and Wouters (2003) reports an i.i.d. cost push shock with a much smaller standard deviation in the model with inflation persistence, while Rudebusch (2002) estimates a standard deviation of 0.01 for an i.i.d. cost push shock. In the analysis below, we calibrate the standard deviation of an i.i.d. cost push shock $\hat{\upsilon}_t$ as 0.005.

Finally, all losses we compute are conditional on the initial state, assumed to be the non-stochastic steady state, which all variants of the policy regimes share.

4.2 Solution Algorithm

Our definition of discretionary policy is conventional and is widely used in the monetary policy literature, see, for example, Backus and Driffill (1986), Oudiz and Sachs (1985), Clarida et al. (1999), and Woodford (2003). Solving the cooperative case is straightforward, and the numerical algorithm follows Söderlind (1999). The algorithm to solve the non-cooperative discretionary problem with intra-period leadership is given in Blake and Kirsanova (2011). In the non-cooperative case, as well as in case of cooperation, the system of first order conditions is reduced to a system of matrix Riccati equations in the unknown coefficients of decision rules and value function matrices. A fixed point solution to this system satisfies economic agents' expectations and the policy makers' Bellman equations. However, the assumption of intra-period fiscal leadership affects the form of the monetary authority's decision rule. The solution of the optimization problem of the follower – the monetary policy maker, who observes fiscal policy decisions and treats $\mathcal{F}_t$ as an additional state – yields a monetary decision rule which takes into the account the current value of fiscal policy instrument $\mathcal{F}_t$, the current values of shocks and the level of debt $\tilde{B}_{t-1}$. Therefore, the intra-period leading fiscal policy maker influences the decisions of the follower and the fiscal authorities take this influence into account when formulating policy. More details of the solution algorithm are provided in Appendix D.

5 Value of Delegation

In this section we study the implications of the fiscal environment in terms of the level of debt and its maturity on the nature of the stabilization bias and the value of alternative delegation

[14] Schmitt-Grohe and Uribe (2007) do not consider cost-push shocks.

schemes which aim to reduce the welfare costs of shocks relative to the case of cooperative discretion, and bring outcomes closer to the case of cooperative commitment. First, we examine the relative efficacy of the two fiscal instruments, distortionary taxation and government spending, in responding to technology and cost-push shocks in order to provide intuition for subsequent results where the choice of instrument is key. Second, we explore the stabilization bias itself again using various permutations of taxes and government consumption as fiscal policy instruments. Third, we explore to what extent the delegation schemes outlined above can improve outcomes relative to cooperative discretion, effectively offsetting some of the stabilization bias. Throughout, we explore the implications of the government only having access to one fiscal instrument for stabilization purposes in line with the empirical evidence presented in the introduction, since this is a key determinant of the efficacy of the two delegation schemes.

5.1 Alternative Fiscal Instruments

Some intuition for the relative efficacy of the tax and spending fiscal instruments can be found by, following Eser et al. (2009), considering what optimal policy would be if the policy maker had access to a lump-sum tax to satisfy its budget constraint. This assumption implies Ricardian Equivalence holds and, as a result, the government's budget constraint ceases to impose any costs on the policy maker. However, we still wish to see how the policy maker would utilize government spending and distortionary taxation in order to mitigate the welfare consequences of shocks in a sticky-price economy, in the absence of a need to stabilize debt. In this case the policy problem under commitment reduces to the following Lagrangian

$$\begin{aligned} L &= \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t [\pi_t^2 + \frac{\theta\kappa}{\sigma\epsilon} c_t^2 + \frac{\kappa}{\psi\epsilon} y_t^2 + \frac{(1-\theta)\,\kappa}{\sigma\epsilon} g_t^2 \\ &\quad +2\lambda_t^{\pi}(\pi_t - \hat{\upsilon}_t - \frac{\kappa\psi}{\epsilon+\psi}\left(\frac{\Upsilon}{1-\Upsilon}\tau_t + \frac{1}{\psi} y_t + \frac{1}{\sigma} c_t\right) - \beta\pi_{t+1}) \\ &\quad +2\lambda_t^{y}(y_t - \theta c_t - (1-\theta)\, g_t)], \end{aligned}$$

with first order conditions for the output gap

$$\frac{\kappa}{\epsilon\psi} y_t - \frac{\kappa}{\epsilon+\psi}\lambda_t^{\pi} + \lambda_t^{y} = 0,$$

consumption gap

$$\frac{\theta\kappa}{\epsilon\sigma} c_t - \frac{\kappa\psi}{(\epsilon+\psi)\sigma}\lambda_t^{\pi} - \theta\lambda_t^{y} = 0,$$

and government spending gap

$$\frac{(1-\theta)\kappa}{\epsilon\sigma}g_t - (1-\theta)\lambda_t^y = 0,$$

which can be combined to yield,

$$\begin{aligned} g_t &= \lambda_t^y = 0 \\ y_t &= \theta c_t = \frac{\epsilon\psi}{\epsilon+\psi}\lambda_t^\pi \end{aligned}$$

In other words, the government spending gap would always be zero in the presence of both technology and cost-push shocks regardless of the weight attached to public consumption in utility. This implies that variations in government spending do not contribute anything to the stabilization of the economy following cost push shocks (assuming access to a lump-sum tax to satisfy the government's budget constraint) even although inflation and the output gap may be non-zero in the face of such shocks. The intuition is that monetary policy is a more effective stabilization tool than government spending. Tightening monetary policy not only reduces demand through its impact on consumption, but increases supply as households reduce leisure in line with consumption. In contrast, government spending impacts solely on aggregate demand, implying a more costly reduction in output to achieve a given reduction in inflation. This makes monetary policy better placed to deal with the trade-offs implied by cost-push shocks even although it cannot offset such shocks completely.[15]

The first-order condition for inflation is given by

$$\pi_t + \lambda_t^\pi - \lambda_{t-1}^\pi = 0,$$

which can be combined with the first order condition for output to give the usual target criterion

$$\pi_t = -\frac{\epsilon+\psi}{\epsilon\psi}\Delta y_t,$$

which reveals the optimal trade-off between output and inflation stabilization in the face of cost-push shocks. It also implies the price level control which is a feature of policy under commitment.[16]

When the policy maker also utilizes the distortionary tax rate as a policy instrument then its first order condition implies $\lambda_t^\pi = 0$ which can be achieved by adjusting the tax rate to perfectly offset the cost-push shock,

$$\frac{\kappa\psi}{\epsilon+\psi}\frac{\Upsilon}{1-\Upsilon}\tau_t = -\hat{\upsilon}_t$$

[15] See Eser et al. (2009) for a full discussion of this result.

[16] Since the output gap must eventually be eliminated this first order condition implies that the sum of changes in the output gap, and therefore, cumulative inflation will both be zero. This implies that the price level is returned to base following shocks.

without generating any inflation. Effectively, the policy maker offsets the distortion generated by the cost-push shock by varying the distortion associated with taxation in an offsetting way. Therefore, when Ricardian Equivalence holds, monetary policy and variations in distortionary tax rates can replicate the first-best outcome: monetary policy perfectly offsets technology shocks without requiring any fiscal policy response, while variations in distortionary taxes can perfectly offset the inflationary consequences of cost-push shocks without generating efficiency gaps in other welfare relevant variables. In the face of either shock the government spending gap is always zero. We can see these results in the impulse response functions presented in Figure 2. In the face of the technology shock, when the policy maker can eliminate the fiscal consequences of the shock with lump sum taxation, neither fiscal instrument is needed to optimally stabilize the economy and all gaps and inflation are zero. In the face of a cost-push shock, the policy maker faces a trade-off between output and inflation stabilization unless the distortionary tax instrument is employed to completely offset that shock too.

Our policy problem is complicated by not allowing the policy maker to have access to a lump-sum tax to stabilize debt following shocks, and as a result the policy maker must deviate from this first-best policy in order to ensure that the government's budget constraint is satisfied. This is what creates meaningful policy trade-offs in our model, which will be more costly the greater the direct fiscal consequences of either type of shock are. Since, in the absence of a fiscal constraint, there is no desire to vary either g_t or τ_t following technology shocks, the direct fiscal implications of technology shocks are captured by the coefficient in expression (17), which tends to be quite small such that the deviation from the first best policy in response to technology shocks is not quantitatively important. This can be seen in the second set of panels of Figure 2 where the inflationary and fiscal consequences of a technology shock are small across both permutations of fiscal policy instrument.[17] However, the relative magnitude of the degree of price level drift is significantly higher when the fiscal authority is unable to vary the distortionary tax instrument.

In the case of cost-push shocks the nature of the policy trade-offs depends crucially on whether or not the policy maker can respond to the shock with the distortionary tax instrument. When they can, the tax instrument largely offsets the cost-push shock with limited inflationary and fiscal consequences. In contrast, when this instrument is not employed to mitigate the effects of a cost-push shock, there is a far larger inflationary and fiscal response to the same cost-push shock which government spending is not effective in offsetting. This can be seen in Figure 2 where we

[17] As a result of the welfare impact of technology shocks being small we focus on cost-push shocks for the remainder of the paper since these drive the results. Nevertheless, the small impact from technology shocks are still included in all welfare calculations.

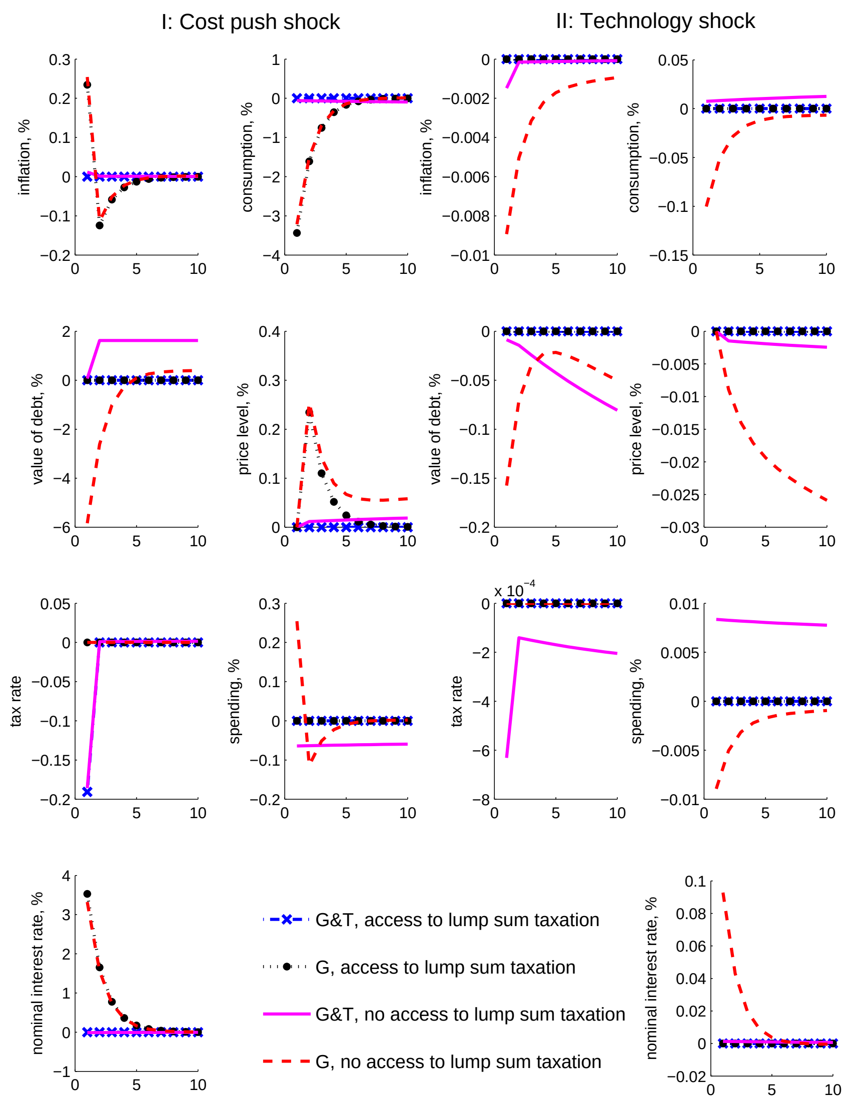

Figure 2: Impulse responses to one-standard-deviation positive shock. Annual debt to output ratio is 20%, and maturity of debt is 8 years. All values are quarterly.

can see that with access to distortionary taxation as a stabilization tool, under commitment, debt rises permanently as a result of the cost-push shock and the price level is not fully returned to base. This is different from the case where debt can be stabilized with lump-sum taxes where there would be no drift in either debt or the price level. However, the magnitude of the price level drift is small. Turning to the case when the distortionary tax rate is held constant, the fiscal authority uses government spending to help stabilize debt even although it contributes nothing to combating the cost-push shock itself. This means that the initial rise in inflation is even greater than in the case where lump-sum taxes can satisfy the government's budget constraint and we see a permanent drift in the price level which, at this steady-state debt level, is far greater than that observed when distortionary taxes are used to offset the cost-push shock.

Therefore, under commitment, when the policy instruments available to the policy maker are effective in dealing with the consequences of specific types of shock in the absence of a need to stabilize debt, creating an additional need to stabilize debt implies that there is only limited drift in the price level even although formally strict price level control is no longer a feature of optimal policy. However, when the available instruments are less effective in dealing with a specific shock, the optimal policy will tend to allow a greater degree of price level drift which is only partially offset in the long-run.

5.2 The Stabilization Bias: Commitment vs. Discretion

5.2.1 Commitment

Figure 3 plots contour maps of the percentage of steady-state consumption that the consumer would be willing to give up to move from the regime being considered to the steady-state allocation in maturity-debt space under commitment and discretion (and the difference between them, the stabilization bias), where the fiscal instruments include either both taxes and government spending jointly, or each instrument individually. Two results are apparent. First, consider the first row of Figure 3 which details the welfare losses under commitment. These are very low when the benevolent policy maker has access to taxes as a fiscal instrument, but are substantially higher when only government spending is available as a fiscal instrument. Second, the pattern of losses across debt levels and maturity also differ conditional on the availability of the tax instrument. When taxation is available as an instrument, welfare losses rise with debt levels and maturity, while when government spending is the only available instrument, welfare losses are falling with maturity.

We can see this more clearly by looking at the impulse responses to a cost-push shock under two scenarios: (i) high debt – short maturity, and (ii) low debt – long maturity in Figures 4-5. Impulse responses under commitment are plotted with dotted-circled lines.

In Figure 4 the fiscal authority employs both fiscal instruments. Under commitment we obtain the usual result from the literature that the steady state level of debt follows a random walk (see, for example, Benigno and Woodford (2003) and Schmitt-Grohe and Uribe (2004)), such that in the long run the benevolent policy maker will adjust available fiscal instruments to service the new steady state debt level. The reason why the policy maker does not attempt to return debt to its pre-shock level is that the long run benefits of going further and reducing steady state debt are exactly balanced by the short-run costs of doing so. This, in essence, is the standard tax smoothing result generalized to a New Keynesian economy. Despite this, there is, however, some attempt to offset the fiscal consequences of the shock in the initial periods following the shock. To do so the policy maker seeks to raise inflation slightly to reduce the *ex post* real rates of return on government debt relative to the *ex ante* rates. With only single period debt, this inflation surprise would only occur in the initial period, while with longer-maturity debt the policy maker can spread the inflation surprise over a longer time period (see Sims (2013)). Additionally, the advantage of doing so is greater with higher debt levels as the impact on real interest rates is more effective when applied to a larger stock of debt. In both cases (high debt – short maturity and low debt – long maturity) the response, is however, extremely small such that there is very little drift in the price level following the cost-push shock. In the initial period taxes are cut to moderate the initial jump in inflation arising from the i.i.d. cost-push shock. Subsequently, there is a permanent increase in taxation, and very slight cut in spending to service the higher debt stock. The rise in the debt stock is greater in the high debt – short maturity case as the ability to sustain a moderate inflation surprise with longer maturity dominates the impact of a higher initial debt level. Essentially, once we move beyond the shortest of debt maturities, the key fiscal variable determining welfare losses under commitment is the debt to output ratio. This is reflected in the welfare contours of Figure 3. If the policy maker only has access to the tax instrument the results are very similar: government spending contributes very little to the fiscal adjustment and, again, there is very little drift in the price level under the optimal commitment policy.[18]

In Figure 5, where the benevolent policy maker is forced to rely solely on government consumption as its fiscal instrument, the results are quite different. The long run still features a rise in government debt following the cost-push shock, which is serviced by cutting government

[18]See Figure 1 in Appendix E.

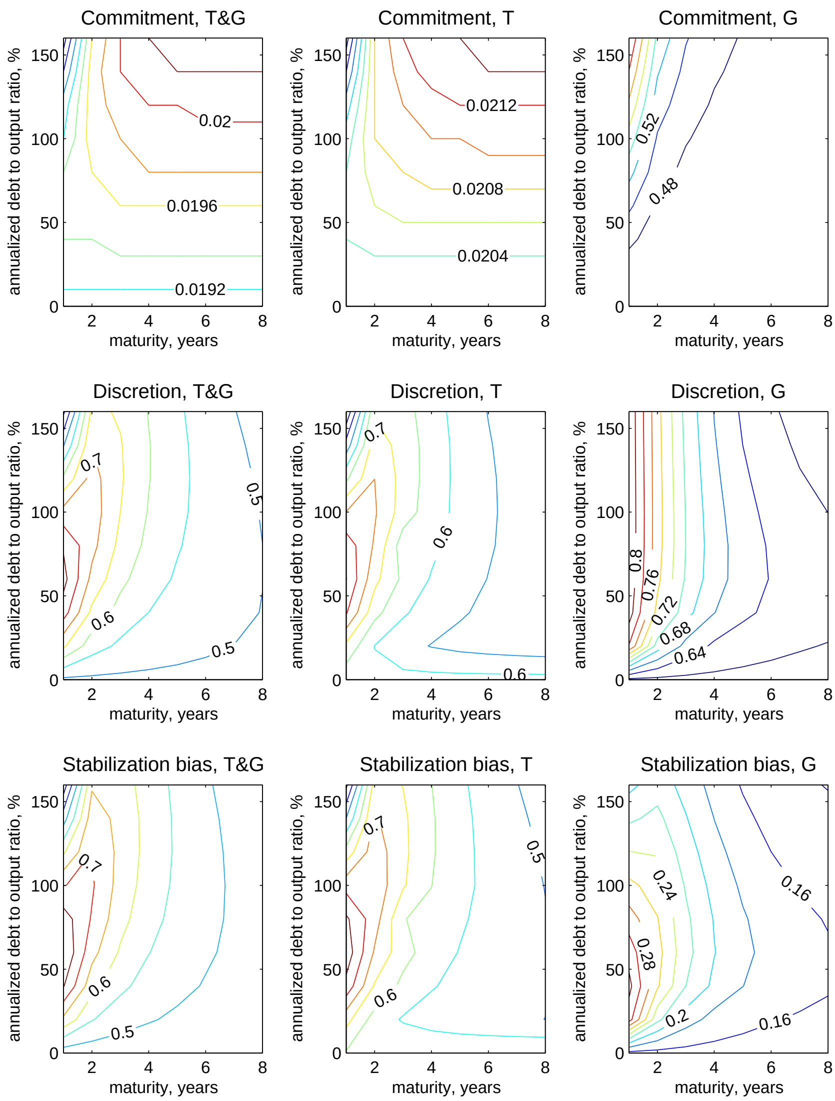

Figure 3: Welfare losses for commitment and discretion and the stabilization bias. All losses are measured in percentage of steady-state consumption that the consumer would be willing to give up to move from the actual regime to the steady-state allocation. T&G, T and G refer to 'taxes and spending', 'taxes only' and 'spending only' based fiscal stabilization, respectively. Both technology and cost-push shocks are used.

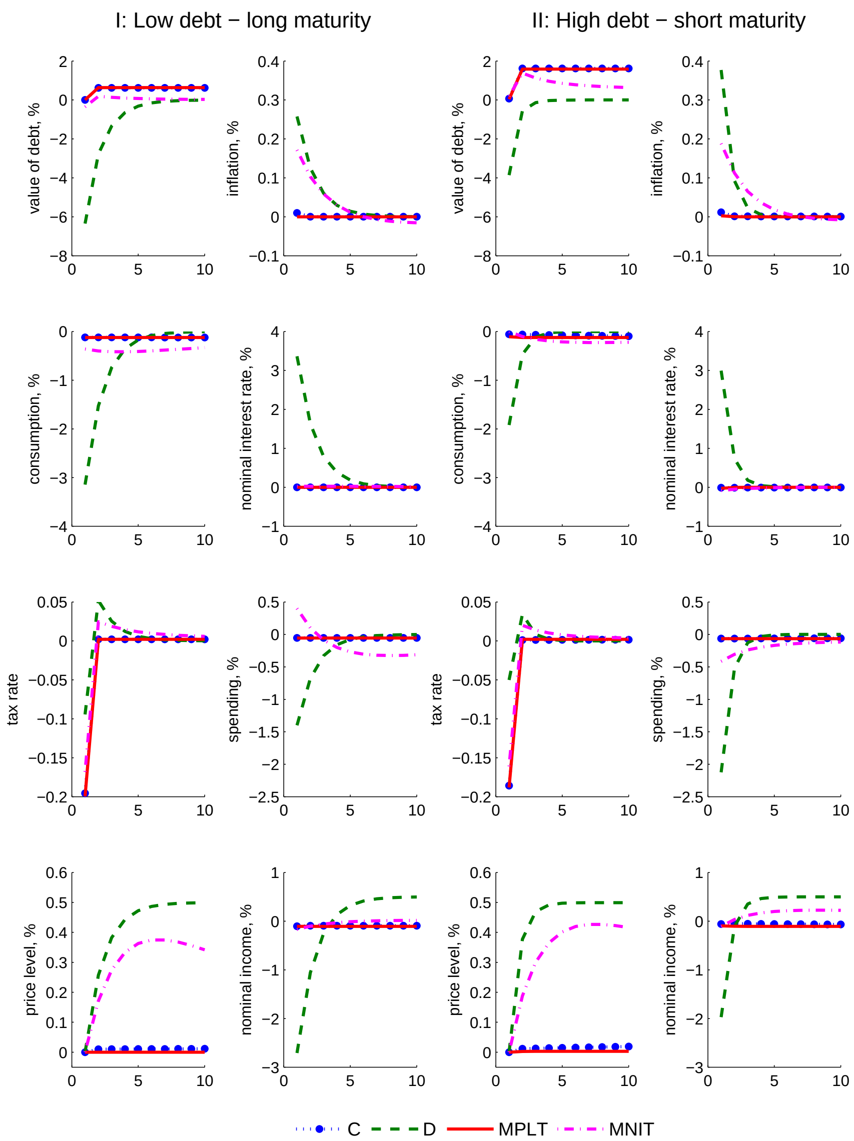

Figure 4: Dynamic responses to one-standard-deviation positive cost push shock. Tax–spending based fiscal stabilization for different delegation schemes. Panel I: Annualized debt to output ratio $\Theta = 20\%$, maturity $m_a = 8$ years, Panel II: Annualized debt to output ratio $\Theta = 120\%$, maturity $m_a = 3$ years.

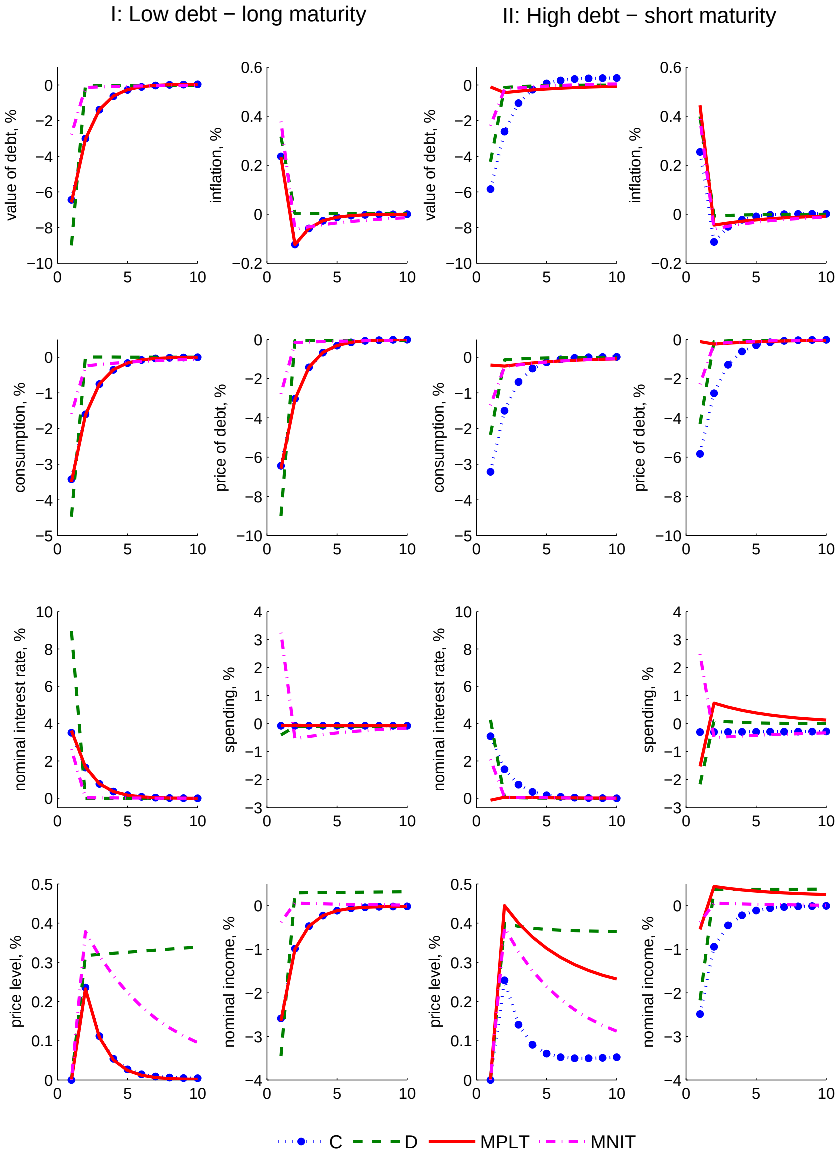

Figure 5: Dynamic responses to one-standard-deviation positive cost push shock. Spending-based fiscal stabilization for different delegation schemes. Panel I: Annualized debt to output ratio $\Theta = 20\%$, maturity $m_a = 8$ years, Panel II: Annualized debt to output ratio $\Theta = 120\%$, Annualized debt to output ratio $m_a = 3$ years.

consumption. However, in the transition to the new steady state there is a sustained rise in real interest rates, and a commitment to reduce inflation below target – after the shock has passed – to moderate the initial inflation consequences of the cost-push shock. However, this commitment is not nearly strong enough to prevent the increase in the price level immediately following the cost-push shock. This depresses bond prices, so that the value of government debt actually falls during the transition, despite ultimately rising in the long-run. Under the high debt – short maturity scenario the permanent adjustment of government spending is greater, as there is less scope to deflate debt through surprise inflation as debt maturity falls. This is also reflected in the welfare contours in the top right corner of Figure 3.

In summary, optimal policy implies a commitment to adjust fiscal instruments to permanently sustain the debt stock that emerges following shocks. However, unlike the policy implemented in the standard monetary policy-only version of the New Keynesian model, the commitment policy does not fully stabilize the price level. The degree of price level slippage depends on both the level and maturity structure of the debt stock, but most particularly on the availability or otherwise of taxation as a fiscal instrument. When distortionary taxation is available, the policy maker will tend to only allow a very mild degree of drift in the price level following cost-push shocks. In contrast, without access to this policy instrument, the fiscal response to cost-push shocks is far more muted and, although there is an attempt to influence inflationary expectations through a medium term tightening of policy, there is a larger short- and long-run deviation from price level stability. This is reflected in significantly higher welfare costs when taxation is unavailable as a policy instrument, and is likely to make delegation schemes with price level targets less attractive.

5.2.2 Discretion and the Stabilization Bias

We now turn to consider the implications of the policy maker not having an ability to commit. The second row of Figure 3 gives the corresponding welfare contour maps for the case of discretion. Again, two results are apparent. First, the size of the reduction in social welfare relative to commitment – the stabilization bias – depends on the choice of fiscal instrument. In the case where the fiscal authority has access to taxes – either on their own or in conjunction with government spending – shows that the welfare losses under discretion rise substantially relative to commitment, such that the stabilization bias in the first two columns is almost identical to the welfare losses under discretion. In the final column, where government spending is the sole fiscal instrument, there is a far less dramatic deterioration in welfare when moving from commitment to discretion. Second, in contrast to commitment, the shape of the welfare contours is similar across all permutations of fiscal policy instrument. The stabilization bias is higher with shorter maturity, although when maturity is very short, the bias is an inverse U-shaped function of the debt to output ratio if taxes are available. In other words, given a relatively short maturity, welfare initially falls as debt levels rise, but eventually higher debt makes stabilization less costly.

As above, we can obtain intuition for these results by considering the impulse response functions to an i.i.d. cost push shock under the same two scenarios: high debt – short maturity and low debt – long maturity. Figure 4 plots the case of both fiscal instruments. Under discretion, steady state debt no longer follows a random walk in the face of shocks, but returns to its initial steady state value. In the face of the i.i.d. cost push shock there is a surprise rise in inflation in the initial period, which reduces the value of government debt. This is mitigated by a fall in the tax rate in the initial period, although this offsetting fiscal policy reacts far less than it would do under commitment. As a result, monetary policy is tightened in an attempt to control inflation. The gradual stabilization of debt proceeds by raising taxes with a tightening of monetary policy to reduce the inflationary consequences of this. This policy mix returns debt to its initial value, but the welfare costs of doing so are substantial. Having access to government spending does not materially affect the policy maker's ability to stabilize the economy in the face of cost-push shocks, provided they do have access to taxes. These patterns are similar across the two cases of debt levels and maturities, although with higher debt surprise inflation becomes a more effective tool in stabilizing debt, see Leeper and Leith (2016) for a discussion. This changing policy mix, particularly across debt levels, then drives the patterns of welfare losses.

When we examine the case where the fiscal authorities only have access to government spending as their fiscal instrument, then welfare is lower relative to the case where taxes are available, but the deterioration in welfare for discretion relative to commitment is less sharp. The reason for this can be seen from the impulse response functions in Figure 5, again considering the two cases of high debt – short maturity and low debt – long maturity. Under discretion the policy maker cannot commit to maintain debt at a new higher level following the cost push shock, and is compelled to return debt to its original value. This adds a welfare cost relative to commitment. However, under commitment the policy maker already struggled to successfully offset the cost push shock – the now unavailable tax instrument is the ideal tool to offset such shocks through their impact on marginal costs – so that the discretionary policy which both offsets the cost push shock and returns debt to steady state is simply a slightly more aggressive form of the policy under commitment. The pattern of adjustments under commitment and discretion – with only government spending available as a fiscal instrument – is similar, although the steady state debt levels have an impact on the policy mix, such that under the high debt case government spending is cut by more and interest rates are raised by less as a result of the heightened debt stabilization bias and higher inflation that emerges.

5.3 Delegation Schemes

We now turn to consider the welfare gains from two alternative delegation schemes: MPLT and MNIT. These schemes are parameterized to give the highest possible welfare given their structure. The first row of Figure 6 replicates the stabilization bias contour map detailed in the last row of Figure 3. Rows 2 and 3 of Figure 6 then plot the welfare *gains* associated with the two delegation schemes. For MNIT, provided the fiscal authorities have access to the tax instrument, the welfare gains are substantial, but leave a non-trivial residual welfare cost. In contrast, when the government can only employ government consumption as its fiscal instrument, the welfare gains are very modest and can actually turn negative, i.e. the delegation scheme can make outcomes worse. Turning to the final row of Figure 6, with access to the tax-instrument-delegation of a price level target can effectively reduce the welfare loss to the level achieved under cooperative commitment for most debt levels and maturities, while, without access to this instrument, welfare gains from delegation are only realized at low debt levels – long maturities, and are likely to be negative at high debt levels – short maturities.

We can see these patterns more clearly in Figure 7, which presents pictograms where the area of each bar corresponds to the percentage of steady-state consumption that the consumer would be willing to give up to move from the regime being considered to the steady-state allocation free of shocks under discretion, the delegation scheme and commitment respectively.[19] These are plotted for the cases of taxes and spending being jointly available as instruments, or with only government consumption being available.[20] When the welfare losses under the delegation scheme are shaded this indicates that the losses under that scheme are actually worse than the outcome under cooperative discretion. The first column of the chart shows that when the fiscal authorities have access to taxation as an instrument, there are potentially substantial welfare gains to delegation under both schemes, but particularly under a MPLT which largely reduces the loss to levels similar to those under cooperative commitment unless debt levels are particularly

[19]The absolute levels of welfare losses are not crucial, but the figure shows the relative levels of welfare across discretion, the delegation scheme and commitment simultaneously, so the shape of each loss is clear across debt levels and maturity, as well as the proportion which is eliminated/remains under delegation scheme.

[20]The case of only taxes being available looks very similar to the case of both government consumption and taxes being used since government spending adds very little to stabilization policy in this case and so is omitted. It is available upon request.

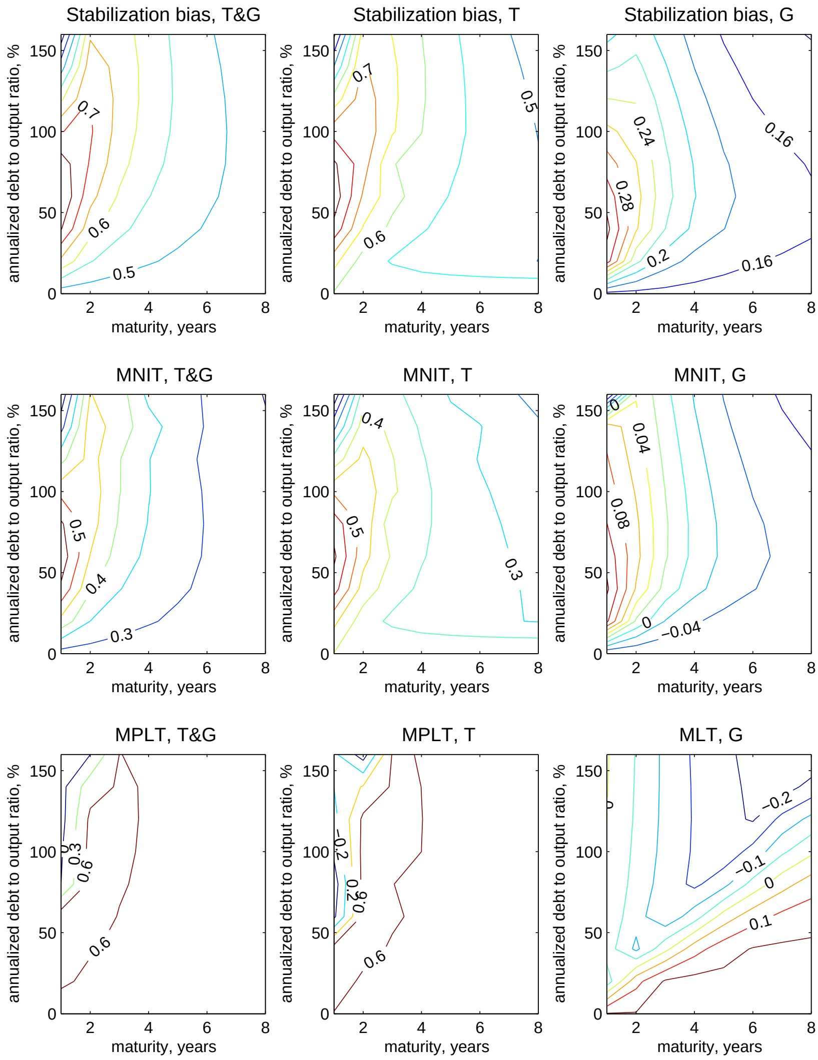

Figure 6: Welfare losses for different delegation schemes. All losses are measured in percentage of steady-state consumption that the consumer would be willing to give up to move from the actual regime to the steady-state allocation. T&G, T and G refer to 'taxes and spending', 'taxes only' and 'spending only' based fiscal stabilization, respectively. Both technology and cost-push shocks are used.

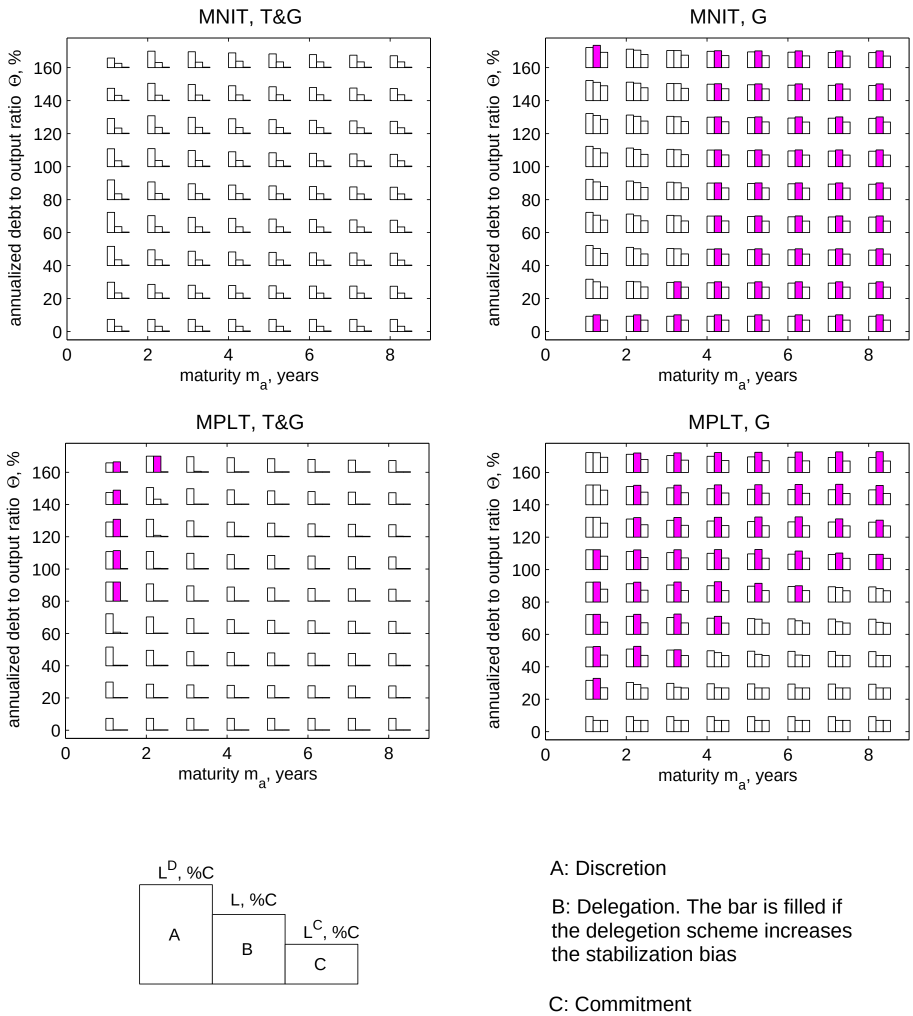

Figure 7: Welfare losses for different delegation schemes. All losses are measured in percentage of steady-state consumption that the consumer would be willing to give up to move from the actual regime to the steady-state allocation. T&G, T and G refer to 'taxes and spending', 'taxes only' and 'spending only' based fiscal stabilization, respectively. Both technology and cost-push shocks are used.

high and maturity particularly short.[21]

In contrast, when, as in the latest evidence on the form of fiscal consolidations from the IMF (2012), fiscal stabilization largely takes place through government spending, the gains to delegation are far more fragile. Under nominal-income targeting the gains to delegation are only positive, and still modest, if maturity is sufficiently low and turn negative for high debt maturities. While the price level target is only beneficial if debt to output ratios are sufficiently low and maturities sufficiently long. Again, even in the cases where there are benefits to delegation when fiscal adjustment is through spending alone, these gains are modest.

We can gain intuition for these results by returning to the plots of the impulse response functions following an i.i.d. cost-push shock in Figures 4-5 where the permutation of fiscal instruments, available to the fiscal authority, varies across the figures.[22] Considering the case of the fiscal authority having access to both fiscal instruments in Figure 4 and again allowing for the two scenarios of high debt – short maturity and low debt – long maturity, we explore the policy mix under the two delegation schemes. For price level targeting the outcomes are very close to those under commitment and, since commitment largely eliminates inflation, the form of MPLT is optimally chosen to be strict, i.e. the limiting case of $\Phi_p = 0$. Over the time horizon plotted it even appears as though debt is permanently higher, although it is actually the case that debt very gradually returns to its steady state. In essence the strict price level target prevents the policy maker being tempted to inflate away the debt. This in turn has a beneficial impact on expectations allowing outcomes to move closer to the case of cooperative commitment.

Under MNIT, given that taxes are employed as the fiscal instrument, the optimal nominal-income target is strict across both cases of debt level/maturity considered, i.e. the limiting case of $\Phi_n = 0$. (The desirability of strict MNIT is common across all but the most heavily indebted economies in our sample of economies considered in Section 6. Only Greece, Italy and Japan would benefit from implementing a flexible form of MNIT, given taxation is the fiscal stabilization instrument.) In this case, MNIT produces results which, while they improve upon cooperative discretion do not achieve as significant an improvement as MPLT. Essentially, MNIT produces an outcome which is a half-way house between cooperative commitment and discretion, which is clearly observed in Figure 7.

Given the form of monetary objectives under strict MNIT, the loss of the monetary authorities

[21] In most cases the second bar in each pictogram is virtually indistinguishable from the third bar such that the delegation scheme comes close to achieving the welfare levels under commitment.

[22] We only consider cost-push shocks when discussing transmission mechanisms. All losses/gains, however, are computed based on both shocks.

will be eliminated if $p_t = -\hat{Y}_t = -\theta\hat{C}_t$ so a reduction in consumption can increase the monetary authority's tolerance of positive inflation, *cet. par.* This in turn reduces the policy makers' desire to reduce government debt as rapidly as they would under cooperative discretion, thereby moving equilibrium outcomes towards those observed under commitment, see Figure 1 in Appendix E.

Expectations of future price stabilization play a very important role in both regimes, MNIT and MPLT. These expectations drive the level of consumption down by enough to generate the required reduction in marginal costs. In this sense inflation is stabilized by mere expectations of future policy. This is particularly relevant for MNIT as the nominal interest rate initially falls, but the resulting reaction of inflation is sufficient to ensure a welfare gain relative to the outcome under cooperative discretion. While price stabilization is expected, it does not need to be achieved under MNIT as quickly as under MPLT. For the monetary policy maker, who determines the speed of adjustment, the desire to reduce the increased price level is offset by lower real income, and these variables can only move in opposite directions if the adjustment is slow. However, since the commitment policy using taxes as its fiscal instrument generates negligible inflation – and therefore a near constant price level – a delegated policy objective of strict MPLT comes closest to mimicking commitment outcomes.

When we turn to government spending based stabilization the fiscal environment starts to matter much more. With the price level target, the optimal target is not strict as it is when taxes are part of the policy mix, and during the transition the price level deviates from base substantially. In this case the delegated policy allows the price level to initially rise before returning it to base. Since commitment policy neither generates price stability nor is hugely successful in offsetting the cost push shock in this case, this softens the desirability of making the price level target strict. In the high debt – short maturity scenario welfare actually deteriorates under a delegated price level target. The eventual stabilization of the price level means that the initial inflation is undone relatively quickly which mitigates the ability of surprise inflation to reduce the need for subsequent fiscal adjustments to stabilize debt. The policy mix involves an initial fall in interest rates and government spending, the latter seeking to reduce both debt and the initial boost to inflation caused by the cost-push shock. Subsequently, the interest rate and government spending rise, such that the balance of this combination is tilted towards reducing aggregate demand to facilitate the return of the price level to its initial value. Such behavior generates large deviations of the price level from the target. However, even if the optimal weight on the price level target, Φ_p, is reduced, the constraint to stabilize price level is too restrictive to deliver welfare gains. In contrast, when debt is low and maturity long, price level targeting delivers outcomes similar to those under commitment.

Turning to MNIT with only spending as a fiscal instrument, the high debt – short maturity case allows the fiscal authority to raise spending in the knowledge that the monetary authority will raise interest rates to achieve the nominal income target. This gives rise to a large fall in the value of debt. Thereafter, government spending is reduced slightly and monetary policy remains tight to return debt and the price level to their long-run values. Therefore, MNIT allows monetary and fiscal policy to generate an initial reduction in the value of government debt, before they gently return debt and the price level to steady state. In contrast, when debt levels are low but maturity long, MNIT delegation worsens welfare outcomes: the desire to stabilize nominal income means that the initial fall in the real value of debt is reduced once the government spending substantially increases in order to stabilize nominal income. The magnitude of the volatility of spending and inflation over the transition explains the deterioration in welfare.

In summary, with access to the tax instrument, the two policy makers can deal effectively with shocks, while the two delegation schemes, especially price-level targeting, can reduce welfare losses below those under cooperative discretion. This is due to the fact that the delegated nominal target prevents the policy makers inducing inflation surprises as a means of stabilizing debt. Without access to the tax policy instrument, the response to the cost-push shock in particular is far less effective and the optimal policy response includes a substantial deviation from short-run price level control. As a result the delegated targets can actually worsen outcomes by encouraging larger policy adjustments. Price level targeting increases the pace of adjustment towards the price level target relative to nominal income targeting, this is desirable when debt is large and of short maturity, but is less desirable when debt is of longer maturity.

6 Country Specific Experience

The results indicate that the steady-state debt level and debt maturity structure matter for the performance of monetary delegation schemes. In this section, we seek to show that these findings are relevant in practice. In particular, we look at how the different delegation schemes would fare for the debt and maturity structures of a set OECD countries, where debt and maturity are set to their levels measured in 2015.

Table 1 describes the welfare outcomes under commitment, discretion and the two delegation schemes. More specifically, Table 1 reports the values of social welfare losses for a representative sample of advanced economies. Columns (1)-(2) determine the position of a country in Figure 1. All losses are measured in terms of the equivalent percentage loss of steady state consumption,

Table 1: The value of delegation for selected countries

	Θ	m_a	Fiscal Stabilization T&G						Fiscal Stabilization G					
			MPLT		MNIT		D	C	MPLT		MNIT		D	C
			L	Δ^L	L	Δ^L	L^D	L^C	L	Δ^L	L	Δ^L	L^D	L^C
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
FR	89.4	6.8	0.02	0.50	0.23	0.28	0.52	0.02	0.65	-0.02	0.67	-0.04	0.63	0.47
GE	48.4	6.6	0.02	0.49	0.22	0.29	0.51	0.02	0.50	0.14	0.67	-0.04	0.63	0.46
GR	175.0	7.9	0.02	0.46	0.23	0.25	0.48	0.02	0.95	-0.34	0.68	-0.06	0.61	0.47
IR	82.4	12.4	0.02	0.44	0.22	0.24	0.46	0.02	0.47	0.14	0.67	-0.06	0.61	0.46
IT	113.5	6.4	0.02	0.50	0.24	0.29	0.53	0.02	0.79	-0.16	0.68	-0.04	0.63	0.47
JP	126.0	6.8	0.02	0.49	0.24	0.28	0.52	0.02	0.83	-0.20	0.68	-0.05	0.63	0.47
SP	64.8	6.0	0.02	0.51	0.23	0.30	0.53	0.02	0.59	0.05	0.67	-0.03	0.64	0.47
SE	-18.4	5.0	0.02	0.45	0.21	0.26	0.47	0.02	0.46	0.15	0.67	-0.06	0.61	0.46
SW	24.9	8.8	0.02	0.47	0.21	0.28	0.49	0.02	0.46	0.16	0.67	-0.05	0.62	0.46
UK	80.3	14.5	0.02	0.43	0.22	0.23	0.46	0.02	0.46	0.15	0.67	-0.06	0.61	0.46
US	79.9	5.7	0.02	0.52	0.23	0.30	0.54	0.02	0.70	-0.06	0.67	-0.03	0.65	0.47

Notes: Θ in column (1) is annualized debt to output ratio, measured in percents; m_a in column (2) is maturity of debt measured in years. L^D and L^C are losses under benevolent discretion and commitment, respectively, L measures welfare loss under the corresponding delegation regime, and $\Delta^L = L^D - L$ is the loss relative to benevolent discretion; all welfare losses in columns (3) – (14) are percentages of steady-state consumption that the consumer would be willing to give up to move from the actual regime to the deterministic steady state allocation. The IMF Fiscal Monitor is the source of data in columns (1) and (2). The data are for 2015 for all countries except Greece, the data for Greece are for 2014.

which would match the welfare losses due to the stochastic volatility of the economy. Columns (8) and (14) report the loss under commitment regime (C). It is apparent that the loss, when policy makers are free to commit, in tax-based stabilization regimes (T&G) is much smaller than the loss in spending-based (G) regimes. This largely reflects the relative efficacy of the two fiscal instruments in combination with conventional monetary policy. The tax instrument can act to offset cost-push shocks while monetary policy can mitigate the inflationary consequences of technology shocks. In contrast government spending is less effective as a stabilization tool in the face of either type of shock.

Columns (7) and (13) report the loss under the cooperative discretionary regime (D) and allow us to infer the size of stabilization bias (not reported, but see Figure 3). The stabilization bias is of order of 0.17% of steady state consumption for spending-based stabilization policies, while it is around three times that for tax-based stabilization policy. Therefore, while the combination of tax and monetary policy is particularly potent in the hands of a benevolent policy maker who is able to commit, when the policy makers are forced to act in a time-consistent manner this potency leads to a significant increase in welfare losses (above those attained under cooperative commitment) relative to the case where government spending is the fiscal instrument.

Columns (3), (5) and (9), (11) report the loss under a particular delegation scheme. Furthermore, columns (4), (6) and (10), (12) report the gain $\Delta^L = L^D - L$ if the particular delegation scheme is implemented, where L is the loss under the corresponding delegation regime. A positive value of Δ^L indicates the delegation scheme has improved welfare, while anything negative has worsened welfare. For example, if Germany implements MPLT delegation while the German fiscal authority operates with taxes and spending, the outcome will nearly replicate the best outcome under commitment policy.[23] However, if Japan implements MPLT while their fiscal authority uses spending as the fiscal instrument, then the welfare losses of 0.17% of steady-state consumption due to stabilization bias will be increased by further 0.20%, such that they will more than double. It is interesting to note that despite the fact that the underlying stabilization bias is greatest when taxes are the fiscal instrument employed by the fiscal authorities, the effectiveness of delegating a price-level target to the monetary authority is so large that all economies would be better off under such a scheme.

7 Conclusion

This paper revisits the idea that discretionary monetary price level and nominal-income targeting delegation schemes can reduce the welfare losses below those achieved under cooperative discretionary policy. We demonstrate that in an economy with a strategic fiscal policy maker, who can act as an intra-period leader and who seeks to follow a policy which minimizes the social welfare loss as a policy objective, delegating a price level target to the monetary policy maker results in a substantial welfare gain for a wide range of debt to output ratios and 'not too short' maturities, but only if fiscal policy uses the tax rate as its policy instrument. Using government spending as the fiscal instrument substantially limits the range of acceptable combinations to those economies with relatively low debt to output ratios and long debt maturity. Out of a sample of 11 advanced economies, only the low debt economies of Sweden and Switzerland would benefit from delegating a price-level target to the monetary authority when government spending serves as the fiscal instrument, and none would wish to adopt a nominal income target.

[23] Further calculations show that only 0.10% of the original stabilization bias of 0.49% will be left.

The mechanisms underpinning these results are driven by the ability of the different delegation schemes to offset the stabilization bias inherent in the New Keynesian model extended to include fiscal policy. Under commitment, policy makers can effectively offset both cost push and technology shocks with very little drift in the price level provided they have access to distortionary taxes as a policy instrument. Without access to taxation, but possibly with access to government consumption, their ability to offset cost-push shocks is much reduced, welfare costs increase and the optimal drift in the price level is correspondingly greater. However, without an ability to commit, policy makers face a temptation to inflate away the fiscal consequences of shocks which is particularly damaging relative to commitment when taxes are available a stabilization tool. Delegation schemes, which impart an element of price level control, help mitigate the risks of governments being tempted to induce inflation surprises to reduce debt levels and, when taxes are used as a stabilization tool, allow monetary and fiscal policy to return to effectively responding to shocks. In contrast, when taxes are not available, optimal commitment policy allows for a non-trivial degree of price level drift such that adopting a price-level or nominal-income target can actually worsen outcomes relative to the case without delegation.

Although recent fiscal consolidations have tended to be heavily skewed towards adjustment of government spending, our comparison of the relative efficacy of fiscal instruments in stabilization of the economy reveals the relative pre-eminence of taxes. As noted immediately above, they are best suited to mitigating the effects of cost-push shocks on inflation, while the associated losses associated with the stabilization bias can be significantly reduced through the adoption of a price level target by an independent monetary authority.

Despite demonstrating these results using a particular model, this model is at the core of more general and empirically relevant DSGE models widely used in policy analysis. The economic mechanisms discussed here are likely to apply and our results remain valid for this wide class of models.

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