

# Parameter misspecification with optimal targeting rules and endogenous objectives

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## Abstract

Recent research in monetary economics has followed the advice of McCallum (1988) and investigated the robustness properties of monetary policy rules by evaluating them in a variety of models. Evaluation across models is typically based on an exogenously specified loss function. However, the theory on which many recent monetary policy models are based implies that changes in the structure of the model may also have consequences for the policy objectives the central bank should pursue. Objectives are endogenous, not exogenous to the model. In this paper, I investigate the impact of endogenous objectives on the evaluation of optimal targeting rules for monetary policy.

## 1 Introduction

There is a fundamental dichotomy that underlies most monetary policy analysis. On the one hand, there is the model of the economy, consisting of a set of structural equations that characterize the private sector's behavior. On the other hand, there are the preferences of the policy maker. This dichotomy allows economists to provide the policy maker with a menu of the consequences of alternative choices, leaving it to the policy maker to choose

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from among the available options. This view is reflected in a recent paper by McCallum and Nelson:

“Accordingly, it can be useful to explore the way in which difference properties of a modelled economy—e.g., the variances of the endogenous variables—are related to policy rule parameters, leaving it to actual policy makers to assign the relevant weights [to policy objectives].” McCallum and Nelson (2004, p. 5).

Recent work in macro, most prominently by Woodford (2003), calls into question this dichotomy between economic structure and policy objectives. He shows that the standard quadratic loss function that has been a common component of much of the monetary policy literature can be, under suitable conditions, interpreted as a second order approximation to the welfare of the representative agent. But critically, this interpretation of the loss function breaks the standard dichotomy between economic structure and objectives; the relative weights on the variables appearing in the loss function, and even the list of variables that should appear, depend on the structure of the economic model.<sup>1</sup> The policy maker cannot find the marginal rate of substitution between the target variables in a manner that is independent of the transmission mechanism that governs the marginal rate of transformation between them. Even the choice of and definition of the target variables will depend on the policy maker’s views of the transmission mechanism.

This has two important implications. First, it will rarely be appropriate to combine the same loss function with different structural models of the economy. Different models will imply different loss functions. Second, in assessing model and parameter uncertainty, uncertainty about key structural parameters will also imply uncertainty about the correct loss function.

At a practical level, the endogeneity of objectives has implications for the assessment of policy robustness. It may, for example, be inappropriate to take a rule designed to minimize a loss function in one model and evaluate its performance in a different model using the same original loss function.

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<sup>1</sup>See, for example, Erceg, Henderson, and Levin (2000), Steinsson (2003), and Amato and Laubach (forthcoming).

The objective function appropriate for one model cannot be used directly to evaluate outcomes in a different model. Thus, McCallum's influential recommendation to use multiple models to explore the robustness of policy rules (McCallum 1988, 1999) may be less straightforward than it appears.

There is another implication of the dependence of objectives on structure. Just as one could follow McCallum and evaluate the consequences of using a rule optimized for one structural model in a different structural model, one similarly needs to investigate the consequences of employing a rule optimized for one objective function when the true social objective is different. That is, what are the consequences for social welfare if the central bank pursues policy based on an objective function that differs from social welfare? To be more specific, what are the consequences of implementing a policy rule that is optimal from the perspective of the standard quadratic loss function in inflation and output gap volatility if the economy is actually characterized by a model that implies welfare should be measured by a different loss function?

In this paper, I explore some of the implications of this link between economic structure and objectives. The model employed in the analysis draws on the recent extension of the basic new Keynesian model by Benigno and Woodford (2004) that explicitly incorporates the case of a distorted steady state. Two aspects of this model will be the primary foci of the analysis. These are the degree of structural inflation inertia and the degree of nominal price stickiness. Both have generated much empirical debate and also appear to be important for the evaluation of alternative policies. One of the earliest criticisms of forward-looking models of inflation was that they were incapable of matching the highly serially correlated nature of actual inflation processes (Nelson 1998). While the persistence displayed by inflation could result from serially correlated inflation shocks or from the behavior of monetary policy (Goodfriend and King 2001), there is great uncertainty about the respective roles of forward and backward elements in the inflation process. For example, Rudebusch (2002) estimates the weight on lagged inflation to be over twice that on expected future inflation, while Galí and Gertler (1999) find essentially the reverse. This uncertainty about the degree of structural inflation inertia is unfortunate, since the existing literature has identified

it as one of the most critical factors affecting the evaluation of alternative policies. For example, Rudebusch (2002) found that nominal income targeting does well when inflation is forward looking but poorly when it is more backward looking. Similarly, when current inflation is affected by both expected future inflation and lagged inflation, the performance of price-level targeting deteriorates significantly as the relative weight on lagged inflation rises (Walsh 2003a), and Levin and Williams (2003a) demonstrate that policy rules that are optimal in a forward-looking model can lead to disastrous results if the true model is in fact backward looking.

The degree of nominal price rigidity, like the degree of structural inflation inertia, is also an issue around which there is great uncertainty. Early structural estimates of forward-looking new Keynesian Phillips curves obtained values for the average period between price adjustments that were very long, on the order of a year or more (Galí and Gertler 1999, Sbordone 2002, and Dennis 2003). This is much longer than is consistent with micro evidence (Bils and Klenow 2002). More recently, Christiano, Eichenbaum, and Evans (forthcoming) and Eichenbaum and Fischer (2004) have extended the basic new Keynesian Phillips curve to allow for structural inflation inertia, the use of lagged information, and variable rates of capital utilization, and they obtained estimates closer to the micro evidence on how long prices remain unchanged.

While most of the literature on monetary policy has analyzed various forms of instrument rules, I represent monetary policy in terms of a specific targeting rule (Svensson 2003, Svensson and Woodford 2004). These targeting rules are based on the first order conditions from the central bank's policy decision problem. They depend, therefore, on both the nature of the central bank's objectives and the constraints imposed by the economy's structure.

In the next section, the basic model is set out and the optimal targeting rule that minimizes the expected present discounted value of a second order approximation to the welfare of the representative household is derived. The way in which this objective function depends on the model's structural parameters is discussed. Section 3 then considers the case in which the central

bank's model of the economy is correct, but policy is based on the wrong objectives. The purpose of this section is to investigate how conclusions reached in standard models with exogenous objectives might need to be altered once model consistent objectives are employed. Section 4 examines the robustness of the optimal targeting rule to parameter misspecification. Section 5 looks at the consequences of parameter misspecification when the central bank's targeting rule is also based on incorrect objectives. Conclusions are summarized in the final section.

## 2 The basic model and optimal targeting rules

The basic model has been described as either new Keynesian or new synthesis (Goodfriend and King 1997, Rotemberg and Woodford 1997, Yun 1997, McCallum and Nelson 1999, Woodford 2003), and the specific version employed here borrows from Benigno and Woodford (2004). They provide a detailed discussion of the underlying assumptions of the model; consequently, the presentation here is kept quite brief.

Define  $x \equiv \hat{Y}_t - \hat{Y}_t^n$  as the gap between actual output  $\hat{Y}_t$  and the flexible-price equilibrium output level  $\hat{Y}_t^n$  (all expressed as log deviations from the steady-state). The Euler condition from the representative household's consumption decision can be represented as

$$x_t = E_t x_{t+1} - \left(\frac{1}{\sigma}\right) (i_t - E_t \pi_{t+1} - r_t^n), \quad (1)$$

where  $i$  is the nominal interest rate and  $r^n$  is the Wicksellian real rate of interest. This equilibrium real interest rate is equal to

$$r_t^n \equiv \sigma \left\{ E_t \left( \hat{Y}_{t+1}^n - \hat{Y}_t^n \right) - (1 - s_C) E_t \left( \hat{G}_{t+1} - \hat{G}_t \right) \right\},$$

where  $\hat{G}_t$  is the log deviation of government consumption from its steady-state value and  $s_C$  is the steady-state ratio of consumption to output. The parameter  $\sigma$  is equal to the representative household's coefficient of relative risk aversion divided by  $s_C$ , the steady-state ratio of consumption to income.

Benigno and Woodford (2004) show that equilibrium output with flexible prices depends positively on government spending through a standard neo-classical labor supply response, negatively on a distortionary income tax rate, and positively on aggregate productivity. If  $a_t$  is an aggregate productivity shock,  $\tau_t$  is the income tax shock, and  $\bar{\tau}$  is the steady-state tax rate,

$$\hat{Y}_t^n = \frac{\sigma \hat{G}_t + \phi(1 + \nu)a_t - [\bar{\tau}/(1 - \bar{\tau})] \tau_t}{\omega + \sigma},$$

where  $\nu$  is inverse of the wage elasticity of labor supply,  $\phi$  is the elasticity of firm output with respect to labor input, and  $\omega = \phi(1 + \nu) - 1 > 0$  is the inverse of the elasticity of firm marginal cost with respect to output.

Inflation adjustment is based on the assumption that each period a fixed fraction  $1 - \alpha$  of randomly chosen firms optimally adjust their price while the remaining firms simply index their price to a fraction  $\gamma$  of last period's inflation rate. As Woodford (2003) shows, this assumption yields an aggregate inflation equation of the form

$$\pi_t - \gamma\pi_{t-1} = \beta (E_t\pi_{t+1} - \gamma\pi_t) + \kappa x_t. \quad (2)$$

The parameter  $\gamma$  measures the degree of structural inflation inertia,  $\beta$  is the discount rate, and the output elasticity of inflation,  $\kappa$ , is given by

$$\kappa = \frac{(1 - \alpha)(1 - \alpha\beta)}{\alpha(1 + \theta\omega)}(\omega + \sigma),$$

where  $\theta$  is the demand elasticity faced by individual firms.

## 2.1 Endogenous policy objectives

Woodford (2003) has stressed that in models based on well defined optimization problems for the agents in the model, one should view the maximization of the welfare of the representative agent as the appropriate objective of policy. In the model that leads to (1) and (2), Woodford shows social welfare, interpreted as a second-order approximation to the welfare of the represen-

tative household, is proportional to

$$\mathcal{L}_t^{sl} = E_t \sum_{i=0}^{\infty} \beta^i \left[ (\pi_{t+i} - \gamma \pi_{t+i-1})^2 + \lambda \left( \hat{Y}_{t+i} - Y_{t+i}^* \right)^2 \right], \quad (3)$$

where  $Y_t^*$  is the first-best, efficient level of output (expressed as a log deviation around the steady-state). Benigno and Woodford (2004) show that this first-best output level is given by

$$Y_t^* = w_1 \hat{Y}_t^n - w_2 \hat{G}_t + w_3 \hat{\tau}_t,$$

where

$$w_1 = \frac{\omega + \sigma + \Phi(1 - \sigma)}{\xi},$$

$$w_2 = \frac{\Phi \sigma s_c^{-1}}{(\omega + \sigma) \xi},$$

$$w_3 = \frac{\bar{\tau}}{(1 - \bar{\tau}) \xi},$$

and

$$\Phi = 1 - \frac{\theta - 1}{\theta} (1 - \bar{\tau}) < 1,$$

where  $\xi \equiv (\omega + \sigma) + \Phi(1 - \sigma) - \frac{\Phi \sigma (s_c^{-1} - 1)}{\omega + \sigma}$ . The parameter  $\Phi$  is a measure of the steady-state distortions in the economy. These arise from two sources: the presence of imperfect competition (reflected in  $\theta$ ) and taxes. If  $\Phi$  is zero (as is often assumed),  $w_1 = 1$  and the efficient level of output moves one-for-one with the flexible-price output level.

In the social loss function  $\mathcal{L}_t^{sl}$ , the weight placed on the welfare gap relative to inflation,  $\lambda$ , depends on the structural parameters of the model. In particular, it is given by

$$\lambda = \frac{\kappa}{\theta} \left[ \frac{\omega + \sigma + \Phi(1 - \sigma) - \frac{\Phi \sigma (s_c^{-1} - 1)}{\omega + \sigma}}{\omega + \sigma + \Phi(1 - \sigma)} \right] = \frac{\kappa}{w_1 \theta}. \quad (4)$$

The two parameters of primary interest,  $\gamma$  measuring the degree of struc-

tural inflation inertia and  $\alpha$  measuring the degree of price rigidity, have difference effects on the loss function. The value of  $\gamma$  affects the social loss function, but only in terms of the definition of the quasi-difference of inflation whose volatility is associated with a welfare loss. The relative weight placed on objectives,  $\lambda$ , is independent of the degree of structural inflation inertia. The degree of nominal price stickiness,  $\alpha$ , affects  $\lambda$  through its effect on  $\kappa$ , the output gap elasticity of inflation. Greater price rigidity (an increase in  $\alpha$ ) reduces  $\kappa$  and lowers the relative weight the central bank should put on stabilizing the output gap measure. With a higher  $\alpha$ , it becomes more important to stabilize the quasi-difference of inflation.

It is convenient to re-express the model in terms of the gap between output and the efficient output level, since this is the gap variable that appears in the loss function (3). Let  $\tilde{x}_t \equiv \hat{Y}_t - Y_t^*$  be this welfare gap, and define  $\mu_t \equiv Y_t^* - \hat{Y}_t^n$  as the gap between the efficient output level and the flexible-price level. Then  $x_t = \tilde{x}_t + \mu_t$ , and the model can be written in terms of the welfare gap  $\tilde{x}_t$  as

$$\tilde{x}_t = E_t \tilde{x}_{t+1} - \left( \frac{1}{\sigma} \right) (i_t - E_t \pi_{t+1} - \tilde{r}_t^n) \quad (5)$$

and

$$\pi_t - \gamma \pi_{t-1} = \beta (E_t \pi_{t+1} - \gamma \pi_t) + \kappa \tilde{x}_t + \kappa \mu_t, \quad (6)$$

where the real interest rate variable  $\tilde{r}$  is now defined as

$$\tilde{r}_t^n \equiv \sigma \left\{ E_t (Y_{t+1}^* - Y_t^*) - (1 - s_C) E_t (\hat{G}_{t+1} - \hat{G}_t) \right\}. \quad (7)$$

Note that the “cost shock” in (6) arises from any stochastic variation in the wedge between the efficient level of output and the flexible-price output level. When  $\Phi > 0$ ,  $\mu_t$  fluctuates in response to movements in the flex-price output level, government spending, and taxes. The standard deviation of the cost shock is proportional to  $\kappa$ ; increases in price rigidity that reduce the output gap elasticity of inflation also reduce the volatility of cost shocks. Demand shocks, represented by  $\tilde{r}_t^n$  are potentially correlated with the cost

shocks.<sup>2</sup>

The loss function (3) is model consistent – it corresponds to the second order approximation to the welfare of the represent agent in the model that gave rise to the structural equations (5) and (6) – and I will refer to it as the social loss function. However, given the structural equations (5) and (6), the vast majority of researchers have assumed that policy objectives can be represented by a loss function of the form

$$\mathcal{L}_t^{std} = \frac{1}{2} E_t \sum_{i=0}^{\infty} \beta^i (\pi_{t+i}^2 + \bar{\lambda} y_{t+i}^2), \quad (8)$$

where  $y$  is an output gap measure. In this standard specification,  $\bar{\lambda}$  is an exogenous parameter, treated as independent of the specification of the structural equations of the model. Critically, this loss function is treated as fixed as other aspects of the structural model are varied.<sup>3</sup> For example, Levin and Williams (2003) employ such a loss function to evaluate the consequences of employing a policy that is optimal for one model when the economy is characterized by a difference economic model.<sup>4</sup> Angeloni, Coenen, and Smets (2003) investigate the implications of misspecifying the degree of structural inflation inertia, with outcomes all evaluated using a fixed objective function. A similar exercise is conducted by Walsh (2003).

The loss function in (3) contrasts with (8) in three ways. First, social loss depends on the volatility of a particular quasi-difference of the inflation rate rather than on inflation volatility itself. Second, the appropriate output gap measure is defined specifically in terms of the distortions that underlie the economic model. And third, the relative weight placed on the two objectives is a function of the model’s structural parameters.

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<sup>2</sup>It is common to treat demand and cost shock disturbances as if they were independent. Neglecting their correlation may be important when evaluating optimal simple rules.

<sup>3</sup>As noted above, Erceg, Henderson, and Levin (2000), Steinsson (2003) and Amato and Laubach (2004) are among the exceptions.

<sup>4</sup>In common with many other authors, they also include an interest rate smoothing objective, again with an exogenous weight on this objective. In his comments on the Levin and Williams paper, Ireland (2003) notes that using a common loss function across alternative structural models may be inconsistent.

In what follows, one of the objectives will be to investigate how policy conclusions depend on whether a standard loss function such as (8) is used to evaluate outcomes or whether outcomes are evaluated using the social loss function (3).

## 2.2 Specific targeting rules

The model consisting of equations (5) - (7) plus the definition of  $\mu_t$  will constitute the central bank's reference model. The best way to model policy is a topic of much debate (e.g., Svensson 2003, 2004a, 2004b, McCallum and Nelson 2004). I focus here on specific targeting rules of the type analyzed by Svensson and Woodford (2004), and Svensson (2003, 2004a). These correspond to the robustly optimal rules analyzed by Giannoni and Woodford (2003). Specific targeting rules are derived from the first order conditions of the central bank's decision problem and are represented as a linear relationship among endogenous variables. They thus represent an equilibrium condition among the target variables that the central bank commits to maintain.

Adopting the timeless perspective, the specific targeting rule that minimizes the social loss function (3) subject to (5) - (7) is

$$\pi_t - \gamma\pi_{t-1} = - \left( \frac{\lambda}{\kappa} \right) (\tilde{x}_t - \tilde{x}_{t-1}). \quad (9)$$

In terms of the underlying structural parameters,  $\lambda/\kappa = (w_1\theta)^{-1}$ , so this targeting rule can be written as

$$\pi_t - \gamma\pi_{t-1} = - (w_1\theta)^{-1} (\tilde{x}_t - \tilde{x}_{t-1}). \quad (10)$$

Because (9) involves contemporary endogenous variables, it represents an equilibrium condition rather than an explicit rule for setting the policy instrument. The actual implementation of policy requires that the central bank determine the nominal interest rate consistent with (9). As discussed in Svensson (2004b), this will involve the bank constructing forecasts (possibly judgement based) and setting its interest rate instrument so that the equi-

librium consistent with those forecasts (or projections) satisfies (9). Since my interest is primarily on how the evaluation of targeting rules is affected by whether model consistent objectives or exogenous objectives are used, I will simply assume that the central bank is able to credibly commit that the specific targeting condition given by (9) is satisfied. As Svensson and Woodford (2004) note,

“...the central bank may announce only the targeting rule ...that it intends to follow. If this announcement is credible, in the sense that people expect the bank to succeed in bring about the target condition, or at least expect others to expect the condition to hold, the optimal equilibrium will again be the only outcome.”  
(Svensson and Woodford 2004)

Suppose the central bank chooses policy to minimize the social loss function (3) subject to (5) and (6). Letting  $z_t \equiv \pi_t - \gamma\pi_{t-1}$ , this problem can be written as

$$\min E_t \sum_{i=0}^{\infty} \beta^i (z_{t+i}^2 + \lambda \tilde{x}_{t+i}^2)$$

subject to

$$z_t = \beta E_t z_{t+1} + \kappa \tilde{x}_t + \kappa \mu_t. \quad (11)$$

This is isomorphic to a standard policy problem with the exception that the variable  $z$  replaces inflation in both the objective function and the inflation adjustment equation. The optimal targeting rule from a timeless perspective, given by (10), can be expressed in terms of  $z$  as

$$\tilde{x}_t = \tilde{x}_{t-1} - \left(\frac{\kappa}{\lambda}\right) z_t = \tilde{x}_{t-1} - w_1 \theta z_t. \quad (12)$$

The equilibrium behavior of  $z$  and  $\tilde{x}$  are obtained by jointly solving (11) and (12) under rational expectations. The behavior of  $z$  and  $\tilde{x}$ , and therefore social welfare, are not affected by the value of  $\gamma$ .<sup>5</sup> The equilibrium behavior of the rate of inflation does depend on  $\gamma$ , as does the behavior of the nominal

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<sup>5</sup>Recall that we are considering the case in which the central bank knows the value of  $\gamma$  so that it bases policy on the correct definition of the variable  $z$ .

rate of interest, but the behavior of these two variables is irrelevant for social welfare.

This result illustrates clearly the effects of endogenous objectives. In standard analysis, the loss function is treated as exogenous while aspects of the structural equations are altered. With that approach, policy performance deteriorates as the structural inflation process becomes more inertial. In addition, as Levin and Williams (2003a) demonstrate, policy rules designed for forward-looking models perform poorly when structural equations are characterized by more inertial behavior. However, when evaluating using a loss function that reflects the way the inflation process affects welfare, one finds that loss no longer depends on the degree of structural inflation inertia.<sup>6</sup>

Allowing for endogenous objectives also alters the role of the other parameter of interest,  $\alpha$ . Levin and Williams (2003b), Kurozumi (2003), and Aoki and Nikolov (2004) have made the point that the policy rule (12) is independent of  $\alpha$ . However, the output gap elasticity of inflation ( $\kappa$ ) does depend on  $\alpha$ , and variations in  $\kappa$  affect the variance of the disturbance terms in the inflation equation. Thus, equilibrium inflation and the output gap are affected by  $\alpha$ , even though the optimal specific targeting rule is not.

When the central bank minimizes the standard loss function (8), the specific targeting rule that characterizes optimal policy differs from (9). Assume that the same output gap appears in both. That is,  $y_t \equiv \tilde{x}_t$ .<sup>7</sup> Then, the first order conditions for the optimal commitment (timeless perspective) policy that minimizes (8) subject to (5) are

$$\pi_t + (1 + \beta\gamma)\phi_t - \phi_{t-1} - \beta\gamma E_t\phi_{t+1} = 0$$

and

$$\bar{\lambda}\tilde{x}_t - \kappa\phi_t = 0,$$

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<sup>6</sup>Of course, this result is specific to the way inflation inertia has been modeled here. Steinsson (2003) and Amato and Laubach (2004) show how the approximation to the loss function is affected by alternative approaches to introducing inertia.

<sup>7</sup>I am ignoring the important issues involved in measuring the appropriate output gap. See Orphanides (2003a, 2003b) and Orphanides and Williams (2002).

where  $\phi$  is the Lagrangian multiplier on the inflation adjustment equation. Combining these to eliminate the Lagrangian multiplier yields the specific targeting rule

$$\pi_t = -\left(\frac{\bar{\lambda}}{\kappa}\right)(\tilde{x}_t - \tilde{x}_{t-1}) + \beta\gamma\left(\frac{\bar{\lambda}}{\kappa}\right)(E_t\tilde{x}_{t+1} - \tilde{x}_t). \quad (13)$$

The optimal targeting rule (9) can be compared to the rule given in (13) and followed by a central bank facing the same structural economic model but employing a standard ad hoc quadratic objective function of the form given by (8). When  $\gamma = 0$  (no structural inflation inertia), (13) reduces to the optimal targeting rule (9). When  $\gamma > 0$ , the targeting rules differ in two ways. First, the rule that minimizes social loss is backward looking in the sense that, given the change in the welfare gap, current inflation is a function of lagged inflation. This dependency arises because the central bank should reduce volatility in  $\pi_t - \gamma\pi_{t-1}$ , not  $\pi_t$ . Second, a policy designed to reduce the volatility of inflation is forward looking in that the targeting rule depends on the expected future change in the output gap measure. This aspect of the rule arises because current inflation affects future inflation when  $\gamma > 0$ . And third, the coefficient on the output gap change terms in (9) is independent of  $\kappa$  (see 10), while it is decreasing in  $\kappa$  in (13).

### 3 Right parameters, wrong objectives

In this section, I investigate the implications of ignoring the endogeneity of objectives when the true structural model is known. To do so, I examine the consequences for social welfare if the central bank uses a rule that is optimal for the standard loss function (8) when social welfare is actually represented by (3).

This exercise parallels the more common investigation of robustness in which a rule that is optimal for one model, based on an exogenous loss function, is employed in a different model, with the outcomes evaluated according to the fixed, exogenous loss function. In contrast, I assume the model is constant (and known) and evaluate policies that are optimal for

one loss function when social welfare is actually measured by a different loss function.

Suppose the central bank adopts the standard loss function given by (8) and implements the specific targeting rule that minimizes this loss function. This corresponds to the case of using the correct model but failing to use model consistent objectives. To explore this case, I solve a calibrated version of the model. The baseline parameter values are taken from Giannoni and Woodford (2003b) and Woodford (2003) and are based on the work of Rotemberg and Woodford (1997). The values are reported in Table 1.<sup>8</sup> Parameter values not taken from Woodford’s work are the standard deviations and serial correlation properties of the shocks. In most studies of policy in new Keynesian models, the standard deviations of the cost shock (the disturbance in the inflation equation) and the natural real rate of interest (the disturbance in the IS equation) are taken directly from empirical estimates and are commonly assumed to be uncorrelated. In the present model, the underlying primitives are the standard deviations (and serially correlations) of the productivity, government spending, and tax shocks. For the productivity shocks  $a_t$ , I drawn on standard values from the real business cycle literature and set  $\sigma_a = 0.007$  and  $\rho_a = 0.95$ . The values for the government spending and tax shocks are obtained from estimating AR(1) processes for detrended log fiscal variables, using the data on tax revenue and government consumption from Blanchard and Perotti (2002). Current and lagged detrended log real GDP is included in the tax equation to account for the procyclicality of tax revenues. Both fiscal processes are highly serially correlated.

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<sup>8</sup>All values are based on the structural equations expressed in terms of inflation and interest rates at quarter rates. Following Woodford, the value of  $\lambda$  reported in the table is for the loss function expressed in terms of inflation at annual rates.

Table 1

Calibrated parameters

Structural parameters		Implied Values	
$\alpha$	0.66	$\kappa$	0.024
$\beta$	0.99	$\lambda$	0.048
$\gamma$	0.50	$\omega$	1.235
$\sigma$	0.16	$w_1$	1.0062
$\phi$	1.5	$w_2$	0.0311
$\theta$	7.88	$w_3$	0.1503
$sc$	0.8	$\xi$	1.6633
$\eta$	0.49		
$\bar{\tau}$	0.2		
Innovations			
$\sigma_a$	0.007	$\rho_a$	0.95
$\sigma_G$	0.0108	$\rho_G$	0.99
$\sigma_\tau$	0.024	$\rho_\tau$	0.80

### 3.1 Structural inflation inertia

Let  $\mathcal{L}^{sl}(sl)$  denote the value of the social loss function when the central bank implements the target rule optimal for  $\mathcal{L}^{sl}$ , and let  $\% \Delta \mathcal{L}^{sl}(std)$  denote the percentage increase in social loss when the rule optimal for the standard loss function is used instead. Table 2 reports  $\mathcal{L}^{sl}(sl)$  and  $\% \Delta \mathcal{L}^{sl}(std)$  for various values of structural inflation inertia. Also reported is  $\% \Delta \mathcal{L}^{std}(sl)$ , the percent increase in the standard loss function when the targeting rule optimal for social loss is implemented but outcomes are evaluating using  $\mathcal{L}^{std}$ .  $\% \Delta \mathcal{L}^{sl}(std)$  provides an estimate of the costs of basing policy on the wrong objectives, while  $\% \Delta \mathcal{L}^{std}(sl)$  measures how costly switching to the socially optimal targeting rule would appear to a central bank using the standard objective function. Results are given for  $\bar{\lambda} = \lambda = 0.048$  and  $\bar{\lambda} = 1$ , a standard choice in the literature.

Table 2  
Effects of Structural Inflation Inertia ( $\gamma$ )

$\gamma$	$\lambda$	$\bar{\lambda}$	$\mathcal{L}^{sl}(sl)$	$\% \Delta \mathcal{L}^{sl}(std)$	$\% \Delta \mathcal{L}^{std}(sl)$
0.1	0.048	0.048	0.065	0.3	0.3
0.3	"	"	"	2.6	3.5
0.7	"	"	"	13.3	37.4
1.0	"	"	"	22.6	264.0
0.1	0.048	1	0.065	194.5	127.7
0.3	"	"	"	137.4	93.8
0.7	"	"	"	40.0	32.4
1.0	"	"	"	12.2	17.3

Recall that under the optimal specific targeting rule, social loss is independent of  $\gamma$ . The volatility of inflation rises by a factor of 15 as  $\gamma$  increases from zero to one, but this is irrelevant for social loss. Under the policy designed to minimize the standard form of the loss function, but using a value of  $\lambda$  consistent with the social loss function, the deterioration (as measured by social loss) as structural inflation increases arises because policy stabilizes the volatility of the level of inflation rather than its quasi-difference. To stabilize inflation, the volatility of the output gap increases by 50% as  $\gamma$  increases from zero to one. This suggest that a policy designed to minimize the standard loss but with a greater weight on output gap volatility might lead to a smaller deterioration of social loss. This is the case as shown by the bottom half of Table 1. When  $\gamma = 0$ , (9) and (13) no longer yield the same outcomes, with the policy based on the incorrect loss function producing significantly higher loss. As structural inflation inertia increases, however, the policy based (incorrectly) on the standard loss function and with a high weight on output gap fluctuations undergoes a relative improvement.

For either  $\bar{\lambda} = \lambda$  or  $\bar{\lambda} = 1$ , loss as measured by  $\mathcal{L}^{std}$  increases with structural inflation inertia under targeting rule (13). However, when  $\bar{\lambda} = 1$ , social loss under the policy optimal for the standard loss function actually declines. Thus, employing the wrong loss function can provide misleading

conclusions about the impact on social welfare of greater backward-looking aspects in the model. When the theoretically correct value of  $\lambda$  is used in the loss function (the top panel of Table 1), policy based on the targeting rule derived from  $\mathcal{L}^{std}$  is more robust than the targeting rule based on  $\mathcal{L}^{sl}$ , particularly if there is a high degree of structural inflation inertia. However, if  $\bar{\lambda}$  takes on a larger value, this conclusion is generally reversed. With a large weight on output gap volatility, both rules perform poorly when structural inflation is low, while they both improve significantly if  $\gamma$  is large.

While the robustly optimal targeting rule succeeds in minimizing social loss, achieving outcomes that do not depend on  $\gamma$ , the last column of the table suggests this rule would not appear very attractive to a central bank using the standard loss function (8), except for low values of both  $\bar{\lambda}$  and  $\gamma$ . Using a standard loss function to evaluate policy rules would incorrectly conclude that the rule (9) is not robust to misspecification of  $\gamma$  even though, in fact, it achieves a level of loss that is both lower than that obtained under (13) and makes welfare independent of the value of  $\gamma$ .

### 3.2 Nominal rigidity

The parameter  $\alpha$  plays two roles in the standard analysis of optimal targeting rules. First, it affects the output gap elasticity of inflation  $\kappa$ . Second, by affecting  $\kappa$ , it also alters the coefficient that appears in the targeting rule (9). When the endogeneity of objectives is recognized, however,  $\lambda$  is also affected by  $\alpha$ , and the ratio  $\lambda/\kappa$  that appears in the targeting rule is actually independent of  $\alpha$  (see 10). This last point, emphasized by Levin and Williams (2004) in the case of an optimal non-inertial commitment policy, implies that uncertainty about the degree of nominal price stickiness does not affect policy behavior under the optimal commitment targeting rule.<sup>9</sup>

Thus, when the central bank treats the reference model as given, the targeting rule it should follow is independent of the degree of nominal rigidity. Greater price stickiness reduces  $\kappa$ , requiring larger output gap movements to control inflation. But an increase in  $\alpha$  also makes it more important to

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<sup>9</sup>See also Kimura and Kurozumi (2003) and Aoki and Nikolov (2004).

stabilize inflation, reducing the weight  $\lambda$  on  $\tilde{x}^2$  in the loss function. These two effects cancel out, leaving the targeting rule independent of  $\alpha$ . Equilibrium outcomes still depend on  $\alpha$  through its impact on the slope of the Phillips curve and the size of “cost shocks” in the inflation equation, since the standard deviation of these shocks is proportional to  $\kappa$ .

Table 3 reports results outcomes under the different targeting rules for various values of  $\alpha$ . Also shown are the implied values of  $\kappa$  and  $\lambda$  associated with the different values of  $\alpha$ . The top half of the table shows that basing policy on the standard loss function leads to little deterioration in social welfare except when prices are very rigid. If outcomes are evaluating using the standard loss function with  $\bar{\lambda} = \lambda$ , the targeting rule based on social loss would be judged to perform poorly when prices are fairly flexible. A central bank evaluating outcomes (incorrectly) using (8) would conclude that the targeting rule (9), a rule that actually minimizes social loss, is an undesirable rule except when prices are very sticky.

Table 3

Effects of Nominal Price Rigidity ( $\alpha$ )						
$\alpha$	$\kappa$	$\lambda$	$\bar{\lambda}$	$\mathcal{L}^{sl}(sl)$	$\% \Delta \mathcal{L}^{sl}(std)$	$\% \Delta \mathcal{L}^{std}(sl)$
0.2	0.43	0.428	0.428	1.974	7.6	142.8
0.4	0.12	0.121	0.121	0.485	13.0	76.1
0.7	0.02	0.018	0.018	0.042	4.5	6.8
0.9	0.00	0.001	0.002	0.003	51.0	11.1
0.2	0.43	0.863	1	1.974	0.8	1.2
0.4	0.12	0.244	"	0.485	9.5	6.7
0.7	0.02	0.035	"	0.042	109.2	81.5
0.9	0.00	0.003	"	0.003	595.9	422.0

When  $\bar{\lambda} = 1$ , the targeting rule from the standard loss function leads to a large percentage decrease in social welfare if prices are very sticky. The deterioration in welfare under the standard loss rule with a fixed  $\bar{\lambda}$  as

$\alpha$  increases reflects the fact that policy should be putting less weight on output gap volatility as  $\alpha$  increases. The standard loss function treats this weight as fixed and therefore it undervalues inflation objectives when prices are very sticky. However, while a rule designed for the wrong loss function results in a large percentage increase in loss, note that this, in part, reflects the very small value for the loss function when  $\alpha$  is large. The reason for this illustrates the multiple effects structural parameters have in the model. As prices becomes stickier ( $\alpha$  increases), the output gap elasticity of inflation ( $\kappa$ ) falls. However, the disturbance term in the inflation equation is  $\kappa\mu_t$ , so the fall in  $\kappa$  also means that the variance of the cost shock falls. These shocks to the wedge between the flexible-price output level and the efficient output level are the basic cause of policy tradeoffs in this model. Thus, as prices become stickier, the source of policy tradeoffs becomes less important.

While the results are based on a very simple model, the examples provided by  $\gamma$  and  $\alpha$  illustrate how conclusions from standard models based on exogenous objectives (and ad hoc shocks) can potentially be misleading. Contrary to traditional findings, welfare is independent of the degree of structural inflation inertia, though the volatility of inflation is not. The optimal targeting rule is invariant to the degree of price rigidity because of the dependence of the weights in the loss function on the structural parameters, and policy comparisons can be affected by whether economic disturbances are treated as exogenous additions or as arising in a manner consistent with the underlying theory.

## 4 Right objectives, wrong parameters

The previous section investigated the consequences of minimizing the wrong loss function. It was assumed, however, that the policy maker knew the correct structural parameters. In this section, I consider the case in which the central bank employs an incorrect value for one of the model parameters in implementing the socially optimal targeting rule given by (9). The exercise is similar to previous work, for example by Angeloni, Coenen, and Smets (2003), in assessing the consequences of basing policy on an incor-

rect parameter value. However, I also assess how conclusions about the effects of parameter error are influenced by the loss function used to evaluate outcomes. As in the previous section, the focus is, in turn, on structural inflation inertia and nominal price stickiness.

When the central bank has a misspecified model (whether this is reflected in its loss function or not), issues of implementation become particularly important. For example, in the optimal rule based on  $\mathcal{L}^{std}$ , the central bank commits to ensuring an equilibrium condition that involves the expected future output gap will hold (see 13). In the approach to policy advocated, for example, by Svensson (2004b), the central bank would announce its projections for the output gap. However, if the central bank's model is incorrect, these projections will differ (potentially) from the public's forecasts. In section 5, where performance under the targeting rule obtained from the standard loss function is evaluated, the issue of projections will need to be addressed. In this section, because I focus on the targeting rule (9) in which projections do not appear, I restrict attention to the rational expectations equilibrium when the central bank credibly announces it will ensure (9) holds, ignoring the issue of how the central bank manipulates its interest rate instrument to actually achieve this outcome (see Svensson and Woodford 2004). However, I assume the central bank gets one of the structural parameters appearing in the rule wrong.

#### 4.1 Structural inflation inertia

Let  $\gamma^P$  denote the central bank's perceived or estimated value of  $\gamma$ . Assume the central bank implements the targeting rule given by

$$\pi_t - \gamma^P \pi_{t-1} + \left(\frac{\lambda}{\kappa}\right) \Delta \tilde{x}_t = 0. \quad (14)$$

That is, the central bank employs the correct form of the optimal targeting rule but its assumption about structural inflation inertia may differ from  $\gamma$ , the value that characterizes the actual inflation process. I assume the policy maker acts as if the model were known with certainty, even though some

values of the parameters may be misspecified. This approach parallels that of Levin and Williams (2003b), Angeloni, Coenen, and Smets (2003), and Aladid, et. al (2004). If the central bank’s commitment to ensuring (14) holds is credible, then the rational expectations equilibrium of the economy is obtained by jointly solving this targeting rule together with (6).<sup>10</sup> I then calculate loss as a function of  $\gamma^P$  and  $\gamma$  as each varies from zero to one.

The effects of misspecifying the degree of structural inflation inertia in the targeting rule can be illustrated using the notion of fault tolerance introduced by Levin and Williams (2003b). They examined the effects on the objective function of varying one of the coefficients in an instrument rule. Rather than varying an instrument rule parameter, I consider variations in the central bank’s estimate of a structural parameter under the assumption that, given the estimates of the parameter, policy is implemented through a specific optimal targeting rule. For a given value of  $\gamma$  in the structural inflation equation, the effect on  $\mathcal{L}^{sl}$  as  $\gamma^P$  varies corresponds to Levin and Williams’ fault tolerance for a given model. By also varying  $\gamma$ , a risk surface is traced out, showing combinations of  $\gamma$  and  $\gamma^P$  that may produce especially bad outcomes.

The effects of misspecifying  $\gamma$  are illustrated in the top panel of figure 1. The figure shows the percent increase in social loss when the targeting rule is based on  $\gamma^P$  and the actual degree of structural inflation inertia is  $\gamma$ . The figure can be interpreted as showing how outcomes are affected if the central bank errs in over- or under-estimating  $\gamma$ . The figure suggests that a central bank concerned with protecting against error by following a min-max strategy should behave as if inflation is relatively non-inertial, that is, base policy on a moderate value of  $\gamma^P$ . The value of  $\gamma^P$  that minimize the maximum social loss that could arise from misspecification is 0.55. This result is in contrast to the conclusions reached by Angeloni, Coenen, and Smets (2003), Coenen (2004), and Walsh (2003) who all found that a robust

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<sup>10</sup>This ignores the problems faced by the central bank in ensuring that (14) holds since the interest rate necessary to ensure it holds will depend on the central bank’s projections of future output gaps and inflation.

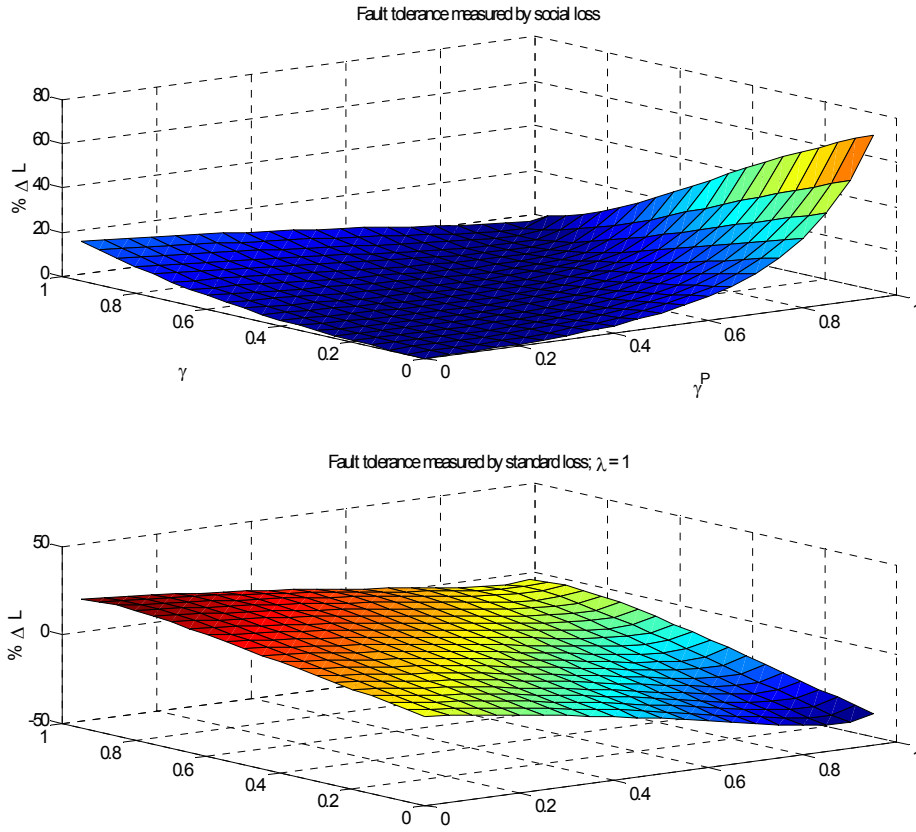


Figure 1: Fault tolerance ( $\% \Delta \mathcal{L}$ ): Each surface shows the percent difference in the loss relative to the first-best policy based on the true structural parameter. The top figure is based on social loss, the bottom one on a standard loss function with  $\bar{\lambda} = 1$ . In both cases, results are based on the optimal targeting rule (9).

strategy involved over-estimating the degree of structural inflation inertia. However, these earlier results ignored the implications of  $\gamma$  for the social loss function and evaluated outcomes using a standard, exogenous loss function.

The role played by the loss function is revealed by the bottom panel of the figure, which uses a standard loss function in inflation and output gap volatility with  $\bar{\lambda} = 1$  to evaluate the outcomes for different combinations of  $\gamma$  and  $\gamma^P$ . Here, the min-max strategy would set  $\gamma^P = 0.9$ . Over-estimating structural inflation inertia appears to lead to a more robust policy, the result found in the earlier literature. The reason for this result is that the variance of the output gap increases as  $\gamma^P$  falls relative to  $\gamma$ . This increase in output gap volatility is very costly when  $\bar{\lambda} = 1$ . Not surprising, using a standard loss function but with a smaller value of  $\bar{\lambda}$  consistent with the underlying model can yield very different conclusions, since the rise in output gap volatility has less weight on the loss function. If  $\bar{\lambda} = 0.048$ , the min-max strategy recommended by the standard loss function would base policy on the assumption of no structural inflation inertia. However, the general lesson from comparing the two panels of the figure is that employing the standard loss function can provide a misleading assessment policy robustness.

## 4.2 Nominal price rigidity

Misspecification of the degree of nominal price rigidity has no effect on the optimal targeting rule, whether based on the social loss function or the standard loss function, as long as the endogeneity of  $\lambda$  is recognized. In either case, the effects of  $\alpha$  on  $\kappa$  and  $\lambda$  leave the ratio  $\lambda/\kappa$  that appears in the targeting rule unaffected. An increase in price rigidity reduces the output gap elasticity of inflation, but it also reduces the relative weight placed on output stabilization in the social loss function. Thus, both targeting rules are robust to misspecifying the degree of nominal rigidity. However, if  $\bar{\lambda}$  is treated as a fixed parameter as  $\alpha$  varies, the targeting rule implemented by the central bank (whether minimizing social loss or the standard loss function) will be affected. For example, suppose  $\bar{\lambda}$  is fixed and the central

bank implements the targeting rule

$$\pi_t - \gamma\pi_{t-1} = - \left( \frac{\bar{\lambda}}{\kappa^P} \right) (\tilde{x}_t - \tilde{x}_{t-1}), \quad (15)$$

where  $\kappa^P$  is the central bank's estimate of the output elasticity of inflation based on  $\alpha^P$ . Because the central bank's targeting rule now varies with  $\kappa^P$ , outcomes are no longer independent of the bank's estimate of  $\alpha$ . Figure 2 shows the risk surface under policy rule (15).<sup>11</sup> Basing policy on an estimate of price rigidity that is too high leads to a deterioration in social welfare. Using the standard loss with  $\bar{\lambda} = 1$  to evaluate outcomes yields similar a similar surface. Thus, unlike the example with  $\gamma$ , the standard loss function does not provide a misleading qualitative assessment of outcomes under rule (15).

This result contrasts with the findings in Walsh (2004). There, it was found that using a standard loss function tended to exaggerate the costs of basing policy on the belief that prices were very sticky, whereas, as figure 2 suggests, an evaluation based on social loss shows that a policy based on a  $\alpha^P$  that exceeds the actual degree of price stickiness produces the greatest loss. An important reason for the different conclusions can be traced to an aspect of the underlying model that is neglected in most other analyses of policy rules. According to (6), the standard deviation of the cost shock is proportional to  $\kappa$ . Thus, as  $\alpha$  increases, and  $\kappa$  falls, two factors are at work in affecting social loss. First, with greater price rigidity,  $\lambda$  falls as the central bank should place relatively more weight on inflation stabilization. Second, the volatility of the cost shocks falls, improving the ability of monetary policy to achieve both inflation and output gap stabilization. The importance of this second channel can be assessed by holding the variance of the disturbance term in the inflation equation fixed as  $\alpha$  (and therefore  $\kappa$ ) varies. Figure 3 shows the outcome of this experiment. The figure suggest underestimating the extent of price rigidities leads to a significant increase in the loss function, a conclusion that is contradicted by an evaluation based on the

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<sup>11</sup>When policy is based on the correct rule so that  $\lambda^P/\kappa^P$  is independent of  $\alpha^P$ , the surface would vary with  $\alpha$  but not with  $\alpha^P$ .

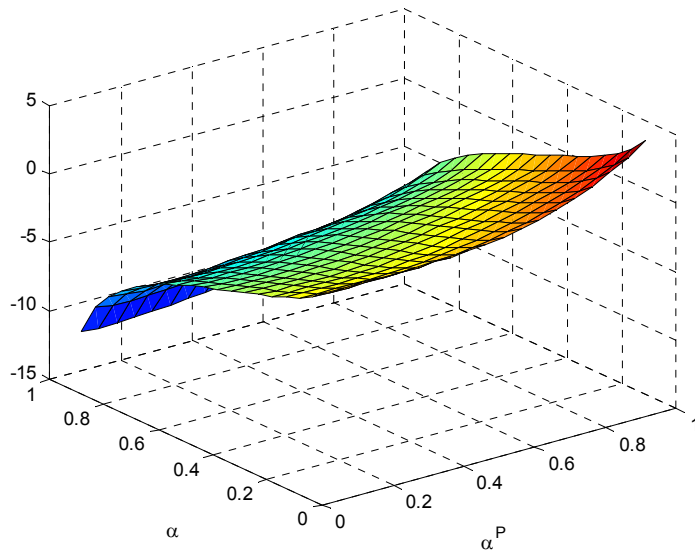


Figure 2: Log social loss under the targeting rule (15).

social loss function. Thus, accounting for the way distortions affect the economy, in this case through the presence of a wedge between the flexible-price equilibrium output and the first-best output that enters as a disturbance to the inflation equation, can be important for gaining an accurate assessment of alternative targeting rules.

## 5 Wrong objectives, wrong parameters

A final case to consider involves the use of a targeting rule based on incorrect parameters *and* an incorrect objective function. Does employing a targeting rule that is optimal for the standard loss function give misleading conclusions about the robustness of policy to parameter misspecification? Section 4 showed that using the standard loss function to evaluate outcomes under the socially optimal targeting rule (9) could provide incorrect conclusions about the effects of misspecifying the degree of structural inflation inertia.  $\mathcal{L}^{sl}(sl)$  differed significantly from  $\mathcal{L}^{std}(sl)$ . In this section, an alternative comparison

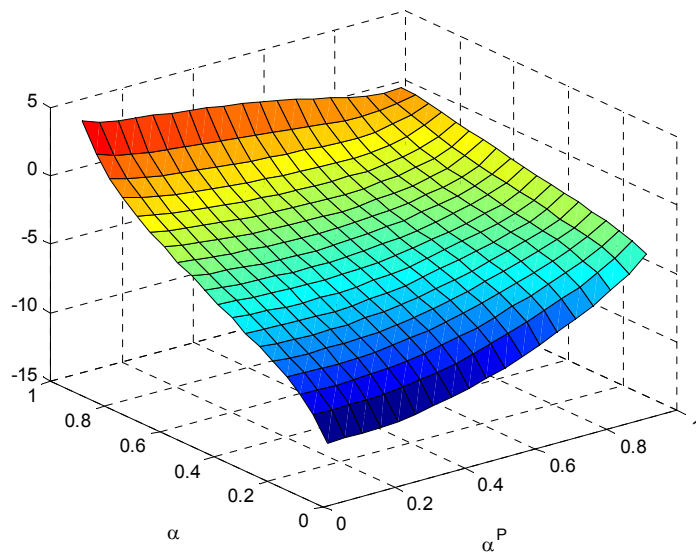


Figure 3: Log standard loss under targeting rule (15) when the variance of “cost shock” is held fixed.

is carried out. How does  $\mathcal{L}^{sl}(std)$  differ from  $\mathcal{L}^{std}(std)$  when  $\gamma^P$  differs from  $\gamma$ ? Does the standard loss function, when used to derive the targeting rule and to evaluate outcomes, provide an accurate assessment of the effects on the true social loss function? This comparison also provides an assessment of the robustness to parameter misspecification of the targeting rule based on the social loss function relative to the rule based on the standard loss function.

Suppose the central bank adopts a policy rule that minimizes the standard quadratic loss  $\mathcal{L}^{std}$  given by (8) with  $y = \tilde{x}$ . When the parameters are known, the first order conditions imply the robustly optimal targeting rule is

$$\pi_t + \left(\frac{\bar{\lambda}}{\kappa}\right) [(1 + \beta\gamma)\tilde{x}_t - \tilde{x}_{t-1} - \beta\gamma E_t \tilde{x}_{t+1}] = 0, \quad (16)$$

which involves the expected future output gap. If the central bank announces its projections for the future output gap, and these projections are based on an incorrectly specified forecasting model, the announced projections will differ from the rational expectations of the public. Various assumptions have been made in the literature to deal with this situation. For example, Levin, Wieland, and Williams (2003) make two alternative assumptions. In the first, they assume the central bank, despite having a misspecified model, generates forecasts that coincide with the rational expectations of future variables. In the second approach, they assume the central bank's forecasts are generated by its misspecified model. Aoki and Nikolov (2004) assume that the central bank announces its forecasts (based on its misspecified model) and that the public adopts these projections for their forecasts. They then study how the central bank can learn from observed outcomes to update their model of the economy.

For simplicity, I only consider the case in which projections correspond to what Levin, Wieland, and Williams call “model consistent” forecasts. In this case, the policy maker is committed to implementing (16) but has misspecified some of the parameters in the rule. However, the policy maker uses staff forecasts that are based on the true model of the economy. The equilibrium is then found by jointly solving (16) together with the inflation

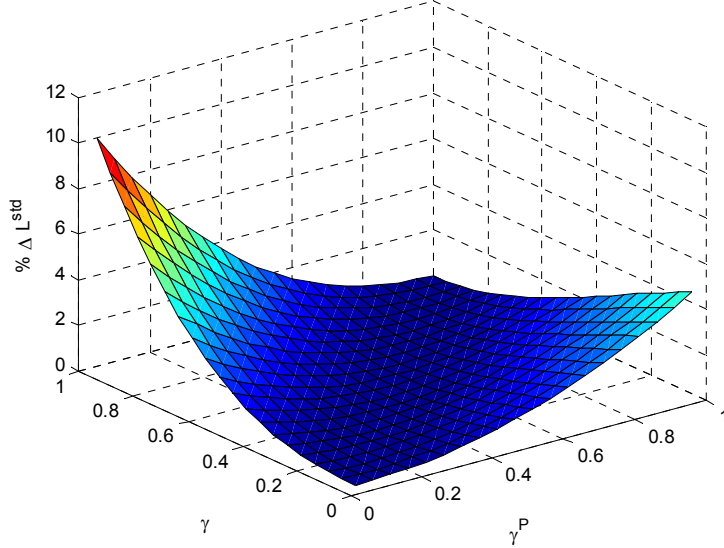


Figure 4: Percent increase in loss as measured by the standard loss under the targeting rule (16).

adjustment equation and the structural equations determining the welfare wedge  $\mu_t$ .

Let  $\mathcal{L}^{std}(std, \gamma, \gamma^P)$  denote the value of the standard loss function when the targeting rule is optimal for  $\mathcal{L}^{std}$  and based on  $\gamma^P$ , while the actual inflation process involves  $\gamma$ . The costs of parameter misspecification can be measured by  $\% \Delta \mathcal{L}^{std}(std, \gamma, \gamma^P) = \log \mathcal{L}^{std}(std, \gamma, \gamma^P) - \log \mathcal{L}^{std}(std, \gamma, \gamma)$ . This measure is shown in figure 4. Along the diagonal it equals zero since this corresponds to the case in which the rule is based on the correct parameters. The consequences of misspecifying  $\gamma$  according to  $\mathcal{L}^{std}$  are asymmetric, with loss increasing significantly when  $\gamma^P < \gamma$ . As noted earlier, this is consistent with previous work suggesting a robust strategy is to over-estimate the extent of structural inflation inertia. In general, however, the deterioration in  $\mathcal{L}^{std}$  is fairly small.

When the same outcomes are evaluating using the social loss function, a

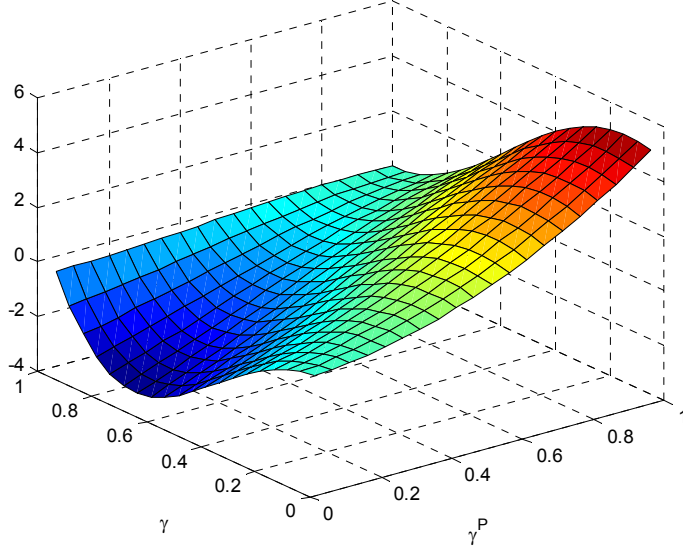


Figure 5: Percent increase in loss as measured by the social loss under the targeting rule (16).

different picture emerges. Figure 5 shows  $\% \Delta \mathcal{L}^{sl}(std, \gamma, \gamma^P) = \log \mathcal{L}^{sl}(std, \gamma, \gamma^P) - \log \mathcal{L}^{sl}(std, \gamma, \gamma)$ . Negative values can occur because (16) is not optimal for  $\mathcal{L}^{sl}$ , so outcomes with the rule based on incorrect parameters can dominate the suboptimal rule based on the true value of  $\gamma$ . Using the model consistent loss function would suggest that over-estimating inflation inertia leads to a decrease in social welfare, although again the deterioration is relatively slight.

Figure 6 makes a similar comparison for misspecification of the degree of price rigidity under the targeting rule that is optimal for the standard loss function. The top panel shows  $\% \Delta \mathcal{L}^{std}(std, \alpha, \alpha^P) = \log \mathcal{L}^{std}(std, \alpha, \alpha^P) - \log \mathcal{L}^{std}(std, \alpha, \alpha)$ . It would suggest that misspecifying  $\alpha$  can be very costly, particularly if the degree of price rigidity is over-estimated in designing the targeting rule. The bottom panel shows  $\% \Delta \mathcal{L}^{sl}(std, \alpha, \alpha^P) = \log \mathcal{L}^{sl}(std, \alpha, \alpha^P) - \log \mathcal{L}^{sl}(std, \alpha, \alpha)$ , the comparison based on the model

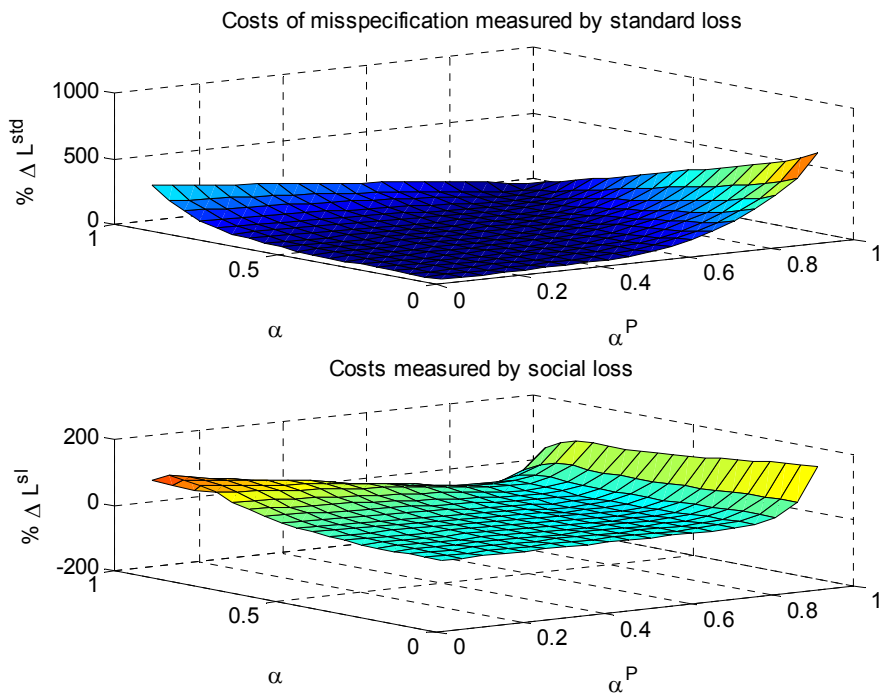


Figure 6: The cost of misspecifying  $\alpha$  according to  $\mathcal{L}^{std}$  (top panel) and  $\mathcal{L}^{sl}$  (bottom panel) under the targeting rule (16).

consistent loss function (3). One aspect to note is that, based on the social loss function, the costs of misspecifying  $\alpha$  appear to be somewhat lower.

## 6 Summary and conclusions

The standard approach to monetary policy analysis treats the objectives of policy as exogenously specified, independent of the model used to represent the economy. Economic theory, however, draws a tight link between the objectives a policy maker concerned with maximizing the welfare of the representative agent should pursue and the underlying structure of the economy. Objectives are endogenous. The purpose of this paper has been to investigate the role of endogenous objectives for the evaluation of optimal

specific targeting rules. This has been done in a very simple model, but one in which the link between structural equations, social welfare, and the underlying parameters of the model is quite clear.

A variety of comparisons were made that indicated the potential for conclusions based on the standard exogenous objectives common in monetary policy analysis to be misleading. Because the representation of social welfare in terms of policy objectives is model dependent, any conclusions will themselves be specific to the model employed. However, several interesting results emerge from the simple new Keynesian model used in this paper. The analysis suggested that the use of ad hoc objectives and the addition of ad hoc disturbances can significantly affect the evaluation of alternative policies. The use of the standard loss function provided misleading guidance on the effects of misspecifying structural inflation inertia, suggesting that a robust policy should assume a high degree of such inertia. In contrast, using the social loss function showed this not to be the case, even under the targeting rule that was optimal for the standard loss function. The link between the economy's distortions and the presence of a disturbance to the inflation adjustment equation also played an important role in assessing alternative targeting rules and the effects of price rigidity. Increased price rigidity reduces the output gap elasticity of inflation, but it also increases the relative weight on inflation objectives in the social loss function and reduces the importance of cost shocks. Failing to incorporate these last two effects made a difference for policy evaluation. And, not surprisingly, even the socially optimal targeting rule could appear to perform poorly and to lack robustness when evaluated using the standard ad hoc loss function.

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