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Optimal Monetary Policy Rules from a  
Timeless Perspective\*

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ABSTRACT

The timelessly optimal monetary policy proposed by Woodford (2003) may be dominated by alternative timeless policies. We provide a formal justification for these alternative policies. We demonstrate why discount rates do not matter and establish that optimizing over the unconditional expectation of the policy criterion function recovers these alternative strategies.

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**Keywords:** Time consistency, unconditional expectation, timeless perspective, optimal monetary policy.

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## 1. Introduction

Kydland and Prescott (1977) brought into sharp focus the issue of time inconsistency of optimal policy design in macroeconomic models with forward-looking behavior and rational expectations. Taylor (1979) proposed searching for policies, under rational expectations, which maximize the unconditional expectation of the government's objective function. This idea has been exploited many times e.g., Rotemberg and Woodford (1997, 1998), Woodford (1999), Clarida, Gali and Gertler (1999), Erceg, Henderson and Levin (2000) and Kollman (2002). However, in most of those papers a numerical approach is adopted to uncover the optimal rule (sometimes restricted to some or other arbitrary parametric class).

Woodford (2003) proposed a dynamic optimization-based method for solving for the optimal policy, which he has labelled a "timeless perspective for optimal policy". However, Blake (2001) and Jensen and McCallum (2002) independently provided a counterexample which implies that alternative feasible timeless policies exist which dominate that proposed by Woodford. In this note, building on the Blake-Jensen-McCallum insight, we provide the first full formal justification of these alternative strategies. We demonstrate why discount rates don't matter in the formulation of our optimal timeless policy, something that a number of economists have asserted, e.g., Taylor, (1979). Using that insight, we pose and solve a policy optimization problem that delivers the Blake-Jensen-McCallum timeless policies.

## 2. The timeless perspective on optimal policy

### 2.1. A definition

The timelessly optimal policy is the policy that the government would have decided upon for the current period had such a decision been taking infinitely far in the past. This perspective is attractive for a number of reasons. In particular, in the context of monetary policy rules, as Giannoni and Woodford (2002) note:

"The selection of a policy rule from this perspective means that it is not necessary to view the choice of the rule as a once and for all commitment, by which the central bank will be bound no matter how unappealing the rule may come to appear at a later time. Instead, the bank need only be committed to determine policy at the later dates by a rule that is optimal from a similar timeless

perspective. Insofar as the bank model of the economy is expected to guide its decision in the future as well, there is no reason to expect future behavior that does not conform to the rule currently adopted - and so there is no inconsistency involved in adopting the rule now because of its desirable properties if the bank is expected to follow it indefinitely."

## 2.2. Formalization

We formalize the Giannoni-Woodford timeless perspective. Consider a discounted quadratic loss function of the form

$$L_t = \frac{1}{2} E_t \sum_{j=0}^{\infty} \beta^j (x_{t+j} - x_{t+j}^*)' Q (x_{t+j} - x_{t+j}^*). \quad (2.1)$$

$E_t$  is the expectations operator *conditional on information up through date  $t$* ,  $\beta$  is the time discount factor,  $x_t$  is a vector of target variables,  $x^*$  is a vector of target values which could depend on disturbance terms, and  $Q$  is a symmetric positive definite matrix.

$$x_t = \begin{bmatrix} z_t \\ Z_t \\ i_t \end{bmatrix}$$

Here  $i_t$  is a vector of policy instruments, the value of which is chosen in period  $t$ ,  $z_t$  is a vector of non-predetermined endogenous variables, the value of which may depend upon both policy actions and exogenous disturbances at date  $t$ ,  $Z_t$  is a vector of predetermined endogenous variables (lags of variables that are included in  $z_t$  and  $i_t$ ).

We further assume that the evolution of the endogenous variables  $z_t$  and  $Z_t$  is determined by a system of simultaneous equations

$$\hat{I} \begin{bmatrix} Z_{t+1} \\ E_t z_{t+1} \end{bmatrix} = A \begin{bmatrix} Z_t \\ z_t \end{bmatrix} + B i_t + C s_t, \quad (2.2)$$

where  $B = \begin{bmatrix} 0 \\ B \end{bmatrix}$ ,  $C = \begin{bmatrix} 0 \\ C \end{bmatrix}$  and  $s_t$  is a vector of exogenous disturbances.

The policy maker minimizes the loss function (2.1) subject to constraint (2.2). He searches for a policy rule of the general form

$$\phi'_i i_t + \phi'_z z_t + \phi'_Z Z_t + \phi'_s s_t = \bar{\phi}. \quad (2.3)$$

The timeless perspective policy which we seek to justify is to minimize the unconditional expectation of the loss function; this is equal to the expectation over all possible initial states of the economy (Taylor, 1979).

More formally, the optimal policy from a timeless perspective that we are looking for can be defined as a policy rule  $\phi' = (\phi'_i, \phi'_z, \phi'_Z, \phi'_s, \bar{\phi})$  which minimizes the unconditional expectation ( $\tilde{E}$ ) of the loss function (2.1), subject to constraint (2.2).

$$\phi^{t*} = \arg \min \tilde{E} L_t(\phi'), \quad (2.4)$$

### 2.3. Woodford's methodology

Giannoni and Woodford (2002) proposed the following algorithm for finding the optimal policy from their timeless perspective:

- Step 1: Write the conditionally expected discounted Lagrangian:

$$J_t = E_t \left\{ \sum_{j=0}^{\infty} \beta^j \left[ \frac{1}{2} (x_{t+j} - x_{t+j}^*)' Q (x_{t+j} - x_{t+j}^*) + \mu'_{t+j} (\tilde{A}x_{t+j} - \tilde{I}x_{t+j+1}) \right] \right\},$$

where  $\tilde{A} := [ A \ B ]$ ,  $\tilde{I} := [ \hat{I} \ 0 ]$ , and  $\mu_{t+j}$  is a vector of Lagrange multipliers associated with the constraints (2.2) (see Giannoni and Woodford (2002), p. 28).

- Step 2: Write the first-order conditions with respect to the endogenous variables,  $x_{t+j}$

$$\begin{aligned} (x_{t+j} - x_{t+j}^*)' Q + \mu'_{t+j} \tilde{A} - \beta^{-1} \mu'_{t+j-1} \tilde{I} &= 0, \text{ for } j > 0; \\ (x_t - x_t^*)' Q + \mu'_t \tilde{A} &= 0, \text{ for } j = 0. \end{aligned} \quad (2.5)$$

- Step 3: Ensure commitment to the policy program by ignoring the first-order conditions for period zero (2.5) and replace them with (2.6):

$$(x_t - x_t^*)' Q + \mu'_t \tilde{A} - \beta^{-1} \mu'_{t-1} \tilde{I} = 0. \quad (2.6)$$

The following example demonstrates Giannoni and Woodford's (2002) method.

**Example 2.1.** *Following Clarida, Gali and Getler (1999) consider the loss function*

$$L_t = E_t \sum_{j=0}^{\infty} \beta^j \{ \pi_t^2 + \alpha y_t^2 \}, \quad (2.7)$$

and a forward-looking Phillips curve given by

$$\pi_t = \beta E_t \pi_{t+1} + \lambda y_t + \varepsilon_t, \quad (2.8)$$

where  $\pi_t$  is inflation at time  $t$ ,  $y_t$  is the output gap, and  $\varepsilon_t$  is an i.i.d. shock process with variance  $\sigma^2$ . The Lagrangian for the policy problem may be written as

$$J_t = \sum_{j=0}^{\infty} \beta^j E_t \left\{ (\pi_{t+j}^2 + \alpha y_{t+j}^2) + \mu_{t+j} [\pi_{t+j} - \beta E_t \pi_{t+1+j} + \lambda y_{t+j} + \varepsilon_{t+j}] \right\}. \quad (2.9)$$

The commitment solution, or timelessly optimal solution, proposed by Giannoni and Woodford (2002) is simply to ignore the first-order conditions for  $j = 0$ . So, in any time period, we have the following pair of optimality conditions

$$\begin{aligned} \pi_t &= -\frac{1}{2}\mu_t + \frac{1}{2}\mu_{t-1}; \\ y_t &= \frac{\lambda}{2\alpha}\mu_t. \end{aligned} \quad (2.10)$$

Hence,

$$\pi_t = -\frac{\alpha}{\lambda}(y_t - y_{t-1}). \quad (2.11)$$

(2.11) relates the path of inflation and output to one another in a manner that is commonly characterized as the timelessly optimal program, and which is used to back out the optimal value of the interest rate (i.e., policy instrument).

### 3. What is wrong with this?

Blake (2001) proposed that the optimal timeless policy should in fact maximize the undiscounted sum of temporal utilities. Using his method he demonstrates that if one replaces equation (2.11), with

$$\pi_t = -\frac{\alpha}{\lambda}(y_t - \beta y_{t-1}) \quad (3.1)$$

then unconditional welfare is higher. To prove his statement he assumes that output and inflation follow the simple dynamic paths

$$\pi_t = f_{11}y_{t-1} + f_{12}u_t; \quad (3.2)$$

$$y_t = f_{21}y_{t-1} + f_{22}u_t. \quad (3.3)$$

On the assumption that  $u_t$  is white noise, the Phillips curve imposes the following restrictions

$$\begin{aligned} f_{21} &= \frac{f_{11}}{\beta f_{11} + \lambda}; \\ f_{22} &= \frac{(1 - \beta\rho) f_{12} - 1}{\beta f_{11} + \lambda}. \end{aligned}$$

The unconditional expectation of the value of the loss function can be shown to be

$$\tilde{E}U_t = -\frac{\sigma^2}{1-\beta} \left[ \frac{(f_{11}^2 + a)}{1-f_{21}^2} f\phi_{22}^2 + f_{12}^2 \right]$$

where  $\sigma$  is the standard deviation of  $u_t$ . Using a numerical algorithm Blake (2001) shows that policy (3.1) satisfies the first-order and second-order conditions for an optimum. Jensen and McCallum (2002) also make this point and offer a simulation-based justification for replacing (2.11) with (3.1).

Blake and Kirsanova (2004), using the methodology described in Soderlind (1999), have also shown that there is a time consistent linear policy which results in smaller losses. However, those numerical simulations only demonstrate that such policies are *conditionally* better than the policy proposed by Woodford's timeless perspective methodology. Both simulations made assumptions concerning the output gap in the preceding period. However, as Soderlind (1999) shows, the optimal (simple) policy parameters depend on initial values, and therefore it is to be expected that under some values of initial conditions some policies perform better than others. For instance, in the example just considered, Woodford's timeless perspective methodology always dominates when  $y_{t-1} = 0$ , for, in this case, the timeless perspective policy is the same as the optimal (time inconsistent) policy.

The correct numerical comparison of unconditional timeless policies would involve Monte-Carlo simulations which would compare the values of loss functions integrating over all possible initial states; in the current example, of the lagged output gap. None of the numerical work carried out to date has done this. This was pointed out by Woodford 2003, p.508. However, Blake's (2001) counterexample remains without clarification.

### 3.1. On the optimal timeless policy and the households' time discount factor

In this subsection we shall prove that the optimal unconditionally timeless rule does not depend on the consumers' discount factor. In the next section, we shall use this insight to justify the results of Blake-Jensen-McCallum. The formal statement is provided in Proposition 3.1 which we ascribe to John Taylor as he is the first explicit reference to the issue of unconditionality emphasized above of which we are aware.

**Proposition 3.1.** *(Taylor, 1979) The consumer's time preference parameter is not important for the timeless policymaker. That is, the best timeless policy minimizes losses (3.4)*

for all discount factors  $\gamma \in (0, 1)$

$$\tilde{E}L_t(\gamma) = \tilde{E}E_t \sum_{j=0}^{\infty} \gamma^j l_{t+j} \quad (3.4)$$

Here,  $l_t$  denotes the period loss function. It follows immediately that,

$$\arg \min_{\phi'} \tilde{E}L_t(\gamma) = \arg \min_{\phi'} \frac{1}{1-\gamma} \tilde{E}l_t = \arg \min_{\phi'} \tilde{E}l_t.$$

Hence, we have proved that the same policy is unconditionally optimal for  $L_t(\gamma)$  for any  $\gamma \in (0, 1)$

The Lagrangian constructed in Woodford's timeless perspective methodology depends on the consumers' discount factor, but the optimal policy which minimizes unconditional losses does not.

Proposition 3.1 is additionally interesting as it demonstrates that the same policy is unconditionally optimal for all households, regardless of their individual time discount factors.

## 4. The Solution

The problem with the timeless perspective methodology proposed by Giannoni and Woodford (2002) is that it proposes first to find the optimality conditions for a time inconsistent or (time) conditional policy and then make the rule "time less" by ignoring first period constraints. In other words, it is as if one were trying to find an optimum of the composite function  $\arg \min f(g(x))$  by writing the first order condition for  $g(x)$  only. The correct approach would appear to be to apply the unconditional expectation operator in formulating the policy Lagrangian and then deriving the optimality conditions. As we shall see, this is exactly the justification required for the Blake-Jensen-McCallum result to go through.

Hence, we propose the following methodology:

- Step 1: Write the (time) conditional Lagrangian (2.9).
- Step 2: Re-formulate this as an unconditional Lagrangian:

$$J = \tilde{E}J_t;$$

$$J = \frac{1}{1-\beta} \tilde{E} \left( \frac{1}{2} (x_t - x_t^*)' Q (x_t - x_t^*) + \mu'_t \tilde{A}x_t - \mu'_{t-1} \tilde{I}x_t \right).$$

- Step 3: Write the first-order conditions for the optimal timeless policy with respect to all endogenous variables;

$$\frac{\partial J}{\partial x_t} = \frac{1}{1-\beta} \tilde{E} \left( (x_t - x_t^*)' Q + \mu'_t \tilde{A}_t - \mu'_{t-1} \tilde{I} \right) = 0. \quad (4.1)$$

Condition (4.1) implies the following dynamics for the Lagrange multipliers

$$(x_t - x_t^*)' Q + \mu'_t \tilde{A}_t - \mu'_{t-1} \tilde{I} = 0. \quad (4.2)$$

The general conclusion can be formulated in the following proposition.

**Proposition 4.1.** *The first order conditions (4.2) are the necessary conditions for problem (2.4, 2.2)*

*The proof follows immediately by applying Pontryagin's Maximum Principle.*

We contrast these with the Giannoni and Woodford (2002) dynamics, (2.6) above.

#### 4.1. Example

**Example 4.2.** *We search for a timeless policy which minimizes the loss function*

$$U = E_t \sum_{j=0}^{\infty} \beta^j \{ \pi_{t+j}^2 + \alpha y_{t+j}^2 \}, \quad (4.3)$$

*subject to the constraint*

$$\pi_t = \beta E_t \pi_{t+1} + \lambda y_t + u_t.$$

*We formulate the time-dependant Lagrangian*

$$L_t = E_t \sum_{j=0}^{\infty} \beta^j \left( (\pi_{t+j}^2 + \alpha y_{t+j}^2) + \mu_{t+j} (\pi_{t+j} - \beta E_t \pi_{t+j+1} - \lambda y_{t+j} - u_{t+j}) \right).$$

*Since we search for the timeless optimal policy, we need to minimize the "timeless" Lagrangian, which means we must formulate the problem using the unconditional expectation of the Lagrangian  $L_t$  :*

$$L = \tilde{E} L_t = \tilde{E} \left( E_t \sum_{j=0}^{\infty} \beta^j \left( (\pi_{t+j}^2 + \alpha y_{t+j}^2) + \mu_{t+j} (\pi_{t+j} - \beta E_t \pi_{t+j+1} - \lambda y_{t+j} - u_{t+j}) \right) \right).$$



The unconditional expectation operator has the following property  $\forall t, j, \tilde{E}x_t = \tilde{E}x_{t+j}$  which implies that  $\tilde{E}E_t\mu_{t+j}\pi_{t+j+1} = \tilde{E}\pi_t\mu_{t-1}$ . The timeless Lagrangian may then be rewritten as

$$L = \frac{1}{1-\beta} \tilde{E} \left[ (\pi_t^2 + \alpha y_t^2) + \mu_t (\pi_t - \lambda y_t - u_t) - \tilde{E} \beta \pi_t \mu_{t-1} \right]$$

The first order conditions follow:

$$\frac{\partial L}{\partial \pi_t} = \frac{1}{1-\beta} (2\pi_t + \mu_t - \beta \mu_{t-1}) = 0;$$

$$\frac{\partial L}{\partial y_t} = \frac{1}{1-\beta} (2\alpha y_t - \lambda \mu_t) = 0.$$

These relations can be written as  $\pi_t = -\frac{\alpha}{\lambda} y_t + \beta \frac{\alpha}{\lambda} y_{t-1}$ . This is the optimal program proposed by Blake-Jensen-McCallum.

## 5. Conclusion

We provided a rationale for the numerical-based conclusions of Jensen and McCallum (2002), and a formal justification for the arguments in Blake (2001). We showed how one can justify and formulate timelessly-optimal policy programs using unconditional expectations.

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