

Castelnuovo, Efrem

**Working Paper**

## Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model

Nota di Lavoro, No. 6.2003

**Provided in Cooperation with:**

Fondazione Eni Enrico Mattei (FEEM)

Suggested Citation: Castelnuovo, Efrem (2003) : Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model, Nota di Lavoro, No. 6.2003, Fondazione Eni Enrico Mattei (FEEM), Milano

This Version is available at:

<http://hdl.handle.net/10419/118033>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

**Squeezing the Interest Rate  
Smoothing Weight with a Hybrid  
Expectations Model**

Efrem Castelnuovo

NOTA DI LAVORO 6.2003

**JANUARY 2003**

ETA – Economic Theory and Applications

Efrem Castelnuovo, *Bocconi University*

This paper can be downloaded without charge at:

The Fondazione Eni Enrico Mattei Note di Lavoro Series Index:

[http://www.feem.it/web/attiv/\\_wp.html](http://www.feem.it/web/attiv/_wp.html)

Social Science Research Network Electronic Paper Collection:

[http://papers.ssrn.com/abstract\\_id=XXXXXX](http://papers.ssrn.com/abstract_id=XXXXXX)

The opinions expressed in this paper do not necessarily reflect the position of  
Fondazione Eni Enrico Mattei

# Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model

## Summary

Successful descriptions of short-term nominal interest rates *inertial* behavior have frequently been obtained with small scale macro models in which a Central Banker minimizes a loss function embedding an argument labelled as *interest rate smoothing*. The *rationale* for this argument is not straightforward. Indeed, there has been a lively debate about it in the literature. In this paper we perform an empirical exercise to evaluate the relationship existing between private sector's *rational expectations* and interest rate gradualism. Our findings strongly support rational expectations as an element capable to remarkably reduce the importance of the interest rate smoothing weight in replicating the observed path of the federal funds rate. However, we find a predominance of adaptive expectations in shaping the paths of inflation and output gap. Our results also suggest that the Fed has followed a 'Strict Inflation Targeting' strategy under Greenspan's regime.

**Keywords:** Central Banker, interest rate smoothing, rational expectations, hybrid Phillips curve, hybrid IS curve.

**JEL:** C51, E52

*The author thanks Nicola Cantore, Richard Dennis, Carlo Favero, Francesca Monti, Davide Pettenuzzo, Saverio Simonelli, Ulf Söderstrom, and Paolo Surico for valuable comments and suggestions. The usual disclaimers apply.*

*Address for correspondence:*

Efrem Castelnuovo  
Bocconi University  
Via Sarfatti 25  
20136 Milano  
Italy  
Phone: +39 349 1425415  
Fax: +39 0341 421795  
E-mail: [efrem.castelnuovo@uni-bocconi.it](mailto:efrem.castelnuovo@uni-bocconi.it)

## 1 Introduction

In the recent applied monetary policy literature, a simple framework representing the Central Banker (CB hereafter)'s problem has been extensively exploited. In this framework, the CB's loss function considers variables such as the inflation rate and the output gap (or the unemployment rate), while the economy is represented by a Phillips curve and an IS schedule.<sup>1</sup> Interestingly enough, with this framework the solution of the Central Banker (CB hereafter)'s optimal control problem turns out to be an interest rate path featured by frequent reversals, reversals due to the willingness of the CB to tackle the various shocks affecting the economy. In fact, in reality we observe smooth paths of the policy rates; this tendency has been labeled as *interest rate smoothing*.<sup>2</sup> To capture this feature of the policy rate, many authors have added to the CB's loss function an *interest rate smoothing argument*, i.e. an argument function of the interest rate *change*.

Indeed, there seems to exist a *trade-off* between economic plausibility (of the relative weight  $\mu$  attributed to the interest rate smoothing volatility in the loss function) and goodness-of-fit (associated to the small-macro scale model in use). Castelnuovo and Surico (2003) consider different studies (i.e. Dennis, 2002; Ozlale, 2003; Favero and Rovelli, 2003) in which researchers have estimated the Fed's relative preferences. In these empirical efforts, there is a common economic model (i.e. Rudebusch and Svensson, 1999,2002), but different econometric techniques are employed. It turns out that when economically sensible (i.e. relatively low) values of the  $\mu$  parameter are estimated, the optimal simulated interest rate (in first differences) shows a puzzling larger volatility than the historical one. Furthermore, au-

---

<sup>1</sup>A very incomplete list includes Ball (1999), Rudebusch and Svensson (1999,2002), Nessén and Vestin (2000), Dennis (2002,2003), Söderlind, Söderström, and Vredin (2002), Favero and Rovelli (2003), Rudebusch (2001,2002a,b,c), Smets (2002), Masuch, Nicoletti Altimari, Pill, and Rostagno (2002), and Aksoy, De Grauwe, Dewachter (2002), Ozlale (2003), and Castelnuovo and Surico (2003).

<sup>2</sup>Rudebusch (1995), Goodhart (1997), Lowe and Ellis (1998), Sack and Wieland (2000), and Srouf (2001) are examples of studies focused on the interest rate smoothing evidence. Interestingly, in a recent contribution Rudebusch (2002a) sustains that the monetary policy inertia observed at a quarterly frequency is just an *illusion*. Nevertheless, English, Nelson, and Sack (2003) and Castelnuovo (2003a,b) run a direct test on the existence of the CB's sluggish adjustment strategy, finding it statistically relevant.

thors such as Goodhart (1999), Sack (2000), Sack and Wieland (2000), and Cecchetti (2000) claim that a smooth interest rate may very well be the solution of a problem in which there is *not* any interest rate smoothing targeting. In fact, forward looking agents, uncertainties regarding the dynamics of the economy, and measurement-errors problems could induce monetary authorities to implement a cautious policy. From this standpoint, the interest rate smoothing element embedded into the loss function is just a *residual* capturing what it is left out of the model.

Sack and Wieland (2000)'s considerations motivate this research. In particular, in this paper we focus our attention on the relationship between interest rate smoothing and *forward looking agents* (FLA hereafter). In fact, private sector's expectations play a key role in monetary policy making. Prices and production primarily react to long-term interest rates, which are in turn influenced by expectations on future movements of the short-term ones. Then, the announcement of a small change in the short term policy rate's reference value may trigger important nominal and real effects if private agents *expect* this change to be followed by a sequence of others. Of course, these expectations are formed only if agents *believe* this is going to happen, e.g. if the CB has historically implemented *smooth* patterns of the policy rates. To support this reasoning, Sack and Wieland (2000) report a statement by Otmar Issing (1997), current member of the Executive Board of the European Central Bank and former Chief Economist at the Bundesbank:

*"If changes in official rates in a certain direction that are confirmed by repetition and not expected to be reversed soon have most influence on longer-term rates, it would seem appropriate for the Bundesbank to adjust its official rates in the smoothest manner."*

Many researchers (e.g. Amato and Laubach, 1999; Levin, Wieland, and Williams, 1999,2002; Rotemberg and Woodford, 1999; Williams, 1999; Woodford, 1999) have investigated this issue from a *normative* standpoint, e.g. they have replied to a question like "Can a credible, inertial policy be beneficial when the private sector is forward looking?". The answer coming from these studies has been unanimously positive. In fact, if agents expect

future gradual moves by the CB, they will adjust their inflation and output gap expectations toward the CB's targets, so helping it to stabilize the economy.

Somewhat surprisingly, the importance of FLA in the context of the trade-off pointed out above has not been investigated in the literature. How large is the impact of the FLA component on the interest rate smoothing weight in the CB's penalty function? Is the FLA chunk helpful for tracking the observed federal funds rate path? In this study, we aim at understanding *how much descriptive power* a small macro model may gain when passing from a backward looking formalization of the economy to a representation in which there is room for forward looking agents. In our study, we use an encompassing AD-AS model à la Rudebusch (2002b) that, under some identifying restrictions, may collapse to a backward looking, hybrid, or fully forward looking illustration of the linkages existing among inflation, output gap, and the policy rate. For each different vector of structural parameters identifying the economic framework, we calibrate the weight to be attributed to the interest rate smoothing argument in order to fit the actual federal funds rate at best. The lower the weight, the better the model performs from a positive standpoint.

A comparison of the results obtained with a fully backward looking model with those stemming from our hybrid version of the economy enables us to state that FLA is a very important ingredient capable to dramatically help explaining the observed interest rate persistence. In fact, the gains in terms of descriptive power turn out to be quite large. To our knowledge, this the first effort oriented at quantitatively assessing the role of FLA in designing these small macro models.

Notably, in our simulations the private sector expects an inertial interest rate even under discretion. In fact, private sector knows that the CB aims at minimizing a loss function featured by the presence of a penalty for interest rate volatility. Then, even if the CB re-optimizes in each period, its optimal choice will be history-dependent (Woodford, 1999): That is where optimal inertia comes from. Then, the interest rate smoothing penalty is to be interpreted as a proxy for CB's concerns such as credibility, uncertainties, and learning; these concerns are known by private agents, and provide a

*rationale* for private agents' expectations of an inertial rate under discretion.

Our calibration exercises suggest that a hybrid new-Keynesian may very well fit the data. In particular, a low relative concern for output gap volatility, a low degree of 'forward lookingness' in both the Phillips curve and the IS curve, and a high weight the expected real-interest rate are the features of best positive model. In this sense, our findings are in line with those contained in recent works by Söderlind, Söderström, and Vredin (2002) and Dennis (2003). This suggests that much more should be done in order to better understand the role of adjustment costs, rules of thumb, and habit formation in shaping the dynamics of variables such as inflation and the output gap, following examples such as Fuhrer and Moore (1995), Fuhrer (2000), Estrella and Fuhrer (2002) and Amato and Laubach (2003).

The map of the paper is the following. Section 2 describes the modeling framework we use for our purpose. In Section 3 we discuss our strategy for evaluating the importance of the FLA ingredient. In Section 4 we highlight and comment our findings. Section 5 collects some insights on the importance of FLA. In Section 6 we deepen our analysis with a robustness check. Section 7 reviews some other possible ingredients potentially capable to ultimately reduce the interest rate smoothing weight in the loss function. Section 8 concludes. A Technical Appendix explaining the algorithm we use in order to tackle the optimal stochastic regulator problem is provided. References follow.

## 2 Modeling the Central Banker's problem

Our hypothesis is that the CB determines the optimal path of its control variable, i.e. the short term nominal interest rate. The period loss function reads as follows:

$$L_t = (\bar{\pi}_t - \pi^*)^2 + \lambda(y_t)^2 + \mu(i_t - i_{t-1})^2 \quad (1)$$

where  $\pi_t$  represents the inflation rate,  $\pi^*$  is the inflation target,  $y_t$  is the output gap, and  $i_t$  is the short-term nominal interest rate (e.g. the federal funds rate).<sup>3</sup> A few comments on this definition of the loss function

---

<sup>3</sup>The variables used in our study have been constructed as follows:  $\pi_t$  is the four-

are needed. Regarding the inflation targeted by the CB, we think of it as being an average-inflation; this may better represent the will of the monetary authority to monitor the inflation rate in different periods, rather than just in the 'current one'. Our definition of the output gap implies that the target for the level of output set by the CB is the potential output, as plausibly done by the Fed (Blinder, 1997).<sup>4</sup> Finally, in (1) the weight  $\lambda$  represents the preference of the CB over the output gap relative to inflation. Instead, given our interpretation of the interest rate smoothing argument, the weight  $\mu$  should be seen as a residual, or a necessary proxy for replicating the observed path of the federal funds rate.

We assume that the CB solves an *intertemporal* optimization problem. We shape the CB's loss function as follows:

$$\underset{\{i_t\}}{\text{Min}} E_t \sum_{j=0}^{\infty} \delta^j L_{t+j} \quad (2)$$

As shown by Rudebusch and Svensson (1999), when the discount rate  $\delta \rightarrow 1$ , equations (1) and (2) can be rewritten as follows:

$$\underset{\{i_t\}}{\text{Min}} E(L_t) = \text{Var}(\bar{\pi}_t - \pi^*) + \lambda \text{Var}(y_t) + \mu \text{Var}(i_t - i_{t-1}) \quad (3)$$

So, the conditional mean (2) collapses to its unconditional counterpart, which is equal to the weighted sum of the unconditional variances of the loss function's arguments. Hereafter, we will consider equation (3) as the CB's objective function.

---

quarter inflation rate computed on the basis of the GDP chain-weighted price index  $P_t$ , i.e.  $\pi_t \equiv 4(p_t - p_{t-1})$ , where  $p_t = 100 \ln P_t$ .  $y_t$  is the output gap, i.e.  $y_t \equiv q_t - q_t^*$ , where  $q_t \equiv 100 \ln Q_t$ , while  $q_t^* \equiv 100 \ln Q_t^*$ .  $Q_t$  is the real GDP level, while  $Q_t^*$  is the potential output. Finally, upper-barred variables indicate simple averages taken over the contemporaneous observation and the previous three lags of the variable in consideration. All the series used in our analysis are downloadable from the Federal Reserve Bank of St. Louis' web-site, i.e. <http://research.stlouisfed.org/fred2/>. Notice that the potential output series is the one estimated by the Congressional Budget Office.

<sup>4</sup>Indeed, the monopoly-power held by firms in the underlying structure of the economy might lead to think about a CB willing to set a higher target level, given that the equilibrium production in case of monopolistic competition is lower than the socially desirable one. However, by introducing a target greater than the potential output, the CB would face an inflation bias problem (Barro and Gordon, 1983). That is why in our study the output gap target is equal to zero.



We now turn to the representation of the economic environment. We adopt a model à la Rudebusch (2002b), which reads as follows:

$$\pi_{t+1} = \gamma_\pi E_t \bar{\pi}_{t+4} + (1 - \gamma_\pi) \sum_{j=1}^4 \alpha_{\pi j} \pi_{t-j+1} + \alpha_y y_t + \varepsilon_{t+1} \quad (4)$$

$$y_{t+1} = \gamma_y E_t y_{t+2} + (1 - \gamma_y) \sum_{j=1}^2 \beta_{y j} y_{t-j+1} - \gamma_r \beta_r (i_t - E_t \bar{\pi}_{t+4}) - (1 - \gamma_r) \beta_r (\bar{i}_t - \bar{\pi}_t) + \eta_{t+1} \quad (5)$$

where  $\gamma_\pi$  represent the 'degree of forwardness' of the dynamic Phillips curve (4), while  $\gamma_y$  and  $\gamma_r$  are the weights of the FLA elements of the expected demand and the expected real interest rate in the IS equation (5). A few comments are due here. First, following some researchers' example (e.g. Fuhrer and Moore, 1995; Clarida, Galí and Gertler, 1999; Rudebusch and Svensson, 1999, 2002), we admit a stochastic element in the Phillips curve, the *cost-push* shock  $\varepsilon_t$ , which is responsible for the short-run trade-off existing between inflation and output gap. We also admit a demand shock in the IS curve, namely  $\eta_t$ . In this latter curve, we consider the possibility of having a 'hybrid' representation of the short-term real interest rate; we do so to be consistent with the overall 'hybrid' economic set up we want to take into account performing our exercises. Finally, notice that, when  $\gamma_\pi = \gamma_y = \gamma_r = 1$ , this model collapses to the well-known 'New Neoclassical Synthesis' model by Goodfriend and King (1997).

The model (4)-(5) may be re-written in its state space form as follows:

$$A_0 \begin{bmatrix} x_{1t+1} \\ E_t x_{2t+1} \end{bmatrix} = A_1 \begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix} + B_1 i_t + v_{t+1} \quad (6)$$

where  $A_0$  and  $A_1$  are squared matrices of size  $(n_1 + n_2)$ ,  $B_1$  is a  $((n_1 + n_2) \times 1)$  columns vector,  $x_{1t}$  is a  $(n_1 \times 1)$  column vector of predetermined state variables (with  $n_1 = 9$ ), which is defined as  $x_{1t} = [\pi_t \ \pi_{t-1} \ \pi_{t-2} \ \pi_{t-3} \ y_t \ y_{t-1} \ i_{t-1} \ i_{t-2} \ i_{t-3}]'$ , and  $x_{2t}$  is a  $(n_2 \times 1)$  column vector of forward-looking jump variables (with  $n_2 = 4$ ), which is  $x_{2t} = [E_t \pi_{t+3} \ E_t \pi_{t+2} \ E_t \pi_{t+1} \ E_t y_{t+1}]'$ .<sup>5</sup>

---

<sup>5</sup>A description on how to conveniently set up and solve the optimal control problem proposed in this paper is provided in the Technical appendix.

The CB's aim is that of optimally setting the path of the interest rate  $i_t$  in order to minimize the expected loss (3) subject to the law of motion (6). The timing of the game is the following: At the beginning of each period private agents form their expectations; then, the interest rate level is optimally fixed by the Central Bank; finally, demand and supply shocks strike the economy. Söderlind (1999) proves the optimality of the linear feedback rule

$$i_t = -Fx_{1t} \tag{7}$$

where  $F$  is the  $(1 \times n_1)$  row vector whose elements are convolutions of the structural parameters in (4)-(5) and the coefficients attached to the arguments in the objective function (3).

In our positive exercises we compute the optimal monetary policy under discretion. We do so because we believe that this set up may better approximate the monetary policy management undertaken by the Fed in the last 15 years than the alternative one, i.e. commitment. Our choice is supported both by some academics' opinion (e.g. Jensen, 2002; Söderlind, Söderström, and Vredin, 2002) and by some Governor's official declarations (e.g. Bernanke, 2003).<sup>6</sup>

The model (6)-(7) replicates the dynamics present in the economy. In this framework the transmission of the monetary policy action happens with some lags. This is in line with what the observation of the real economy seems to suggest, i.e. a change in the interest rate level affects the output gap with a certain delay, and the inflation rate even with a larger delay, as underlined in Christiano, Eichenbaum and Evans (1998, 2001). Söderlind, Söderström, and Vredin (2002) verify how this model is capable (under some parametrization) to broadly match the features of the historical series in the model.<sup>7</sup> Indeed, the presence of the backward part of the model enables us

---

<sup>6</sup>To be precise, Bernanke (2003) defines the concept of "constrained discretion", which is in fact closely related to the policy framework we adopt in our work, i.e. inflation targeting under discretion.

<sup>7</sup>In particular, they find that a CB with a small concern for output stability, but a large preference for inflation and interest rate stability, delivers a path for these three variables very much in line with the data. Furthermore, they estimate a small degree of forward-looking behavior for the inflation process, and a larger one for the output gap.

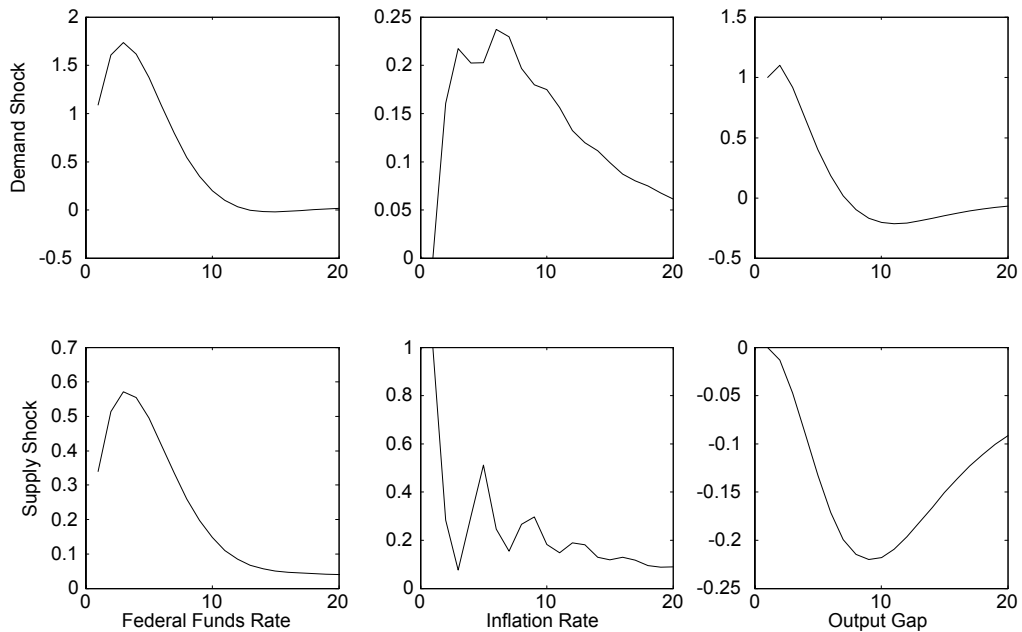


Figure 1: Impulse response functions of the hybrid new-Keynesian model (unitary shocks)

to introduce the FLA component without inducing counterfactual dynamics in the system; for a contribution about this point, see Estrella and Fuhrer (2002).

Figure 2 shows some impulse response functions.<sup>8</sup> It is immediate to notice that shocks to output and inflation are followed by *gradual* movements of the policy rate; this gradualism finds its rationale in the presence of a strictly positive interest rate smoothing weight. After a positive demand shock, the central bank must drive downwards the output gap rendering it negative, in order to tackle the inflationary pressure. Instead, in response to a cost-push shock, the CB raises the short-term nominal interest rate, so depressing the real economy. This induces the return of the average inflation rate to its target, at the cost of periods of under-production. The volatile

<sup>8</sup>These impulse response functions are computed by considering the following key parameters' values:  $\lambda = 0.5$ ,  $\mu = 0.5$ ,  $\gamma_\pi = 0.1$ ,  $\gamma_y = 0.2$ ,  $\gamma_r = 1$ .

pattern shown by the inflation rate in both these cases may be due to the will of the CB to target annual inflation.

With this model at hand, we can calibrate the value of the weight  $\mu$  in order to find the optimal simulated interest rate that most closely replicate Greenspan's federal funds rate. In the next section we describe our econometric strategy.

### 3 Econometric strategy

The aim of our exercise is to fit the policy rate set by Alan Greenspan in the sample 1987Q3-2001Q1.<sup>9</sup> In doing so, we consider two different set of identification restrictions of equations (4)-(5). The first one - our benchmark model, i.e. our fully backward looking specification - is featured by  $\gamma_\pi = \gamma_y = \gamma_r = 0$ .<sup>10</sup> The Benchmark study will deliver us with the weight that we have to assign to the parameter  $\mu$  in order to replicate the historical path of the federal fund rate while employing a backward looking model. The second set of restrictions identify our Hybrid version of the model, featured by the presence of RE. Referring once more to equations (4)-(5), we are in this case allowing for the presence of strictly positive values for the parameters  $\gamma_\pi$ ,  $\gamma_y$ , and  $\gamma_r$ . Notice that we are not exogenously fixing those weights; instead, we want to calibrate them to get the best possible fit of the federal fund rate. So, when the Hybrid version of the model is considered, we will *jointly* calibrate the weight  $\mu$  and the parameters  $\gamma_\pi$ ,  $\gamma_y$ , and  $\gamma_r$ .

The choice of performing a calibration exercise deserves an explanation. Indeed, the optimal stochastic regulator problem offers the possibility of estimating the parameters of the economy and those in the CB's preferences

---

<sup>9</sup>The choice of Greenspan's period is suggested both by sample-length considerations (he has been in charge since the third quarter of 1987, a sample longer than those of the other chairmen) and by our willingness to compare our findings with the available literature, which mostly concentrates on the post-Volcker era. Also, we think it is plausible to consider the Fed's preferences as being chairman-specific.

<sup>10</sup>A fully backward looking framework like this has been used for monetary policy analyses by Ball (1999), Rudebusch and Svensson (1999, 2002), Peersman and Smets (1999), Favero and Milani (2001), Rudebusch (2001), Masuch *et al* (2002), Aksoy *et al* (2002), Ozlale (2003), Favero and Rovelli (2003), and Castelnuovo and Surico (2003), among the others.

via Maximum Likelihood, both in case of a fully backward looking representation (e.g. Ozlale, 2003) and when a hybrid economy is taken into account (e.g. Dennis, 2003). In fact, Dennis (2003) shows that both the backward and the hybrid economic framework may satisfy familiar rank and order conditions for their parameters to be identified. Of course, Maximum Likelihood estimates have the plus of allowing for formal tests on the estimated coefficients. However, this possibility does not come for free. In fact, with Maximum Likelihood we have to assume normality of the errors, something that we are not required to do when performing our calibration exercise. Moreover, Söderlind, Söderström, and Vredin (2002) underline how Maximum Likelihood is quite sensitive to sample selection and outliers. Finally, our focus is that of understanding the impact of FLA on the interest rate smoothing parameter  $\mu$  in the loss function. Then, we do want to keep all the other parameters of the model constant when moving from the fully backward looking representation of the economy to the hybrid one; this would not be possible if we employed Maximum Likelihood.<sup>11</sup>

In order to assign values to the parameters of the model (3) and (6), i.e.  $\lambda$ ,  $\mu$ ,  $\gamma_\pi$ ,  $\gamma_y$ ,  $\gamma_r$ ,  $\alpha_s$ , and  $\beta_s$ , we implement the following calibration strategy:

1) We OLS estimate the parameters  $\alpha_s$  and  $\beta_s$  of our backward looking specification, i.e. we estimate equations (4)-(5) subject to the constraint  $\gamma_\pi = \gamma_y = \gamma_r = 0$ . Our estimates are reported in Table 1.

A key parameter for the transmission of the monetary policy is the interest rate elasticity  $\beta_r$ . Notably, our point estimate - 0.073 - is statistically in line with that of Rudebusch (2002b).<sup>12</sup>

2) We exogenously fix a value for the relative preference  $\lambda$ . We do so to concentrate our attention on the parameters playing a key-role in our story, i.e.  $\mu$ ,  $\gamma_\pi$ ,  $\gamma_y$ , and  $\gamma_r$ . Notice that  $\lambda$  is a structural preference of our set-up, i.e. the relative weight that Alan Greenspan has attributed to the volatility of the output gap versus the volatility of the average inflation rate

---

<sup>11</sup>In fact, to tackle this issue we could employ a Bayesian estimator. However, the limitations listed above and referring to the Maximum Likelihood estimator would still apply.

<sup>12</sup>Instead, probably due to the different samples considered, it is much lower than those provided by Clark, Laxton and Rose (1996) - 0.16 - and Smets (2002) - 0.9.

<b>Phillips curve:</b> $\pi_{t+1} = \alpha_{\pi 1}\pi_t + \alpha_{\pi 2}\pi_{t-1} + \alpha_{\pi 3}\pi_{t-2} + \alpha_{\pi 4}\pi_{t-3} + \alpha_y y_t + \varepsilon_{t+1}$					
<i>Parameter</i>	$\alpha_{\pi 1}$	$\alpha_{\pi 2}$	$\alpha_{\pi 3}$	$\alpha_{\pi 4}$	$\alpha_y$
<i>Point Estimate</i>	0.282	-0.025	0.292	0.385	0.141
<i>Standard Deviation</i>	0.133	0.134	0.134	0.136	0.054
Adjusted R <sup>2</sup> : 0.58; $\sigma_\varepsilon=0.66$ .					
<b>AD curve:</b> $y_{t+1} = \beta_{y1}y_t + \beta_{y2}y_{t-1} + \beta_r(\bar{i}_t - \bar{\pi}_t) + \eta_{t+1}$					
<i>Parameter</i>	$\beta_{y1}$	$\beta_{y2}$	$\beta_r$		
<i>Point Estimate</i>	1.229	-0.244	-0.073		
<i>Standard Deviation</i>	0.136	0.149	0.078		
Adjusted R <sup>2</sup> : 0.93; $\sigma_\eta=0.51$ .					
Variables demeaned before estimation, so no constants appear.					
Sample: 1987Q3-2001Q1.					

Table 1: Estimates of the AD-AS backward looking structure

in deviations from the target.

Indeed, it is possible to find many different sensible values for the relative preference parameter  $\lambda$  in the literature. Focusing on backward representations of the economy à la Rudebusch and Svensson (1999,2002), Favero and Rovelli (2003) estimate with GMM the Euler conditions of the CB's problem, finding a (statistically insignificant) value of 0.00125. Ozlale (2001) exploits Kalman-filtering and estimates a value of 0.525, Dennis (2002) gets 0.815 with a FIML approach, while Castelnuovo and Surico (2003) calibrate a value equal to 1. With a slightly different underlying representation of the economy, Cecchetti, Flores-Lagunes, and Krause (2001) find negligible values for sub-samples regarding the '80s and '90s, while Cecchetti and Ehrmann (2001)'s results support a value of about 1/4. For the same period, but with a VAR representation of the economy, Salemi (1995) finds very low relative weights for the output gap with respect to inflation. Finally, Dennis (2003) designs a hybrid representation of the economy, and estimate a value equal to zero. We somehow arbitrarily fix a benchmark value of  $\lambda = 0.5$ ; however, we check for the robustness of our results by considering also values such as 0.0, 0.2, and 1.0.

3) Given steps 1) and 2), we can perform the calibration of the remaining

parameters  $\mu$ ,  $\gamma_\pi$ ,  $\gamma_y$ , and  $\gamma_r$ .<sup>13</sup> We do so by implementing a grid-search based on a minimum-distance criterium. In particular, we compute, *per each battery*  $j$  :  $[\mu^j, \gamma_\pi^j, \gamma_y^j, \gamma_r^j]$ , an optimal simulated interest rate  $i^{sim,j}$  to be compared with the actual one  $i^{actual}$ .<sup>14</sup> For our calibration we exploit the following measure of Distance:

$$Distance(i^{simulated}, i^{actual}) = \sqrt{\frac{\sum_{t=1}^T (i_t^{simulated} - i_t^{actual})^2}{T}} \quad (8)$$

With this measure of distance we can pick up the simulated interest rate  $i^{sim,j^*}$  (i.e. the one delivering the minimum distance) implied by the calibrated vector  $[\mu^*, \gamma_\pi^*, \gamma_y^*, \gamma_r^*]$ . We recall here that, when the backward looking model is employed, the calibration exercise just regards the weight  $\mu$ , given the identifying restriction  $\gamma_\pi = \gamma_y = \gamma_r = 0$ .<sup>15</sup>

Notice that our calibration strategy relies on the assumption of optimal behavior undertaken by the Fed in the period analyzed. As pointed out by Cecchetti, McConnell, and Perez-Quiros (2002), this is equivalent to assume that Greenspan has operated along the efficiency-frontier that defines the trade-off between inflation and output gap, otherwise labelled as 'Taylor Curve' (Taylor, 1979). Moreover, our search for the optimal weight  $\mu$  assumes that the parameters of our economy remains unvaried after a modification of the monetary policy conduct. Given the presence of FLA, the calibration of our hybrid model is not affected by the Lucas (1976) critique.

---

<sup>13</sup>To have a more easily manageable problem, we demean all the variables involved in our study. As argued by Dennis (2000), this operation does not affect the derivation of the CB's weights in the loss function, but it constraints the average inflation target  $\pi^*$  to be equal to zero, which is to say its sample mean (2.49 in the sample we concentrate on) in an undemeaned world. Actually, our analysis is meant to identify the weights of the CB's loss rather than the targets *per se*. A number of papers cover this latter issue, including Judd and Rudebusch (1998), Sack (2000), Dennis (2002,2003), and Favero and Rovelli (2003).

<sup>14</sup>For our calibration exercise, we consider values belonging to the interval [0.1 - 1.0] for the forwardness coefficients  $\gamma_\pi$  and  $\gamma_y$ , while [0.0 - 1.0] for  $\gamma_r$ . We also take into account a value of  $10^{-4}$  for  $\gamma_\pi$  and  $\gamma_y$ . Finally, for the weight  $\mu$  we take into account values belonging to the interval [0.0 - 10.0]. The step-length of our grid search is 0.1.

<sup>15</sup>In performing these calibrations we do not deal with the Zero Lower Bound issue (see Amirault and O'Reilly, 2001, for a survey on this problem, and Eggertsson and Woodford, 2003, for a recent contribution).

Instead, our exercise with the backward looking specification of the economy is potentially concerned by this critique. Of course, if a variation in the policy rule implied a change of the structural parameters of the economy, our empirical analysis would risk to be flawed. However, the empirical relevance of the Lucas critique in this context seems to be discussable. In fact, Rudebusch (2002c) shows that with an AD-AS backward looking model like the one used in this study the empirical relevance of the critique turns out to be negligible. We now turn to the analysis of our results.

## 4 Findings

In this section we present our findings. In Table 2/Panel a) we collect the results of our joint calibration, the calibration concerning the parameter  $\mu$  and, in case of the Hybrid model, the parameters  $\gamma_\pi$ ,  $\gamma_y$ , and  $\gamma_r$ . Indeed, in absence of FLA, the value of this parameter is quite large, and we judge it as being economically implausible. If we believed that the CB could indeed have an interest rate smoothing goal, this goal would surely not be 2.1 times more important than the volatility of inflation. Since we think of the smoothing argument as being a sort of 'catch all' approximating omitted (potentially important) components, then such a large value might signal the existence of an omitted variable problem. In fact, when adding FLA to the model, our results change quite dramatically. The weight attached to the smoothing argument collapses to 0.5, so indicating FLA as being a central element for correctly representing the economic dynamics. Some descriptive statistics support this intuition. In fact, both for the mean and for the standard deviation of the interest rate *level* the simulated interest rate is much closer than the one deriving from the Benchmark model. As far as the standard deviation of the interest rate *change* is concerned, it is actually difficult to distinguish between the two models; however, we recall that the Benchmark formulation needs an incredible value of 2.1 to replicate the historical data.

What if we control for the weight  $\mu$ ? Table 2/Panel b) collects the results coming from simulations in which the value 0.5 (the calibrated weight  $\mu$  in the Hybrid model case) has been imposed also to our backward looking. This



<b>Panel a): Calibration of the parameter <math>\mu</math></b>						
Interest rate	$\mu$	$E(i_t)$	$\sigma(i_t)$	$\sigma(\Delta i_t)$		
Actual	-	0	1.7273	0.4961		
Backward	2.1	0.8074	2.9924	0.6364		
Hybrid	0.5	0.5692	1.7942	0.5074		
<b>Panel b): Conditional comparison (<math>\mu = 0.5</math>)</b>						
Interest rate	$E(i_t)$	$\sigma(i_t)$	$\sigma(\Delta i_t)$	$\rho(i_{act}, i_{sim})$	$D(i_{act}, i_{sim})$	Dist. reduct.
Actual	0	1.7273	0.4961	-	-	-
Backward	0.8431	3.4839	0.9272	0.9087	2.1445	-
Hybrid	0.5692	1.7942	0.5074	0.9411	0.8519	60.24%
Backward model: $\gamma_\pi=0.0001$ ; $\gamma_y=0.0001$ ; $\gamma_r=0$ .						
Hybrid model: $\gamma_\pi=0.1$ ; $\gamma_y=0.2$ ; $\gamma_r=1$ .						
Moments of the Actual interest rate refer to the demeaned rate.						

Table 2: Calibration outcomes and descriptive statistics with  $\lambda = 0.5$

is done in order to *quantitatively* assess the role of FLA. Notably, all the descriptive statistics are clearly in favor of the Hybrid Model. In particular, with such a low  $\mu$ , the backward looking model's simulated policy exhibits an excessive volatility both in levels and in first differences. Moreover, the distance reduction gained when passing from the B model to the Hybrid one is about 60%. This can loosely be seen as a measure of the bit of the observed smoothness that the Benchmark model is not capable to justify - so implying such a high value of  $\mu$  - and that FLA help explaining. Figure 3 graphs the difference between the Backward Model (i.e. Benchmark) and the FLA-augmented one.<sup>16</sup>

## 5 The importance of FLA

What is the economic *rationale* for this result? Why are forward looking agents so important in describing the observed smooth path of the policy rate, which is to say in *squeezing the interest rate smoothing weight*? A

<sup>16</sup>The path of simulated interest rates deriving from the two models is the one that the federal funds rate would have followed if the Fed had historically implemented the optimal policy rule. Notice that all the policy rates have been demeaned. Key parameters featuring the benchmark model:  $\lambda = 0.5$ ,  $\mu = 0.5$ ,  $\gamma_\pi = 0.0001$ ,  $\gamma_y = 0.0001$ ,  $\gamma_r = 0$ . Instead, those featuring the hybrid model are  $\lambda = 0.5$ ,  $\mu = 0.5$ ,  $\gamma_\pi = 0.1$ ,  $\gamma_y = 0.2$ ,  $\gamma_r = 1$ .

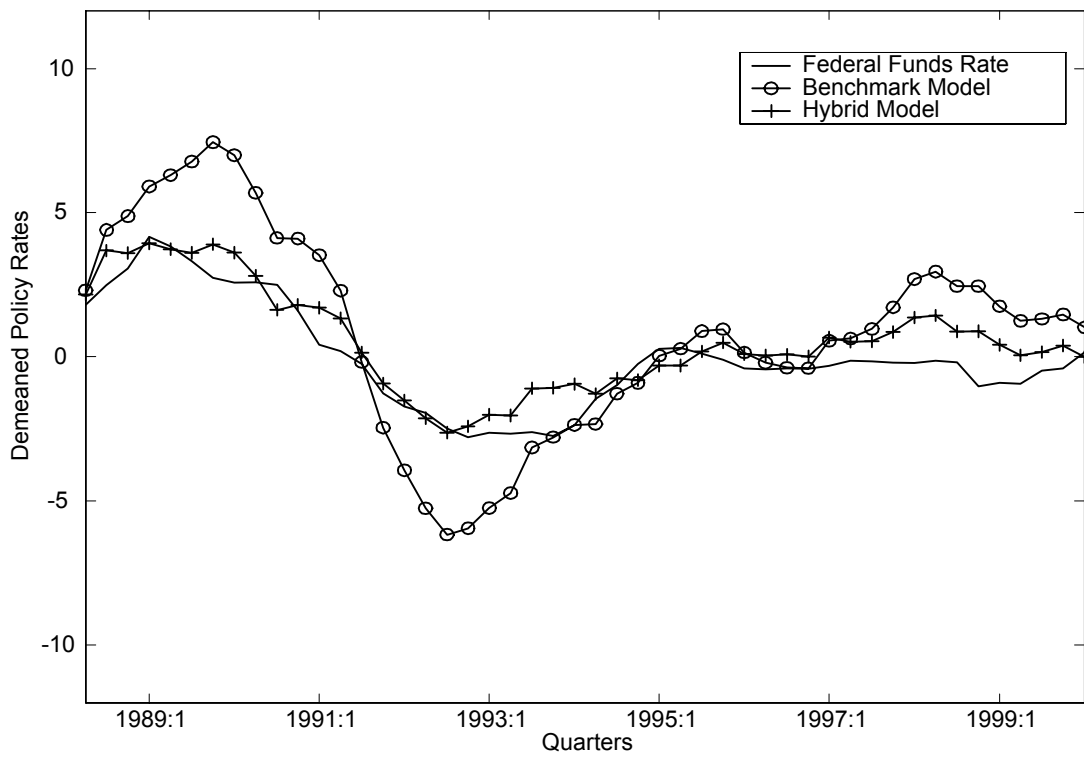


Figure 2: Policy rates behavior: benchmark versus hybrid model

sentence by Woodford (2001) represents a good starting point for our discussion. Woodford (2001, page 15) writes:

*”When the effects of policy depends crucially upon private sector expectations about future policy as well, it is generally optimal for policy to be history-dependent, so that the anticipation of later policy responses can help to achieve the desired effect upon private sector behavior.”*

The presence of FLA implies that current inflation and output gaps are influenced by both current and future expected policy rates. Given the interest rate smoothing penalty in the loss function, private sector agents expect an inertial policy rate, and move their expectations toward the targets, so moving also the current realizations of inflation and output gap toward their steady-state values. This implies that the optimal policy rate, set by following the rule (7), it will be less volatile, because with small changes in the short-term policy rate will be possible to exert a large impact on the macro-variables of interest. Therefore, an optimally determined policy rate will show, *ceteris paribus*, a higher degree of inertia in presence of FLA than when just a fully adaptive private sector is taken into account. Of course, the introduction of the expectations channel will have an impact on the calibrated weight  $\mu$ . Given that our aim is to replicate the observed smooth actual rate, it should be clear that with an economy featured by FLA, just a moderate weight attached to the interest rate argument in the loss function will be sufficient to trigger beneficial, stabilizing expectations. By contrast, in an economy characterized by fully adaptive agents, Woodford’s intuition regarding optimal monetary policy inertia would not find any room; in this case, the optimal policy rate will be less inertial, so forcing a researcher to impose a high weight on the interest rate smoothing argument in order to fit the facts.<sup>17</sup>

---

<sup>17</sup>Another way to understand this result is the following. Suppose that the calibrated fully backward looking model, i.e. the fully backward model that fits at best the federal funds rate, is featured by the weight  $\mu_{FullyBackward}^*$ . Now, suppose that we add the expectations channel to the model, but still keep the same weight  $\mu_{FullyBackward}^*$ . Private sector agents will expect a quite smooth future path for the policy rate; this will lead them to move expectations toward the targets. Given this additional channel, the resulting

## 6 Robustness check: Some considerations

We perform a robustness check of our results focusing on the value of the relative preference parameter  $\lambda$ . The figures concerning this check are contained in Tables 3-5, and refer to values such as 0.0, 0.2, and 1.0. We list here some intuitions that may be gained when looking at our sensitivity analysis:

1) From a descriptive viewpoint, FLA dramatically reduce the importance of the interest rate smoothing argument in the loss function. In fact, the distance reductions got when embedding FLA into the model span from a minimum of 46.67% (case with  $\lambda = 1.0$ ) up to 81.12% ( $\lambda = 0.0$ ).

2) As far as the *real* interest rate in the AD equation is concerned, FLA seem to be particularly important. Indeed, all along our sensitivity exercises,  $\gamma_r$  turns out to be equal to 1. Instead, the percentage of firms and households fully forward looking seems to be low:  $\gamma_\pi$  assumes values such as 0.1 or 0.2, while  $\gamma_y$  figures like 0.2 or 0.3. Notably, these figures are in line with those contained in many empirical investigations: nevertheless, FLA play a key role in our positive exercise.<sup>18</sup>

3) The smallest value of our distance measure is the one related to the framework in which the output gap weight is zero. This means that if we calibrated the preference  $\lambda$  over the grid [0.0; 0.2; 0.5; 1.0] we would find that the first figure is the one that most closely represents Greenspan's preferences. A possible interpretation of this result is provided by Dennis (2002) and Favero and Rovelli (2003), who underline the role of the output gap as leading indicator for future inflation. In other words, the output gap would not have had a big relevance in Greenspan's penalty function, but still it would be an important element for setting the optimal policy rate. An alternative possible explanation, in the spirit of the evidence on output gap uncertainty in Smets (2002) and Estrella and Mishkin (1999) is

---

optimal policy rate will turn out to be *smoother* than the one computed in absence of FLA, then also smoother than the actual one! This implies that, to fit the data with a hybrid model, we will have to *reduce*  $\mu^*$ , i.e.  $\mu_{Hybrid}^* < \mu_{FullyBackward}^*$ .

<sup>18</sup>For similar estimates concerning the Phillips curve, see e.g. Roberts (1998,2001), Lindè (2002), Rudd and Whelan (2001), Rudebusch (2001), Söderlind, Söderström, and Vredin (2002). Relatively to the IS equation, see Fuhrer and Rudebusch, 2002.

<b>Panel a): Calibration of the parameter <math>\mu</math></b>						
Interest rate	$\mu$	$E(i_t)$	$\sigma(i_t)$	$\sigma(\Delta i_t)$		
Actual	-	0	1.7273	0.4961		
Backward	10	0.5369	2.5432	0.3876		
Hybrid	0.4	0.1890	1.5930	0.4026		
<b>Panel b): Conditional comparison (<math>\mu = 0.4</math>)</b>						
Interest rate	$E(i_t)$	$\sigma(i_t)$	$\sigma(\Delta i_t)$	$\rho(i_{act}, i_{sim})$	$D(i_{act}, i_{sim})$	Dist. reduct.
Actual	0	1.7273	0.4961	-	-	-
Backward	0.6079	4.7276	1.0106	0.8672	3.3049	-
Hybrid	0.1890	1.5930	0.4026	0.9478	0.6241	81.12%

Backward model:  $\gamma_\pi=0.0001$ ;  $\gamma_y=0.0001$ ;  $\gamma_r=0$ .  
Hybrid model:  $\gamma_\pi=0.1$ ;  $\gamma_y=0.3$ ;  $\gamma_r=1$ .  
Moments of the Actual interest rate refer to the demeaned rate.

Table 3: Calibration outcomes and descriptive statistics with  $\lambda = 0.0$

<b>Panel a): Calibration of the parameter <math>\mu</math></b>						
Interest rate	$\mu$	$E(i_t)$	$\sigma(i_t)$	$\sigma(\Delta i_t)$		
Actual	-	0	1.7273	0.4961		
Backward	7.4	0.6303	2.5787	0.4309		
Hybrid	0.5	0.4443	1.9436	0.4968		
<b>Panel b): Conditional comparison (<math>\mu = 0.5</math>)</b>						
Interest rate	$E(i_t)$	$\sigma(i_t)$	$\sigma(\Delta i_t)$	$\rho(i_{act}, i_{sim})$	$D(i_{act}, i_{sim})$	Dist. reduct.
Actual	0	1.7273	0.4961	-	-	-
Backward	0.7198	3.8366	0.9031	0.9060	2.4134	-
Hybrid	0.4443	1.9436	0.4968	0.9474	0.7721	68.01%

Backward model:  $\gamma_\pi=0.0001$ ;  $\gamma_y=0.0001$ ;  $\gamma_r=0$ .  
Hybrid model:  $\gamma_\pi=0.2$ ;  $\gamma_y=0.2$ ;  $\gamma_r=1$ .  
Moments of the Actual interest rate refer to the demeaned rate.

Table 4: Calibration outcomes and descriptive statistics with  $\lambda = 0.2$

<b>Panel a): Calibration of the parameter <math>\mu</math></b>						
Interest rate	$\mu$	$E(i_t)$	$\sigma(i_t)$	$\sigma(\Delta i_t)$		
Actual	-	0	1.7273	0.4961		
Backward	2.6	0.9166	2.7908	0.6353		
Hybrid	1.3	0.6977	1.6167	0.4314		
<b>Panel b): Conditional comparison (<math>\mu = 1.3</math>)</b>						
Interest rate	$E(i_t)$	$\sigma(i_t)$	$\sigma(\Delta i_t)$	$\rho(i_{act}, i_{sim})$	$D(i_{act}, i_{sim})$	Dist. reduct.
Actual	0	1.7273	0.4961	-	-	-
Backward	0.9395	3.0101	0.7677	0.8916	1.8648	-
Hybrid	0.6977	1.6167	0.4314	0.9248	0.945	46.67%
Backward model: $\gamma_\pi=0.0001$ ; $\gamma_y=0.0001$ ; $\gamma_r=0$ .						
Hybrid model: $\gamma_\pi=0.1$ ; $\gamma_y=0.2$ ; $\gamma_r=1$ .						
Moments of the Actual interest rate refer to the demeaned rate.						

Table 5: Calibration outcomes and descriptive statistics with  $\lambda = 1.0$

that monetary authorities may have placed a low weight on the most poorly measured goal, or yet, that the market productivity growth of the 90s may have drastically reduced any concern of output stabilization. A similar result is also present in Cecchetti, Flores-Lagunes, and Krause (2001). Finally, this result also arises in studies that take into account analogous hybrid models (e.g. Söderlind, Söderström, and Vredin, 2002, and Dennis, 2003) and in studies in which authors take into account the model uncertainty issue (e.g. Castelnovo and Surico, 2003). Table 6 summarizes the parameters values featuring our best (in terms of descriptive power) model.

Our calibration strategy concentrates on the federal funds rate. Table 7 reports some descriptive statistics relative to the actual and simulated series of the inflation rate and the output gap. Importantly, these statistics are quite close to each other, and the correlation rates reported are fairly satisfactory. We take these figures as evidence in favor of our calibration strategy, i.e. our strategy turns out to produce sensible results also for the other variables of our economic system.

*Still a positive  $\mu$ : possible reasons*

The presence of forward looking agents in the economic framework squeezes

Model components	Parameters	Values (Assignment Strategy)
<i>Loss function</i>	$\lambda$	0.000 (imposed)
	$\mu$	0.400 (calibrated)
<i>Phillips curve</i>	$\gamma_\pi$	0.100 (calibrated)
	$\alpha_{\pi 1}$	0.282 (OLS estimated)
	$\alpha_{\pi 2}$	-0.025 (OLS estimated)
	$\alpha_{\pi 3}$	0.292 (OLS estimated)
	$\alpha_{\pi 4}$	0.385 (OLS estimated)
	$\alpha_y$	0.141 (OLS estimated)
	$\sigma_\varepsilon$	0.660 (OLS estimated)
<i>AD curve</i>	$\gamma_y$	0.300 (calibrated)
	$\beta_{y1}$	1.229 (OLS estimated)
	$\beta_{\pi 2}$	-0.244 (OLS estimated)
	$\gamma_r$	1.000 (calibrated)
	$\beta_r$	-0.073 (OLS estimated)
	$\sigma_\eta$	0.510 (OLS estimated)

Table 6: Best model: List of parameters values

<i>Inflation rate</i>	$E(\pi_t)$	$\sigma(\pi_t)$	$\sigma(\Delta\pi_t)$	$\rho(\pi_{act}, \pi_{sim})$
Actual	0	1.0031	0.8438	-
Simulated	0.1579	0.8517	0.8468	0.5503
<i>Output gap</i>	$E(y_t)$	$\sigma(y_t)$	$\sigma(\Delta y_t)$	$\rho(y_{act}, y_{sim})$
Actual	-0.2612	1.8182	0.5230	-
Simulated	-0.3547	1.0269	0.3975	0.6518
Moments of the Actual variables refer to the demeaned processes.				

Table 7: Best model: Descriptive statistics of inflation and output gap

the value of the parameter  $\mu$  needed in order to track Greenspan's federal funds rate. Nevertheless,  $\mu$  is still strictly positive. Then, what is this model missing in order to fully explain the observed policy gradualism? Sack and Wieland (2000) suggest that also parameter uncertainty and measurement error affecting real-time data may imply optimal gradualism. As far as the former explanation is concerned, Söderström (1999) and Sack (2000), working on an idea originally proposed by Brainard (1967), show that parameter uncertainty may contribute to rationalize the observed cautiousness. However, Estrella and Mishkin (1999), Peersman and Smets (1999), and Rudebusch (2001) claim that parameter uncertainty is not so important from a quantitative viewpoint. Moreover, robust-control oriented work (e.g. Onatski and Stock, 2002) tend to suggest an optimally aggressive conduct of monetary policy.

Does learning enhance gradualism? Sack (1998) shows how a CB that periodically refines his estimates of the key-parameters linking the variables of interest in a given framework may choose to act gradually. This result is due to the stochastic features of the economic dynamics, that render particularly informative the most recent observations. As a result, the Fed faces more uncertainty about the reaction of the economy as it moves the funds rate away from its recent levels. However, Sack (1998) himself and Wieland (2000) point out that there exist a dynamic trade-off between gradualism and learning, i.e. it may become optimal in a dynamic set-up to implement an aggressive policy in order to learn how the economy react to new, different monetary policy shocks. Indeed, an aggressive policy might speed up the learning process. However, this approach, termed *experimentation* (see Bertocchi and Spagat, 1993, and Caplin and Leahy, 1996), do not seem to be supported by Policy Makers' official declarations.<sup>19</sup>

McCallum (1999) sustains that a good policy rule is the one that is capable to perform well across many different models. In fact, not only a CB is uncertain about the key-parameters of the equations formalizing the economy; indeed, he is uncertain regarding the structure of the economy itself.

---

<sup>19</sup>Regarding this point, it is worth to signal a comment by a former Vice-Chairman of the Fed, Alan Blinder (1998, p.11): "You don't conduct experiments on a real economy solely to sharpen your econometric estimates".



From the descriptive side, recent empirical contributions by Favero and Milani (2001) and Castelnuovo and Surico (2003), conducted in a class of linear backward looking models, show that model uncertainty helps explaining the observed policy rate behavior.

Finally, a positive value of the  $\mu$  parameter might also be the expression of the concern that the CB has for the financial markets, markets that are thought as being very reactive to large swings of the nominal interest rate (Goodfriend, 1991; Blinder, 1997; Mishkin, 1999).<sup>20</sup>

## 7 Conclusions

The interest rate smoothing argument has been debated quite intensively in the past few years. From a positive perspective this argument is needed in order to generate the observed policy rate persistence. In fact, in small scale fully backward looking models the interest rate smoothing weight has usually got a puzzling high relative value in the CB's loss function.

In this paper we show that the 'forward looking agents' ingredient may play a big role in partially solving this puzzle. Indeed, by comparing the outcomes stemming from a fully backward looking model with those deriving from a calibrated hybrid one, we found that this ingredient dramatically reduces the interest rate smoothing puzzle otherwise arising. Implicitly, this suggests that the Fed has seriously taken Greenspan has seriously taken into account private sector's expectations taking its policy decisions.

Interestingly enough, when looking at some recent contributions in the literature, it seems to be possible to state that our conclusion on the relationship between forward looking agents and policy rate gradualism holds even when learning is taken into account. Wieland (2002) obtains the same result in a model in which both the Central Banker and the private sector

---

<sup>20</sup>An interesting point tackling this view is provided by Cecchetti (2000). In fact, he claims that large jumps in the policy instruments could be disruptive only if financial markets are relatively certain that it will never happen. Instead, if market participants expect that new information can precipitate large and sudden interest rate changes, then they will defend themselves by building up institutions that can withstand the potential disruptions this would otherwise cause. In synthesis, the only reason that people believe smooth interest rates enhance financial stability is because interest rate has been smooth up to now.

are uncertain about the relationship between inflation and unemployment, and learn on that. We see this evidence as a further confirmation on the robustness of our findings.

Our calibration exercises suggest that a hybrid new-Keynesian model may very well fit the data. In particular, a low relative concern for output gap volatility with respect to inflation volatility, a low degree of 'forward lookingness' in both the Phillips curve and the IS curve, and a high weight for future inflation in the expected real interest rate are the features of our best positive model. In this sense, our findings are in line with those contained in a recent work by Söderlind, Söderström, and Vredin (2002), and suggest that much more should be done in order to better understand the role of adjustment costs, rules of thumb, and habit formation in shaping the dynamics of variables such as inflation and the output gap. It is worth signalling that efforts in this direction have already been undertaken by e.g. Fuhrer and Moore (1995), Fuhrer (2000), Estrella and Fuhrer (2002) and Amato and Laubach (2003).

Although very much important, the presence of forward looking agents in small scale macroeconomic models is not sufficient to get rid of the interest rate smoothing argument when performing positive exercises. Apart from model uncertainty and real-time data (ingredients already suggested by Sack and Wieland in their survey), an interesting attempt could be that of investigating if a framework admitting 'quasi-commitment' solutions of the monetary authorities' optimal control problem might reduce further (if not completely eliminate) the interest rate smoothing penalty in the loss function. In fact, Schaumburg and Tambalotti (2003) and Hakan Kara (2003) notice how the observed monetary policy gradualism is lower than the one suggested by the optimal solution under commitment, but higher than that featuring the optimal solution under full discretion. Following their approach, the introduction of a credibility parameter in the set up analyzed in this paper could lead to having an optimal solution featured by a large degree of inertia even in absence of the interest rate smoothing penalty. This effort is the next one in our research agenda.

## Technical appendix

The algorithm to solve the optimal control problem faced by the CB is more easily understandable if the model representing the economy is written in its state-space form. Consider equations (4) and (5), which we rewrite here below:

$$\begin{aligned} \pi_{t+1} = & \gamma_\pi E_t \left( \frac{\pi_{t+1} + \pi_{t+2} + \pi_{t+3} + \pi_{t+4}}{4} \right) \\ & + (1 - \gamma_\pi)(\alpha_{\pi 1} \pi_t + \alpha_{\pi 2} \pi_{t-1} + \alpha_{\pi 3} \pi_{t-2} + \alpha_{\pi 4} \pi_{t-3}) + \alpha_y y_t + \varepsilon_{t+1} \end{aligned} \quad (9)$$

$$\begin{aligned} y_{t+1} = & \gamma_y E_t y_{t+2} + (1 - \gamma_y)(\beta_{y1} y_t + \beta_{y2} y_{t-1}) \\ & - \beta_r \gamma_r [i_t - E_t \left( \frac{\pi_{t+1} + \pi_{t+2} + \pi_{t+3} + \pi_{t+4}}{4} \right)] \\ & - \frac{\beta_r (1 - \gamma_r)}{4} (i_t + i_{t-1} + i_{t-2} + i_{t-3} - \pi_t - \pi_{t-1} - \pi_{t-2} - \pi_{t-3}) + \eta_{t+1} \end{aligned} \quad (10)$$

To solve the optimal control problem, we basically have to compute the expectations terms  $E_t \pi_{t+4}$  and  $E_t y_{t+2}$ . Noticing that  $\pi_{t+1} = E_t \pi_{t+1} + \varepsilon_{t+1}$  and  $y_{t+1} = E_t y_{t+1} + \eta_{t+1}$  (where  $\varepsilon_{t+1}$  and  $\eta_{t+1}$  are white noise), it is then possible to write (9) and (10) as follows:

$$\begin{aligned} \frac{\gamma_\pi E_t \pi_{t+4}}{4} = & (1 - \frac{\gamma_\pi}{4}) E_t \pi_{t+1} - \frac{\gamma_\pi}{4} E_t \pi_{t+2} - \frac{\gamma_\pi}{4} E_t \pi_{t+3} \\ & - (1 - \gamma_\pi)(\alpha_{\pi 1} \pi_t + \alpha_{\pi 2} \pi_{t-1} + \alpha_{\pi 3} \pi_{t-2} + \alpha_{\pi 4} \pi_{t-3}) - \alpha_y y_t \end{aligned} \quad (11)$$

$$\begin{aligned} \gamma_y E_t y_{t+2} + \beta_r \gamma_r E_t y_{t+4} = & E_t y_{t+1} - (1 - \gamma_y)(\beta_{y1} y_t + \beta_{y2} y_{t-1}) \\ & + \beta_r \gamma_r [i_t - E_t \left( \frac{\pi_{t+1} + \pi_{t+2} + \pi_{t+3}}{4} \right)] \\ & + \frac{\beta_r (1 - \gamma_r)}{4} \sum_{j=0}^3 (i_{t-j} - \pi_{t-j}) \end{aligned} \quad (12)$$

As already specified in the text, we aim at computing the discretionary solution of the problem, given that it is time-consistent. To find it, we use Söderlind (1999)'s strategy.<sup>21</sup> This strategy requires a precise distinction of the elements involved in the problem between state (predetermined) and jump (forward-looking) variables. So, we define the  $(n1x1)$  vector of predetermined state variables as follows ( $n1 = 9$ ):

$$x_{1t} = \left[ \pi_t \quad \pi_{t-1} \quad \pi_{t-2} \quad \pi_{t-3} \quad y_t \quad y_{t-1} \quad i_{t-1} \quad i_{t-2} \quad i_{t-3} \right]' \quad (13)$$

and the  $(n2x1)$  vector of forward-looking jump ones as here below ( $n2 = 4$ ):

$$x_{2t} = \left[ E_t\pi_{t+3} \quad E_t\pi_{t+2} \quad E_t\pi_{t+1} \quad E_t y_{t+1} \right]' \quad (14)$$

Since we are solving a stochastic problem, we also define the  $(n1x1)$  vector of shocks to the predetermined variables as:

$$v_{1t} = \left[ \varepsilon_t \quad 0_{1x3} \quad \eta_t \quad 0_{1x4} \right]' \quad (15)$$

Then, the state-space representation of the problem is the following:

$$A_0 \begin{bmatrix} x_{1t+1} \\ E_t x_{2t+1} \end{bmatrix} = A_1 \begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix} + B_1 i_t + v_{t+1} \quad (16)$$

where

$$v_{t+1} = \begin{bmatrix} v_{1t+1} \\ 0_{n2x1} \end{bmatrix} \quad (17)$$

and where the matrices  $A_0$ ,  $A_1$ , and  $B_1$  read as follows:

---

<sup>21</sup>The Gauss and Matlab routines for solving the optimal stochastic regulator problem presented in this Technical Appendix can be found in Söderlind's webpage, i.e. <http://www.lhs.se/personal/PSoderlind/>.

$$A_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{\gamma_\pi}{4} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \frac{\beta_r \gamma_r}{4} & 0 & 0 & \gamma_y \end{bmatrix}$$

$$A_1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ \tilde{\alpha}_{\pi 1} & \tilde{\alpha}_{\pi 2} & \tilde{\alpha}_{\pi 3} & \tilde{\alpha}_{\pi 4} & -\alpha_y & 0 & 0 & 0 & 0 & -\frac{\gamma_\pi}{4} & -\frac{\gamma_\pi}{4} & (1 - \frac{\gamma_\pi}{4}) & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ \hat{\beta}_r & \hat{\beta}_r & \hat{\beta}_r & \hat{\beta}_r & \tilde{\beta}_{y1} & \tilde{\beta}_{y2} & -\hat{\beta}_r & -\hat{\beta}_r & -\hat{\beta}_r & -\frac{\beta_r \gamma_r}{4} & -\frac{\beta_r \gamma_r}{4} & -\frac{\beta_r \gamma_r}{4} & 1 \end{bmatrix}$$

$$B_1 = \begin{bmatrix} 0_{1 \times 6} & 1 & 0_{1 \times 5} & \beta_r \gamma_r - \hat{\beta}_r \end{bmatrix}'$$

where  $\tilde{\alpha}_{\pi j} = -(1 - \gamma_\pi)\alpha_{\pi j}$ ,  $\hat{\beta}_r = -\frac{\beta_r(1-\gamma_r)}{4}$ ,  $\tilde{\beta}_{yj} = -(1 - \gamma_y)\beta_{yj}$ .

To obtain the standard state-space representation, we just have to pre-multiply (16) by  $A_0^{-1}$ , so obtaining

$$\begin{bmatrix} x_{1t+1} \\ E_t x_{2t+1} \end{bmatrix} = A \begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix} + B i_t + v_{t+1} \quad (18)$$

with  $A = A_0^{-1}A_1$  and  $B = A_0^{-1}B_1$ .<sup>22</sup>

It is useful to express also the CB's objective function in a compact form. To do so, it is necessary to write down the vector of the arguments targeted by the CB. This vector is defined as:

$$z_t = \begin{bmatrix} \bar{\pi}_t & y_t & \Delta i_t \end{bmatrix}' \quad (19)$$

Notice that, given our choice of working with demeaned variables which renders easier the management of the optimal stochastic regulator problem,  $\pi^*$  is normalized to be equal to zero.

The goal variables included in vector (19) can be expressed via the following formula:

$$z_t = C_x x_t + C_i i_t \quad (20)$$

where

$$C_x = \begin{bmatrix} \frac{1}{4} & \frac{1}{4} & \frac{1}{4} & \frac{1}{4} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

and

$$C_i = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix}'$$

The CB attributes to the quadratic transformation of the arguments in (19) different weights. We normalize the weight on the average inflation rate to one, and we attribute relative weights to the other targets, as follows:

$$L_t = \bar{\pi}_t^2 + \lambda y_t^2 + \mu \Delta i_t^2 \quad (21)$$

which can be re-expressed as:

---

<sup>22</sup>Notice that  $A_0^{-1}v_{t+1} = v_{t+1}$ , since  $A_0$  is block diagonal with an identity matrix as its upper left block and the lower block of  $v_{t+1}$  is equal to zero. Notice also that the requirement for having  $\det(A_0) \neq 0$  is that  $\gamma_\pi, \gamma_y \neq 0$ . That is why, when identifying the Benchmark model (i.e. fully backward looking model) in our exercise, we do not set those weights to a zero value. Instead, we set them equal to  $10^{-4}$ . This is a drawback deriving from our choice of using the procedure elaborated by Paul Söderlind (1999) for solving RE models. Richard Dennis made us notice that, if we were to solve for the optimal discretionary rule using the *structural* form of the model rather than the *state-space* form, this problem would vanish. For further information about this point, see Dennis (2000).

$$L_t = z_t' K z_t \quad (22)$$

where  $K$  is a  $3 \times 3$  diagonal matrix containing the relative concerns of the CB.  $K$  is shaped in this way:

$$K = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \lambda & 0 \\ 0 & 0 & \mu \end{bmatrix} \quad (23)$$

Using (20), the period loss function (22) can be re-expressed as follows:

$$\begin{aligned} L_t &= \begin{bmatrix} x_t' & i_t' \end{bmatrix} \begin{bmatrix} C_x' \\ C_i' \end{bmatrix} K \begin{bmatrix} C_x & C_i \end{bmatrix} \begin{bmatrix} x_t \\ i_t \end{bmatrix} \\ &= x_t' C_x' K C_x x_t + x_t' C_x' K C_i i_t + i_t' C_i' K C_x x_t + i_t' C_i' K C_i i_t \\ &= x_t' Q x_t + x_t' U i_t + i_t' U' x_t + i_t' R i_t \end{aligned}$$

$$\text{where } x_t = \begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix},$$

and where  $Q = C_x' K C_x$ ,  $U = C_x' K C_i$ ,  $R = C_i' K C_i$ .

Hence the CB's optimal control problem is given by the intertemporal penalty function

$$J_t = E_t \sum_{\tau=t}^{\infty} \delta^{\tau-t} (x_{\tau}' Q x_{\tau} + x_{\tau}' U i_{\tau} + i_{\tau}' U' x_{\tau} + i_{\tau}' R i_{\tau}) \quad (24)$$

subject to the law of motion of the economy (18). As already written in the text, it turns out that the optimal discretionary policy is a rule for the interest rate as a linear function of the predetermined variables in the vector  $x_{1t}$ , i.e.

$$i_t = -F x_{1t} \quad (25)$$

The law of motion of the predetermined variables is given by

$$x_{1t+1} = M x_{1t} + v_{1t+1} \quad (26)$$

while the jump variables are defined as

$$x_{2t} = Nx_{1t} \tag{27}$$

Details on how to compute the matrices  $M$  and  $N$  are provided by Söderlind (1999).

Notice an important result. Rudebusch and Svensson (1999) underline how, when the discount factor  $\delta \rightarrow 1$ , the intertemporal loss function (24) approaches the unconditional mean of the period loss function. Hence, we can write it as

$$E(L_t) = Var(\bar{\pi}_t) + \lambda Var(y_t) + \mu Var(\Delta i_t) \tag{28}$$

After having

- 1) initialized the vector  $x_{10}$  with historical observations,
- 2) attributed to the vector  $x_{20}$  nil values,
- 3) set the values of the key-coefficients  $\alpha_s, \beta_s, \gamma_\pi, \gamma_y$ , and  $\gamma_r$  in the matrices  $A_0, A_1$ , and  $B$ ,
- 4) stored the structural residuals into the vector  $v_t$ ,
- 5) determined the relative weights  $\lambda$  and  $\mu$  in the loss function (28), and
- 6) computed the optimal feedback coefficients in  $F$ ,

we can exploit expressions (18) and (25) in order to simulate how the economy would have evolved if the CB had implemented the policy rule solution of the optimal control problem. Finally, given the simulated time-series for  $\pi, y$ , and  $i$ , it is easy to compute the value of the expected loss (28).



## References

- Aksoy, Y., P. De Grauwe, and H. Dewachter, 2002, Do asymmetries matter for European monetary policy?, *European Economic Review*, 46, 443-469.
- Amato, J., and T. Laubach, 1999, The Value of Interest Rate Smoothing: How the Private Sector Helps the Federal Reserve, *Economic Review*, Federal Reserve Bank of Kansas City, 47-64.
- Amato, J., and T. Laubach, 2003, Rule-of-thumb behavior and monetary policy, *European Economic Review*, forthcoming.
- Amirault, D., and B. O'Reilly, The Zero Bound on Nominal Interest Rates: How Important Is It?, Bank of Canada, Working Paper No. 2001-6.
- Ball, L., 1999, Efficient Rules for monetary policy, *International Finance*, 2(1), 63-83.
- Barro, R.J., and D.B. Gordon, 1983, A Positive Theory of Monetary Policy in a Natural Rate Model, *Journal of Political Economy*, 91, 4, 589-610.
- Bernanke, B.S., 2003, "Constrained Discretion" and Monetary Policy, Remarks by Governor Ben S. Bernanke before the Money Marketeters of New York University, New York, February 3.
- Bertocchi, G., and M. Spagat, 1993, Learning, Experimentation, and Monetary Policy, *Journal of Monetary Economics*, 32 (1), 169-183.
- Blinder, A.S., 1997, What Central Bankers Could Learn from Academics and Vice Versa, Distinguished Lecture on Economics in Government, *Journal of Economic Perspectives*, 11, 2, Spring, 3-19
- Blinder, A.S., 1998, Central banking in theory and practice, The MIT Press, Cambridge, Massachusetts.
- Brainard, W., 1967, Uncertainty and the Effectiveness of Policy, *American Economic Review Papers and Proceedings*, 57, 411-25.
- Caplin, A., and J. Leahy, 1996, Monetary Policy as a Process of Search, *American Economic Review*, 86 (4), 689-702.
- Castelnuovo, E., 2003a, Describing the Fed's Conduct with Taylor Rules: Is Interest Rate Smoothing Important?, European Central Bank, Working Paper No. 232.
- Castelnuovo, E., 2003b, Taylor Rules, Omitted Variables, and Interest Rate Smoothing in the US, *Economics Letters*, forthcoming.

- Castelnuovo, E. and P. Surico, 2003, Model Uncertainty, Optimal Monetary Policy, and the Preferences of the Fed, *Scottish Journal of Political Economy*, forthcoming.
- Cecchetti, S.G., 2000, Making Monetary Policy: Objectives and Rules, *Oxford Review of Economic Policy*, Vol. 16, No. 4, 43-59.
- Cecchetti, S.G., A. Flores Lagunes and Stefan Krause, 2001. Has monetary policy become more efficient? A cross country analysis. Mimeo, Ohio State University.
- Cecchetti, S.G. and M. Ehrmann, 2001, Does Inflation Targeting Increase Output Volatility? An International Comparison of Policymakers' Preferences and Outcomes, in Schmidt-Hebbel, K. (ed): *Monetary Policy: Rules and Transmission Mechanism*, Proceedings of the third annual conference of the Bank of Chile, forthcoming.
- Cecchetti, S.G., M. McConnell, and G. Perez Quiros, 2002. Policymakers revealed preferences and the output-inflation variability trade-off. *The Manchester School*, Vol.70, No. 4, 2002, 596-618.
- Clarida, R., J. Galí, and M. Gertler, 1999, The Science of Monetary Policy: A New Keynesian Perspective, *Journal of Economic Literature*, XXXVII, December, 1661-1707.
- Clark P., D. Laxton, and D. Rose, 1996, Asymmetry in the U.S. output-inflation nexus, *IMF Staff Papers*, 43, 216-251.
- Christiano, L., M. Eichenbaum, and C.Evans, 1998, Monetary Policy Shocks: What Have We Learnt and to What End, NBER Working Paper No. 6400.
- Christiano, L., M. Eichenbaum, and C.Evans, 2001, Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy, NBER Working Paper No. 8403.
- Dennis, Richard, 2000. Steps toward identifying central bank policy preferences. Federal Reserve of San Francisco working paper No. 2000-13.
- Dennis, R., 2002, The Policy Preferences of the US Federal Reserve, Federal Reserve Bank of San Francisco, Working Paper No. 2001-08.
- Dennis, R., 2003, Inferring Policy Objectives from Economic Outcomes, Federal Reserve Bank of San Francisco, Working Paper No. 2003-05.
- Eggertsson G., and M. Woodford, 2003, The Zero Bound on Interest Rates and Optimal Monetary Policy, mimeo.

- English, W.B., W.R. Nelson, and B.P. Sack, 2003, Interpreting the Significance of the Lagged Interest Rate in Estimated Monetary Policy Rules, *Contributions to Macroeconomics*, Vol. 3(1), Article 5.
- Estrella, A. and F.S. Mishkin, 1999, Rethinking the Role of NAIRU in Monetary Policy: Implications of Model Formulation and Uncertainty, in Taylor, J.B. (ed): *Monetary Policy Rules*, NBER and University of Chicago Press, Chicago.
- Estrella, A., and J.C. Fuhrer, 2002, Dynamic Inconsistencies: Counterfactual Implications of a Class of Rational-Expectations Models, *American Economic Review*, 92(4), 1013-1028, September.
- Favero, C.A., and F. Milani, 2001, Parameter Instability, Model Uncertainty and Optimal Monetary Policy, IGIER Working Paper No. 196.
- Favero, C. A. and R. Rovelli, 2003, Macroeconomic stability and the preferences of the Fed. A formal analysis, 1961-98. *Journal of Money, Credit and Banking*, forthcoming.
- Fuhrer, J.C., 2000, Habit Formation in Consumption and Its Implications for Monetary-Policy Models, *American Economic Review*, 90(3), 367-90, June.
- Fuhrer J.C. and G.R. Moore, 1995, Inflation Persistence, *Quarterly Journal of Economics*, 110, 127-159.
- Fuhrer, J.C., and G.D. Rudebusch, 2002, Estimating the Euler Equation for Output, mimeo.
- Goodfriend, M., 1991, Interest Rate and the Conduct of Monetary Policy, *Carnegie-Rochester Conference Series on Public Policy*, 34, 7-30.
- Goodfriend, M. and R.G. King, 1997, The New Neoclassical Synthesis and the Role of Monetary Policy, in B.S. Bernanke and J.J. Rotemberg (eds): *NBER Macroeconomics Annual 1997* (Cambridge, MA: The MIT Press), 231-283.
- Goodhart, C. A. E., 1997, Why do the Monetary Authorities Smooth Interest Rates, Chapter 8 in *European Monetary Policy*. S. Collignon (ed.), Pinter: London.
- Goodhart, C. A. E., 1999, Central Bankers and Uncertainty, *Keynes Lecture in Economics*, *Proceedings of the British Academy*, 101, 229-271.
- Hakan Kara, A., 2003, Optimal Monetary Policy Rules under Imperfect Commitment: Some Theory and Evidence, mimeo.

- Issing, O., 1997, Comment on Ch. 8, in S. Collignon (ed.): *European Monetary Policy*, London: Pinter, 175-178.
- Jensen, H., 2002, Targeting Nominal Income Growth or Inflation?, *American Economic Review*, 92(4), 928-956, September.
- Judd, John P. and Glenn D. Rudebusch, 1998. Taylor's rule and the fed: 1970-1997. Federal Reserve Bank of San Francisco, *Economic Review*, 3, 3-16.
- Levin, A., Wieland, V., and Williams, J., 1999, The robustness of simple monetary policy rules under model uncertainty, in J.B. Taylor (ed.), *Monetary Policy Rules*, Chicago, NBER and Chicago Press.
- Levin, A., Wieland, V., and Williams, J., 2002, The Performance of Forecast Based Monetary Policy Rules under Model Uncertainty, *American Economic Review*, forthcoming.
- Lindé, J., 2002, Estimating New-Keynesian Phillips Curves: A Full Information Maximum Likelihood Approach, *American Economic Review*, 91 (4), 986-1005.
- Lowe, P. and L. Ellis, 1998, The Smoothing of Official Interest Rates, in Philip Lowe, ed., *Monetary Policy and Inflation Targeting: Proceedings of a Conference*, (Sidney: Reserve Bank of Australia): 286-312.
- Lucas, R.E.Jr., 1976, Econometric Policy Evaluation: A Critique, *Journal of Monetary Economics*, Supplementary Series, 1(7), 19-46.
- Masuch, K., S. Nicoletti Altimari, H. Pill, and M. Rostagno, 2002, Why "A Prominent Role for Money"?, paper presented at the AEA meetings in Atlanta, 4-6 January.
- McCallum, B.T., 1999, Issues in the Design of Monetary Policy Rules, in J.B. Taylor and M. Woodford (eds), *Handbook of Macroeconomics*, Amsterdam, North-Holland.
- Mishkin, F.S., 1999, Comment on Rudebusch and Svensson's paper 'Policy Rules for Inflation Targeting', in Taylor J.B. (ed): *Monetary Policy Rules*, NBER Conference on Research and Business Cycles, University of Chicago Press.
- Nessén, M. and D. Vestin, 2000, Average Inflation Targeting, Sveriges Riksbank, Working Paper No. 119-2000.
- Onatski, A., and J.H. Stock, 2002. Robust monetary policy under model uncertainty in a small model of the US economy, *Macroeconomic Dynamics* 6.

- Ozlale, U., 2003, Price Stability vs. Output Stability: Tales from three Federal Reserve Administration, *Journal of Economic Dynamics and Control*, forthcoming.
- Peersman, G., and F. Smets, 1999, The Taylor rule: a useful monetary policy benchmark for the Euro area?, *International Finance*, No. 1, 85-116.
- Roberts, J.M., 1998, Inflation Expectations and the Transmission of Monetary Policy, mimeo, Board of Governors of the Federal Reserve System.
- Roberts, J.M., 2001, How Well Does the New Keynesian Sticky-Price Model Fit the Data?, mimeo, Board of Governors of the Federal Reserve System.
- Rotemberg, J., and M. Woodford, 1999, Interest rate rules in an estimated sticky-price model, in J.B. Taylor (ed.), *Monetary Policy Rules*, Chicago, NBER and Chicago Press.
- Rudd, J. and K. Whelan, 2001, New Tests of the New Keynesian Phillips Curve, mimeo, Board of Governors of the Federal Reserve System.
- Rudebusch, G. D., 1995. Federal reserve interest rate targeting, rational expectations and the term structure. *Journal of Monetary Economics*, 35, 245-274.
- Rudebusch, G. D., 2001, Is the fed too timid? Monetary policy in an uncertain world. *Review of Economics and Statistics*, 83, 203-217.
- Rudebusch, G.D., 2002a, Term structure evidence on interest rate smoothing and monetary policy inertia, *Journal of Monetary Economics*, 49, 1161-1187.
- Rudebusch, G.D., 2002b, Assessing Nominal Income Rules for Monetary Policy with Model and Data Uncertainty, *Economic Journal*, 112 (April), 1-31.
- Rudebusch, G.D., 2002c, Assessing the Lucas Critique in Monetary Policy Models, Working Paper in Applied Theory No. 2002-02, Federal Reserve Bank of San Francisco.
- Rudebusch, G.D. and L.E.O. Svensson, 1999, Policy Rules for Inflation Targeting, in Taylor J.B. (ed): *Monetary Policy Rules*, NBER Conference on Research and Business Cycles, University of Chicago Press, 203-246.
- Rudebusch, G.D. and L.E.O. Svensson, 2002, Eurosystem Monetary Targeting: Lessons from U.S. Data, *European Economic Review*, 46, 417-442.

- Sack, B., 1998, Uncertainty, Learning, and Gradual Monetary Policy, Board of Governors of the Federal Reserve System, Finance and Economic Discussion Series, 98-17.
- Sack, B., 2000, Does the Fed act gradually? A VAR analysis, *Journal of Monetary Economics*, 46, 229-256.
- Sack, B., and V. Wieland, 2000, Interest-Rate Smoothing and Optimal Monetary Policy: A Review of Recent Empirical Evidence, *Journal of Economics and Business*, 52, 205-228.
- Salemi, M.K., 1995, Revealed preference of the Federal Reserve: using inverse-control theory to interpret the policy equation of a vector autoregression, *Journal of Business and Economic Statistics*, 13, 419-433.
- Schaumburg E., and A. Tambalotti, 2003, An Investigation of the Gains from Commitment in Monetary Policy, mimeo.
- Smets, F., 2002, Output gap uncertainty: does it matter for the Taylor rule?, *Empirical Economics*, 27(1), 113-129.
- Srour, G., 2001, Why Do Central Banks Smooth Interest Rates, Bank of Canada Working Paper Series, No. 2001-17.
- Söderlind, P., 1999, Solution and estimation of RE macromodels with optimal policy, *European Economic Review*, 43, 813-823.
- Söderlind, P., U. Söderström, and A. Vredin, 2002, Can a Calibrated New-Keynesian Model of Monetary Policy Fit the Facts?, SSE/EFI Working Paper Series in Economics and Finance No 511, September.
- Söderström, U., 1999, Should Central Banks Be More Aggressive?, Sveriges Riksbank, Working Paper No. 84, May.
- Taylor, J.B., 1979, Estimation and Control of a Macroeconomic Model with Rational Expectations, *Econometrica*, 47, 1267-1286.
- Wieland, V., 2000, Monetary Policy, Parameter Uncertainty and Optimal Learning, *Journal of Monetary Economics*, 46 (1), 199-228.
- Wieland, V., 2002, Monetary Policy and Uncertainty about the Natural Unemployment Rate, Federal Reserve Board, Finance and Economics Discussion Series Working Paper No. 1998-22 (Revised version).
- Williams, J., 1999, Simple Rules for Monetary Policy, Board of Governors of the Federal Reserve System, Finance and Economics Discussion Series, 1999-12.

Woodford, M., 1999, Optimal Monetary Policy Inertia, NBER Working Paper, 7261, July.

Woodford, M., 2001, The Taylor Rule and Optimal Monetary Policy, American Economic Review, 91(2), 232-237; a longer version is available at M. Woodford's homepage, <http://www.princeton.edu/~woodford/>.

## NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI

### Fondazione Eni Enrico Mattei Working Paper Series

Our working papers are available on the Internet at the following addresses:

[http://www.feem.it/web/attiv/\\_wp.html](http://www.feem.it/web/attiv/_wp.html)

<http://papers.ssrn.com>

SUST	1.2002	<i>K. TANO, M.D. FAMINOW, M. KAMUANGA and B. SWALLOW: <u>Using Conjoint Analysis to Estimate Farmers' Preferences for Cattle Traits in West Africa</u></i>
ETA	2.2002	<i>Efrem CASTELNUOVO and Paolo SURICO: <u>What Does Monetary Policy Reveal about Central Bank's Preferences?</u></i>
WAT	3.2002	<i>Duncan KNOWLER and Edward BARBIER: <u>The Economics of a "Mixed Blessing" Effect: A Case Study of the Black Sea</u></i>
CLIM	4.2002	<i>Andreas LÖSCHEL: <u>Technological Change in Economic Models of Environmental Policy: A Survey</u></i>
VOL	5.2002	<i>Carlo CARRARO and Carmen MARCHIORI: <u>Stable Coalitions</u></i>
CLIM	6.2002	<i>Marzio GALEOTTI, Alessandro LANZA and Matteo MANERA: <u>Rockets and Feathers Revisited: An International Comparison on European Gasoline Markets</u></i>
ETA	7.2002	<i>Effrosyni DIAMANTOUDI and Eftichios S. SARTZETAKIS: <u>Stable International Environmental Agreements: An Analytical Approach</u></i>
KNOW	8.2002	<i>Alain DESDOIGTS: <u>Neoclassical Convergence Versus Technological Catch-up: A Contribution for Reaching a Consensus</u></i>
NRM	9.2002	<i>Giuseppe DI VITA: <u>Renewable Resources and Waste Recycling</u></i>
KNOW	10.2002	<i>Giorgio BRUNELLO: <u>Is Training More Frequent when Wage Compression is Higher? Evidence from 11 European Countries</u></i>
ETA	11.2002	<i>Mordecai KURZ, Hehui JIN and Maurizio MOTOLESE: <u>Endogenous Fluctuations and the Role of Monetary Policy</u></i>
KNOW	12.2002	<i>Reyer GERLAGH and Marjan W. HOFKES: <u>Escaping Lock-in: The Scope for a Transition towards Sustainable Growth?</u></i>
NRM	13.2002	<i>Michele MORETTO and Paolo ROSATO: <u>The Use of Common Property Resources: A Dynamic Model</u></i>
CLIM	14.2002	<i>Philippe QUIRION: <u>Macroeconomic Effects of an Energy Saving Policy in the Public Sector</u></i>
CLIM	15.2002	<i>Roberto ROSON: <u>Dynamic and Distributional Effects of Environmental Revenue Recycling Schemes: Simulations with a General Equilibrium Model of the Italian Economy</u></i>
CLIM	16.2002	<i>Francesco RICCI (I): <u>Environmental Policy Growth when Inputs are Differentiated in Pollution Intensity</u></i>
ETA	17.2002	<i>Alberto PETRUCCI: <u>Devaluation (Levels versus Rates) and Balance of Payments in a Cash-in-Advance Economy</u></i>
Coalition Theory Network	18.2002	<i>László Á. KÓCZY (IIV): <u>The Core in the Presence of Externalities</u></i>
Coalition Theory Network	19.2002	<i>Steven J. BRAMS, Michael A. JONES and D. Marc KILGOUR (IIV): <u>Single-Peakedness and Disconnected Coalitions</u></i>
Coalition Theory Network	20.2002	<i>Guillaume HAERINGER (IIV): <u>On the Stability of Cooperation Structures</u></i>
NRM	21.2002	<i>Fausto CAVALLARO and Luigi CIRAOLO: <u>Economic and Environmental Sustainability: A Dynamic Approach in Insular Systems</u></i>
CLIM	22.2002	<i>Barbara BUCHNER, Carlo CARRARO, Igor CERSOSIMO and Carmen MARCHIORI: <u>Back to Kyoto? US Participation and the Linkage between R&amp;D and Climate Cooperation</u></i>
CLIM	23.2002	<i>Andreas LÖSCHEL and ZhongXIANG ZHANG: <u>The Economic and Environmental Implications of the US Repudiation of the Kyoto Protocol and the Subsequent Deals in Bonn and Marrakech</u></i>
ETA	24.2002	<i>Marzio GALEOTTI, Louis J. MACCINI and Fabio SCHIANTARELLI: <u>Inventories, Employment and Hours</u></i>
CLIM	25.2002	<i>Hannes EGLI: <u>Are Cross-Country Studies of the Environmental Kuznets Curve Misleading? New Evidence from Time Series Data for Germany</u></i>
ETA	26.2002	<i>Adam B. JAFFE, Richard G. NEWELL and Robert N. STAVINS: <u>Environmental Policy and Technological Change</u></i>
SUST	27.2002	<i>Joseph C. COOPER and Giovanni SIGNORELLO: <u>Farmer Premiums for the Voluntary Adoption of Conservation Plans</u></i>
SUST	28.2002	<i><u>The ANSEA Network: Towards An Analytical Strategic Environmental Assessment</u></i>
KNOW	29.2002	<i>Paolo SURICO: <u>Geographic Concentration and Increasing Returns: a Survey of Evidence</u></i>
ETA	30.2002	<i>Robert N. STAVINS: <u>Lessons from the American Experiment with Market-Based Environmental Policies</u></i>



NRM	31.2002	<i>Carlo GIUPPONI and Paolo ROSATO: <u>Multi-Criteria Analysis and Decision-Support for Water Management at the Catchment Scale: An Application to Diffuse Pollution Control in the Venice Lagoon</u></i>
NRM	32.2002	<i>Robert N. STAVINS: <u>National Environmental Policy During the Clinton Years</u></i>
KNOW	33.2002	<i>A. SOUBEYRAN and H. STAHN : <u>Do Investments in Specialized Knowledge Lead to Composite Good Industries?</u></i>
KNOW	34.2002	<i>G. BRUNELLO, M.L. PARISI and Daniela SONEDDA: <u>Labor Taxes, Wage Setting and the Relative Wage Effect</u></i>
CLIM	35.2002	<i>C. BOEMARE and P. QUIRION (lv): <u>Implementing Greenhouse Gas Trading in Europe: Lessons from Economic Theory and International Experiences</u></i>
CLIM	36.2002	<i>T. TIETENBERG (lv): <u>The Tradable Permits Approach to Protecting the Commons: What Have We Learned?</u></i>
CLIM	37.2002	<i>K. REHDANZ and R.J.S. TOL (lv): <u>On National and International Trade in Greenhouse Gas Emission Permits</u></i>
CLIM	38.2002	<i>C. FISCHER (lv): <u>Multinational Taxation and International Emissions Trading</u></i>
SUST	39.2002	<i>G. SIGNORELLO and G. PAPPALARDO: <u>Farm Animal Biodiversity Conservation Activities in Europe under the Framework of Agenda 2000</u></i>
NRM	40.2002	<i>S.M. CAVANAGH, W. M. HANEMANN and R. N. STAVINS: <u>Muffled Price Signals: Household Water Demand under Increasing-Block Prices</u></i>
NRM	41.2002	<i>A. J. PLANTINGA, R. N. LUBOWSKI and R. N. STAVINS: <u>The Effects of Potential Land Development on Agricultural Land Prices</u></i>
CLIM	42.2002	<i>C. OHL (lvi): <u>Inducing Environmental Co-operation by the Design of Emission Permits</u></i>
CLIM	43.2002	<i>J. EYCKMANS, D. VAN REGEMORTER and V. VAN STEENBERGHE (lvi): <u>Is Kyoto Fatally Flawed? An Analysis with MacGEM</u></i>
CLIM	44.2002	<i>A. ANTOCI and S. BORGHESI (lvi): <u>Working Too Much in a Polluted World: A North-South Evolutionary Model</u></i>
ETA	45.2002	<i>P. G. FREDRIKSSON, Johan A. LIST and Daniel MILLIMET (lvi): <u>Chasing the Smokestack: Strategic Policymaking with Multiple Instruments</u></i>
ETA	46.2002	<i>Z. YU (lvi): <u>A Theory of Strategic Vertical DFI and the Missing Pollution-Haven Effect</u></i>
SUST	47.2002	<i>Y. H. FARZIN: <u>Can an Exhaustible Resource Economy Be Sustainable?</u></i>
SUST	48.2002	<i>Y. H. FARZIN: <u>Sustainability and Hamiltonian Value</u></i>
KNOW	49.2002	<i>C. PIGA and M. VIVARELLI: <u>Cooperation in R&amp;D and Sample Selection</u></i>
Coalition Theory Network Coalition Theory Network	50.2002	<i>M. SERTEL and A. SLINKO (liv): <u>Ranking Committees, Words or Multisets</u></i>
ETA	51.2002	<i>Sergio CURRARINI (liv): <u>Stable Organizations with Externalities</u></i>
ETA	52.2002	<i>Robert N. STAVINS: <u>Experience with Market-Based Policy Instruments</u></i>
ETA	53.2002	<i>C.C. JAEGER, M. LEIMBACH, C. CARRARO, K. HASSELMANN, J.C. HOURCADE, A. KEELER and R. KLEIN (liii): <u>Integrated Assessment Modeling: Modules for Cooperation</u></i>
CLIM	54.2002	<i>Scott BARRETT (liii): <u>Towards a Better Climate Treaty</u></i>
ETA	55.2002	<i>Richard G. NEWELL and Robert N. STAVINS: <u>Cost Heterogeneity and the Potential Savings from Market-Based Policies</u></i>
SUST	56.2002	<i>Paolo ROSATO and Edi DEFRANCESCO: <u>Individual Travel Cost Method and Flow Fixed Costs</u></i>
SUST	57.2002	<i>Vladimir KOTOV and Elena NIKITINA (lvii): <u>Reorganisation of Environmental Policy in Russia: The Decade of Success and Failures in Implementation of Perspective Quests</u></i>
SUST	58.2002	<i>Vladimir KOTOV (lvii): <u>Policy in Transition: New Framework for Russia's Climate Policy</u></i>
SUST	59.2002	<i>Fanny MISSFELDT and Arturo VILLAVICENCO (lvii): <u>How Can Economies in Transition Pursue Emissions Trading or Joint Implementation?</u></i>
VOL	60.2002	<i>Giovanni DI BARTOLOMEO, Jacob ENGWERDA, Joseph PLASMANS and Bas VAN AARLE: <u>Staying Together or Breaking Apart: Policy-Makers' Endogenous Coalitions Formation in the European Economic and Monetary Union</u></i>
ETA	61.2002	<i>Robert N. STAVINS, Alexander F. WAGNER and Gernot WAGNER: <u>Interpreting Sustainability in Economic Terms: Dynamic Efficiency Plus Intergenerational Equity</u></i>
PRIV	62.2002	<i>Carlo CAPUANO: <u>Demand Growth, Entry and Collusion Sustainability</u></i>
PRIV	63.2002	<i>Federico MUNARI and Raffaele ORIANI: <u>Privatization and R&amp;D Performance: An Empirical Analysis Based on Tobin's Q</u></i>
PRIV	64.2002	<i>Federico MUNARI and Maurizio SOBRERO: <u>The Effects of Privatization on R&amp;D Investments and Patent Productivity</u></i>
SUST	65.2002	<i>Orley ASHENFELTER and Michael GREENSTONE: <u>Using Mandated Speed Limits to Measure the Value of a Statistical Life</u></i>
ETA	66.2002	<i>Paolo SURICO: <u>US Monetary Policy Rules: the Case for Asymmetric Preferences</u></i>
PRIV	67.2002	<i>Rinaldo BRAU and Massimo FLORIO: <u>Privatisations as Price Reforms: Evaluating Consumers' Welfare Changes in the U.K.</u></i>
CLIM	68.2002	<i>Barbara K. BUCHNER and Roberto ROSON: <u>Conflicting Perspectives in Trade and Environmental Negotiations</u></i>
CLIM	69.2002	<i>Philippe QUIRION: <u>Complying with the Kyoto Protocol under Uncertainty: Taxes or Tradable Permits?</u></i>
SUST	70.2002	<i>Anna ALBERINI, Patrizia RIGANTI and Alberto LONGO: <u>Can People Value the Aesthetic and Use Services of Urban Sites? Evidence from a Survey of Belfast Residents</u></i>
SUST	71.2002	<i>Marco PERCOCO: <u>Discounting Environmental Effects in Project Appraisal</u></i>

NRM	72.2002	<i>Philippe BONTEMS and Pascal FAVARD</i> : <u>Input Use and Capacity Constraint under Uncertainty: The Case of Irrigation</u>
PRIV	73.2002	<i>Mohammed OMRAN</i> : <u>The Performance of State-Owned Enterprises and Newly Privatized Firms: Empirical Evidence from Egypt</u>
PRIV	74.2002	<i>Mike BURKART, Fausto PANUNZI and Andrei SHLEIFER</i> : <u>Family Firms</u>
PRIV	75.2002	<i>Emmanuelle AURIOL, Pierre M. PICARD</i> : <u>Privatizations in Developing Countries and the Government Budget Constraint</u>
PRIV	76.2002	<i>Nichole M. CASTATER</i> : <u>Privatization as a Means to Societal Transformation: An Empirical Study of Privatization in Central and Eastern Europe and the Former Soviet Union</u>
PRIV	77.2002	<i>Christoph LÜLSFESMANN</i> : <u>Benevolent Government, Managerial Incentives, and the Virtues of Privatization</u>
PRIV	78.2002	<i>Kate BISHOP, Igor FILATOTCHEV and Tomasz MICKIEWICZ</i> : <u>Endogenous Ownership Structure: Factors Affecting the Post-Privatisation Equity in Largest Hungarian Firms</u>
PRIV	79.2002	<i>Theodora WELCH and Rick MOLZ</i> : <u>How Does Trade Sale Privatization Work? Evidence from the Fixed-Line Telecommunications Sector in Developing Economies</u>
PRIV	80.2002	<i>Alberto R. PETRUCCI</i> : <u>Government Debt, Agent Heterogeneity and Wealth Displacement in a Small Open Economy</u>
CLIM	81.2002	<i>Timothy SWANSON and Robin MASON (Ivi)</i> : <u>The Impact of International Environmental Agreements: The Case of the Montreal Protocol</u>
PRIV	82.2002	<i>George R.G. CLARKE and Lixin Colin XU</i> : <u>Privatization, Competition and Corruption: How Characteristics of Bribe Takers and Payers Affect Bribe Payments to Utilities</u>
PRIV	83.2002	<i>Massimo FLORIO and Katuscia MANZONI</i> : <u>The Abnormal Returns of UK Privatisations: From Underpricing to Outperformance</u>
NRM	84.2002	<i>Nelson LOURENÇO, Carlos RUSSO MACHADO, Maria do ROSÁRIO JORGE and Luis RODRIGUES</i> : <u>An Integrated Approach to Understand Territory Dynamics. The Coastal Alentejo (Portugal)</u>
CLIM	85.2002	<i>Peter ZAPFEL and Matti VAINIO (Iv)</i> : <u>Pathways to European Greenhouse Gas Emissions Trading History and Misconceptions</u>
CLIM	86.2002	<i>Pierre COURTOIS</i> : <u>Influence Processes in Climate Change Negotiations: Modelling the Rounds</u>
ETA	87.2002	<i>Vito FRAGNELLI and Maria Erminia MARINA (Iviii)</i> : <u>Environmental Pollution Risk and Insurance</u>
ETA	88.2002	<i>Laurent FRANCKX (Iviii)</i> : <u>Environmental Enforcement with Endogenous Ambient Monitoring</u>
ETA	89.2002	<i>Tim GOESCHL and Timothy M. SWANSON (Iviii)</i> : <u>Lost Horizons. The noncooperative management of an evolutionary biological system.</u>
ETA	90.2002	<i>Hans KEIDING (Iviii)</i> : <u>Environmental Effects of Consumption: An Approach Using DEA and Cost Sharing</u>
ETA	91.2002	<i>Wietze LISE (Iviii)</i> : <u>A Game Model of People's Participation in Forest Management in Northern India</u>
CLIM	92.2002	<i>Jens HORBACH</i> : <u>Structural Change and Environmental Kuznets Curves</u>
ETA	93.2002	<i>Martin P. GROSSKOPF</i> : <u>Towards a More Appropriate Method for Determining the Optimal Scale of Production Units</u>
VOL	94.2002	<i>Scott BARRETT and Robert STAVINS</i> : <u>Increasing Participation and Compliance in International Climate Change Agreements</u>
CLIM	95.2002	<i>Banu BAYRAMOGLU LISE and Wietze LISE</i> : <u>Climate Change, Environmental NGOs and Public Awareness in the Netherlands: Perceptions and Reality</u>
CLIM	96.2002	<i>Matthieu GLACHANT</i> : <u>The Political Economy of Emission Tax Design in Environmental Policy</u>
KNOW	97.2002	<i>Kenn ARIGA and Giorgio BRUNELLO</i> : <u>Are the More Educated Receiving More Training? Evidence from Thailand</u>
ETA	98.2002	<i>Gianfranco FORTE and Matteo MANERA</i> : <u>Forecasting Volatility in European Stock Markets with Non-linear GARCH Models</u>
ETA	99.2002	<i>Geoffrey HEAL</i> : <u>Bundling Biodiversity</u>
ETA	100.2002	<i>Geoffrey HEAL, Brian WALKER, Simon LEVIN, Kenneth ARROW, Partha DASGUPTA, Gretchen DAILY, Paul EHRlich, Karl-Goran MALER, Nils KAUTSKY, Jane LUBCHENCO, Steve SCHNEIDER and David STARRETT</i> : <u>Genetic Diversity and Interdependent Crop Choices in Agriculture</u>
ETA	101.2002	<i>Geoffrey HEAL</i> : <u>Biodiversity and Globalization</u>
VOL	102.2002	<i>Andreas LANGE</i> : <u>Heterogeneous International Agreements – If per capita emission levels matter</u>
ETA	103.2002	<i>Pierre-André JOUVET and Walid OUESLATI</i> : <u>Tax Reform and Public Spending Trade-offs in an Endogenous Growth Model with Environmental Externality</u>
ETA	104.2002	<i>Anna BOTTASSO and Alessandro SEMBENELLI</i> : <u>Does Ownership Affect Firms' Efficiency? Panel Data Evidence on Italy</u>
PRIV	105.2002	<i>Bernardo BORTOLOTTI, Frank DE JONG, Giovanna NICODANO and Ibolya SCHINDELE</i> : <u>Privatization and Stock Market Liquidity</u>
ETA	106.2002	<i>Haruo IMAI and Mayumi HORIE (Iviii)</i> : <u>Pre-Negotiation for an International Emission Reduction Game</u>
PRIV	107.2002	<i>Sudeshna GHOSH BANERJEE and Michael C. MUNGER</i> : <u>Move to Markets? An Empirical Analysis of Privatisation in Developing Countries</u>
PRIV	108.2002	<i>Guillaume GIRMENS and Michel GUILLARD</i> : <u>Privatization and Investment: Crowding-Out Effect vs Financial Diversification</u>
PRIV	109.2002	<i>Alberto CHONG and Florencio LÓPEZ-DE-SILANES</i> : <u>Privatization and Labor Force Restructuring Around the World</u>
PRIV	110.2002	<i>Nandini GUPTA</i> : <u>Partial Privatization and Firm Performance</u>
PRIV	111.2002	<i>François DEGEORGE, Dirk JENTER, Alberto MOEL and Peter TUFANO</i> : <u>Selling Company Shares to Reluctant Employees: France Telecom's Experience</u>

PRIV	112.2002	<i>Isaac OTCHERE</i> : <u>Intra-Industry Effects of Privatization Announcements: Evidence from Developed and Developing Countries</u>
PRIV	113.2002	<i>Yannis KATSOUKAKOS and Elissavet LIKOYANNI</i> : <u>Fiscal and Other Macroeconomic Effects of Privatization</u>
PRIV	114.2002	<i>Guillaume GIRMENS</i> : <u>Privatization, International Asset Trade and Financial Markets</u>
PRIV	115.2002	<i>D. Teja FLOTHO</i> : <u>A Note on Consumption Correlations and European Financial Integration</u>
PRIV	116.2002	<i>Ibolya SCHINDELE and Enrico C. PEROTTI</i> : <u>Pricing Initial Public Offerings in Premature Capital Markets: The Case of Hungary</u>
PRIV	1.2003	<i>Gabriella CHIESA and Giovanna NICODANO</i> : <u>Privatization and Financial Market Development: Theoretical Issues</u>
PRIV	2.2003	<i>Ibolya SCHINDELE</i> : <u>Theory of Privatization in Eastern Europe: Literature Review</u>
PRIV	3.2003	<i>Wietze LISE, Claudia KEMFERT and Richard S.J. TOL</i> : <u>Strategic Action in the Liberalised German Electricity Market</u>
CLIM	4.2003	<i>Laura MARSILLANI and Thomas I. RENSTRÖM</i> : <u>Environmental Policy and Capital Movements: The Role of Government Commitment</u>
KNOW	5.2003	<i>Reyer GERLAGH</i> : <u>Induced Technological Change under Technological Competition</u>
ETA	6.2003	<i>Efrem CASTELNUOVO</i> : <u>Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model</u>

- (l) This paper was presented at the Workshop “Growth, Environmental Policies and Sustainability” organised by the Fondazione Eni Enrico Mattei, Venice, June 1, 2001
- (li) This paper was presented at the Fourth Toulouse Conference on Environment and Resource Economics on “Property Rights, Institutions and Management of Environmental and Natural Resources”, organised by Fondazione Eni Enrico Mattei, IDEI and INRA and sponsored by MATE, Toulouse, May 3-4, 2001
- (lii) This paper was presented at the International Conference on “Economic Valuation of Environmental Goods”, organised by Fondazione Eni Enrico Mattei in cooperation with CORILA, Venice, May 11, 2001
- (liii) This paper was circulated at the International Conference on “Climate Policy – Do We Need a New Approach?”, jointly organised by Fondazione Eni Enrico Mattei, Stanford University and Venice International University, Isola di San Servolo, Venice, September 6-8, 2001
- (liv) This paper was presented at the Seventh Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei and the CORE, Université Catholique de Louvain, Venice, Italy, January 11-12, 2002
- (lv) This paper was presented at the First Workshop of the Concerted Action on Tradable Emission Permits (CATEP) organised by the Fondazione Eni Enrico Mattei, Venice, Italy, December 3-4, 2001
- (lvi) This paper was presented at the ESF EURESCO Conference on Environmental Policy in a Global Economy “The International Dimension of Environmental Policy”, organised with the collaboration of the Fondazione Eni Enrico Mattei, Acquafredda di Maratea, October 6-11, 2001
- (lvii) This paper was presented at the First Workshop of “CFEWE – Carbon Flows between Eastern and Western Europe”, organised by the Fondazione Eni Enrico Mattei and Zentrum für Europäische Integrationsforschung (ZEI), Milan, July 5-6, 2001
- (lviii) This paper was presented at the Workshop on “Game Practice and the Environment”, jointly organised by Università del Piemonte Orientale and Fondazione Eni Enrico Mattei, Alessandria, April 12-13, 2002

## 2002 SERIES

<b>CLIM</b>	<i>Climate Change Modelling and Policy</i> (Editor: Marzio Galeotti )
<b>VOL</b>	<i>Voluntary and International Agreements</i> (Editor: Carlo Carraro)
<b>SUST</b>	<i>Sustainability Indicators and Environmental Valuation</i> (Editor: Carlo Carraro)
<b>NRM</b>	<i>Natural Resources Management</i> (Editor: Carlo Giupponi)
<b>KNOW</b>	<i>Knowledge, Technology, Human Capital</i> (Editor: Dino Pinelli)
<b>MGMT</b>	<i>Corporate Sustainable Management</i> (Editor: Andrea Marsanich)
<b>PRIV</b>	<i>Privatisation, Regulation, Antitrust</i> (Editor: Bernardo Bortolotti)
<b>ETA</b>	<i>Economic Theory and Applications</i> (Editor: Carlo Carraro)

## 2003 SERIES

<b>CLIM</b>	<i>Climate Change Modelling and Policy</i> (Editor: Marzio Galeotti )
<b>GG</b>	<i>Global Governance</i> (Editor: Carlo Carraro)
<b>SIEV</b>	<i>Sustainability Indicators and Environmental Valuation</i> (Editor: Anna Alberini)
<b>NRM</b>	<i>Natural Resources Management</i> (Editor: Carlo Giupponi)
<b>KNOW</b>	<i>Knowledge, Technology, Human Capital</i> (Editor: Gianmarco Ottaviano)
<b>IEM</b>	<i>International Energy Markets</i> (Editor: Anil Markandya)
<b>CSR</b>	<i>Corporate Social Responsibility and Management</i> (Editor: Sabina Ratti)
<b>PRIV</b>	<i>Privatisation, Regulation, Antitrust</i> (Editor: Bernardo Bortolotti)
<b>ETA</b>	<i>Economic Theory and Applications</i> (Editor: Carlo Carraro)