Monetary policy regimes in the New Keynesian framework: Results for Accession Countries*

Giovanni Di Bartolomeo
University of Rome "La Sapienza"

Bruno Merlevede
Ghent University

Joseph Plasmans†
University of Antwerp and Tilburg University

Bas van Aarle
University of Leuven and University of Nijmegen

June, 2003

Abstract

This paper studies implications of alternative monetary policy regimes as discretionary and commitment policy rules for closed and small open economies. For each of these two economy types a model with possible frictions in nominal prices is constructed. Such a model is suited for the study of effects of monetary policy rules on inflation rates and output gaps and allows for forward- and backward-looking behavior when determining inflation and output dynamics. We consider each of the EU-accession CEECs as a small open economy and evaluate the empirical size of forward- and backward-looking expectations in these countries. Moreover, we verify whether output gaps and deviations of marginal costs from their equilibrium are good approximations of each other in estimates of hybrid versions of the New Keynesian Phillips curve. It seems that the Slovak Republic, Romania, Slovenia and Poland have shown a more credible monetary policy than the other CEECs considered.

Keywords: EU-accession countries, New Keynesian model, optimal monetary policy rules, rational expectations
JEL codes: E31, E58, F41, P24

*We are grateful to conference participants at the AEA Conference in Washington in January 2003 and the International CESifo 'Area Conference on Macro, Money and International finance' in Munich in February 2003. We would like to thank Jim Malley, University of Glasgow, and Eric Mayer, Universität Würzburg, for providing very valuable comments on a previous version of the paper. Giovanni Di Bartolomeo acknowledges the financial support from the University of Rome 'La Sapienza' (MURST 2000) and the University of Antwerp (Special Research Fund) and Bas van Aarle acknowledges the financial support from the FWO (Fonds voor Wetenschappelijk Onderzoek Vlaanderen).

†Corresponding author, Faculty of Applied Economics UFSIA-RUCA, University of Antwerp, Prinsstraat 13, B2000 Antwerp; Phone: +32 (0)3 220 4149, Fax: +32 (0)3 220 4585, Email: joseph.plasmans@ua.ac.be.

1 Introduction

Many of the Central and Eastern European countries (CEECs) are evolving according to a path that drives them into the European Union (EU) by May 2004. Indeed, their application to the EU constitutes a commitment to the "Acquis Communautaires" for these countries, which accelerates their ongoing transformation process from a planned to a market economy. This fact has an important relevance for their structural policy and reforms. Their EU-accession has also a strong impact in terms of commitments in the management of monetary and exchange rate policies. This paper studies implications of alternative monetary policy regimes for small open economies like the CEECs from theoretical and empirical points of view.

We build a theoretical model to analyze output gaps and inflation in accession countries under a number of alternative settings of monetary policy. We consider each of the accession countries as a small open economy, which is significantly affected by external shocks, by following the recent literature on this issue (e.g. Clarida (2001), Clarida *et al.* (2001), Clarida *et al.* (2002), Galì and Monacelli (2002), Smets and Wouters (2002a), and Caputo (2003)). A focus lies on the effects of both backward- and forward-looking linkages in output and inflation dynamics, since both specifications seem to be important to understand the inflation and real output dynamics of these countries.

In the empirical part, we test the importance of forward- versus backward-looking behavior for these EU-accession countries. In fact, many critical assessments of the New Keynesian paradigm have been concentrated on the forward-looking nature of the inflation dynamics embedded in it. In particular, many authors point out that the pattern of dynamic cross-correlation between inflation and detrended output observed in the data suggests that output leads inflation (Fuhrer and Moore (1995)). However, the detrended gap is a distorted proxy of the output gap involved in the Phillips curve of New Keynesian models (e.g. Galí and Gertler (1999) and Sbordone (2002)). As a way to overcome these problems we also directly estimate the inflation dynamics as a function of the marginal cost of labor as it is directly derived from the micro-foundations of the model (see Galí and Gertler (1999), Galí *et al.* (2001), Gertler *et al.* (2001), Jondeau and Le Bihan (2001), Leith and Malley (2002), and Sbordone (2002) for closed-economy versions of such estimates). Some preliminary evidence for EU-accession countries is provided by Arratibel *et al.* (2002). However, their estimations are based on a pooled sample that merges all the accession countries together without taking account of the institutional differences and of the different demand and supply side features of these countries. We will take account of the heterogeneity of the EU-accession countries explicitly.

Summarizing, we exploit the monetary policy design problem within a simple baseline theoretical framework, which takes account of the fundamental elements characterizing the accession countries, like their small size and high degree of openness in particular to the current EU, and their possible (monetary and economic) behavior based on both forward- and backward-looking expectations. In such a context, we consider the implications of adopting alternative monetary policy regimes as discretionary and commitment optimal policy rules.

The paper is organized as follows. In section 2 the theoretical setup is presented, based in the first instance on a linearized closed-economy model being a direct generalization of the common New Keynesian model with sticky prices described in Galí *et al.* (1999) that also takes account of the backward-looking behavior of output gaps and inflation rates. Hence, the behavior of the private sector is described by two equations which involve both forward- and backward-looking behavior. Following a recent strand of literature, we call such behavior "hybrid". Finally, we extend this approach to an open economy framework. Section 3 discusses econometric estimates of the derived output gap and inflation equations, involving both forward- and backward-looking dynamics through the Generalized Method of Moments (GMM) using a recent database of quarterly data for the EU-accession countries. Finally, section 4 contains some concluding remarks.

2 The Theoretical Framework

2.1 The basic generalized framework

Economists increasingly use dynamic New Keynesian stochastic general equilibrium (DSGE) models for macroeconomic analysis. In order to solve these models and keep them tractable, models with linear rational expectations

(LREs) are typically used as local approximations. We use hybrid LREs models with backward- and forward-looking LREs for output gaps and inflation in this paper.

In this section the theoretical setup for hybrid versions of output-gap and inflation equations is derived as a direct generalization of the closed-economy New Keynesian model with sticky (nominal) prices described in Galí *et al.* (1999). This derivation is presented both for a closed-economy framework as for an open-economy one.

To start with the closed-economy setup, it is assumed that the demand side of the (closed) economy is given by a hybrid output-gap equation:

$$\widehat{y}_t = \pi_1 E_t\left[\widehat{y}_{t+1}\right] + \pi_2 \widehat{y}_{t-1} - \pi_3(r_t - E_t\left[\Delta p_{t+1}\right] - rr_t^0) + u_t \tag{1}$$

which is a dynamic generalization of an IS curve derived from consumer optimization in the presence of habit formation. In equation (1) $\widehat{y}_t \equiv y_t - y_t^0$ is the output gap defined as the difference between the actual output and the potential output,[1] r_t is the nominal interest rate, Δp_t is the inflation rate (i.e. the change in logarithmic prices), rr_t^0 is the potential or steady-state real interest rate, u_t is a stochastic error term,[2] and E_t denotes the private sector's (conditional) expectation operator, given the information available at time t for the output gap and the inflation rate next period.

The supply side of the (closed) economy is assumed to be described by a hybrid Phillips curve:

$$\Delta p_t = \beta_1 E_t\left[\Delta p_{t+1}\right] + \beta_2 \Delta p_{t-1} + \beta_3 \widehat{y}_t + v_t \tag{2}$$

which is the price-setting rule for the monopolistically competitive firms facing constraints on the frequency of future price changes and where v_t is a stochastic error term.[3]

The above hybrid Phillips curve is very general since it can be reduced to the traditional Phillips curve by assuming $\beta_1 = 0$ and $\beta_2 = 1$, to the Taylor (1993) forward-looking Phillips curve by assuming $\beta_1 = 1$ and $\beta_2 = 0$, to the Fuhrer and Moore (1995) forward- and backward-looking Phillips curve with two-period contracts by assuming $\beta_1 = \beta_2 = \frac{1}{2}$ or to the standard (or core) New Keynesian Phillips curve (NKPC) by assuming $\beta_2 = 0$.

The two following subsections analyze (optimal) monetary policies, where hybrid equations as (1) and (2) for a closed economy are derived and open-economy extensions are considered. The last subsection discusses a New Keynesian open-economy setup.

2.2 A New Keynesian closed-economy setup

2.2.1 Discussion of the model

Assuming that $\pi_1 = 1$, $\pi_2 = 0$, $\beta_1 = \beta$, $\beta_2 = 0$ in (1) and (2) , we obtain the two structural equations of the standard New Keynesian sticky-price model for *closed* economies, which consists of an 'expectational IS curve' or a demand equation derived from an Euler equation for the optimal timing of purchases and an aggregate supply equation derived from a first-order condition for optimal Calvo-type price-setting:[4]

$$\begin{aligned} \widehat{y}_t &= E_t\left[\widehat{y}_{t+1}\right] - \pi_3\left(r_t - E_t\left[\Delta p_{t+1}\right] - rr_t^0\right) + u_t && (3)\\ \Delta p_t &= \beta E_t\left[\Delta p_{t+1}\right] + \beta_3 \widehat{y}_t + v_t \quad , && (4) \end{aligned}$$

where an appealing characteristic of the core output-gap equation and NKPC ((3) and (4)) is that they can be derived from firms' and households' optimizing price setting and consumption behavior under market equilibrium.

[1] Potential output is the output that would have been realized when no (nominal price) rigidities were present.

[2] In general, u_t represents a shock to government purchases and/or potential output.

[3] The stochastic error term v_t represents any cost-push shock to inflation other than that entering through $\widehat{y}_t$. Notice that, in practice, it is often impossible to identify the source of stochastic disturbances to inflation, in particular whether an inflation shock is a supply shock or a cost-push shock (see Smets and Wouters (2003)).

[4] It is well known that LREs models as this standard New Keynesian sticky-price model for closed economies (see e.g. Clarida *et al.* (2001)) can have multiple equilibria and, hence, are (generally) indeterminate. In the case of such indeterminacy it is generally possible to construct sunspot equilibria in which stochastic disturbances that are unrelated to fundamental shocks influence the model dynamics. There are only very few empirical studies about the importance of indeterminacy in macroeconomic models. A very recent example is Lubik and Schorfheide (2002) who use a Bayesian analysis where the indeterminacy hypothesis is evaluated by the posterior probability of the parameter region for which there exist multiple stable equilibria.

This optimizing behavior leads to cross-equation restrictions between (3) and (4), which can be illustrated from the application of the open-economy analysis in the appendix of Di Bartolomeo *et al.* (2003)[5] to a closed-economy setting.[6] A Calvo (1983) price-adjustment process induces price stickiness as it restricts the firms' abilities to price setting in a perfectly competitive and, hence, flexible manner. Assuming market equilibrium the aggregate demand for output can be defined as: $Y_t \equiv C_t + G_t$, with C_t the aggregate private consumption and G_t the aggregate government consumption, or $C_t = Y_t(1 - \frac{G_t}{Y_t})$, i.e.

$$\log C_t = c_t = \log Y_t + \log(1 - \frac{G_t}{Y_t}) = y_t - g_t \tag{5}$$

with $g_t \equiv -\log(1 - \frac{G_t}{Y_t})$. If deviations from the steady state are considered, the variables are denoted with a hat, as e.g. for the output gap $\widehat{y}_t$. Since, moreover, government spending is assumed to remain always at its steady-state level (see e.g. Leith and Malley (2002), p. 10), $\widehat{g}_t = 0$ so that $\widehat{c}_t = \widehat{y}_t$. Summarizing, the IS-curve (3) is derived under market equilibrium and from expressing the logarithmized Euler consumption equation in the appendix of Di Bartolomeo *et al.* (2003) for all consumers as a deviation from its steady state, where it is assumed that $rr_t^0 \equiv -\log\beta = rr^0$:

$$\widehat{y}_t = E_t\left[\widehat{y}_{t+1}\right] - \frac{1}{\sigma}\left(r_t - E_t\left[\Delta p_{t+1}\right] - rr_t^0\right) + \underbrace{E_t\left[\Delta g_{t+1} - \Delta y_{t+1}^0\right]}_{g_t^{'}} \tag{6}$$

with σ a parameter of relative risk aversion of households (in the parametric household's utility function in the above-mentioned appendix) and $g_t^{'}$ a (current) demand shock being a function of expected changes in government purchases relative to expected changes in potential output, which can be interpreted as an autocorrelated disturbance term ($g_t^{'}$ being u_t in (3)) that obeys:

$$g_t^{'} = \rho_g g_{t-1}^{'} + \varepsilon_t^g$$

with $0 \leqq \left|\rho_g\right| \leqq 1$ and ε_t^g a white noise stochastic error term with zero mean and constant variance σ_g^2. Assuming now that firms set prices on a staggered basis as in Calvo (1983), each period only a fraction of firms receives a signal to reset prices optimally so that the following closed-economy NKPC is obtained (see Clarida *et al.* (1999) and Galí *et al.* (2001)):

$$\Delta p_t = \beta E_t\left[\Delta p_{t+1}\right] + \lambda\widehat{mc}_t + v_t' \tag{7}$$

where $\widehat{mc}_t$ is the logarithmic (real) marginal cost, defined as a deviation from its steady-state level, and v_t' is determined by the following autocorrelated process:

$$v_t' = \rho_\nu v_{t-1}' + \varepsilon_t^\nu$$

with $0 \leqq |\rho_v| \leqq 1$ and ε_t^ν a white noise stochastic error term with zero mean and constant variance σ_ν^2. For a production function of the Cobb-Douglas form, $Y_t(z) = A_t(N_t(z))^{1-\alpha}$, the parameter λ is determined by the model's structural parameters as follows:

$$\lambda = \frac{(1-\theta_p)(1-\beta\theta_p)(1-\alpha)}{\theta_p\left[1+\alpha(\theta-1)\right]}$$

where θ_p is a measure of the degree of price rigidity in the Calvo-sense (where each firm is assumed to reset its price with probability $(1-\theta_p)$ so that prices are fixed for an expected period of $\frac{1}{1-\theta_p}$),[7] β is the discount factor of

[5] This paper, which is largely an extended version of the current journal paper, is directly available upon simple request with (one of) the authors.

[6] And by taking account of the property that the output gap will generally be negative (because the monopolistic competition, assumed to exist on the intermediate goods market, generally introduces inefficiency so that the output produced will in general be lower than the perfectly competitive output).

[7] The staggered price setting according to Calvo (1983) assumes that during each period t only a fraction $(1-\theta_p)$ of producers reset their prices optimally, while a fraction θ_p keep their prices unchanged. While fixing the reset price the individual firm takes the probability of being stuck with the new reset price for s periods into account. Let $\widetilde{p}_t$ denote the logarithm of the price set by firms adjusting prices in period t, then the evolution of the logarithmic price level over time can be written as the following 'rule of thumb', which is a difference equation in log-linear terms: $p_t = \theta_p p_{t-1} + (1-\theta_p)\widetilde{p}_t$.

the private sector originating from the utility function mentioned in the above-called appendix, α is a measure of the curvature of the production function (labor elasticity) and θ is the elasticity of demand (under the assumption that a company is confronted with an isoelastic demand curve for its product; see the appendix of Di Bartolomeo *et al.* (2003)). Note that $\frac{\theta}{\theta-1}$ is the firm's desired mark-up then.

Using the Cobb-Douglas production, the real marginal cost in period $t+k$ of a company setting its price optimally in period t is determined, again using the derivation in the appendix of Di Bartolomeo *et al.* (2003), as:

$$MC_{t,t+k} = \frac{(W_{t+k}/P_{t+k})}{(1-\alpha)(Y_{t,t+k}/N_{t,t+k})} \tag{8}$$

where $Y_{t,t+k}$ and $N_{t,t+k}$ are the output and employment for a company that optimally sets its price in period t. Assuming equal technology A_t for all firms and averaging over all companies the real marginal cost of a company satisfies:

$$MC_t = \frac{(W_t/P_t)}{(1-\alpha)(Y_t/N_t)} \tag{9}$$

In the simpler Leontief case, $Y_t(z) = A_t N_t(z)$, the marginal cost can be found by setting α equal to 0 in (9).The deviation of the marginal cost from its steady state value can be shown to be linked to the output gap as follows (see e.g. Gali (2002)):

$$\widehat{mc}_t = (\sigma + \phi)\,\widehat{y}_t \tag{10}$$

where ϕ is the inverse of the intertemporal elasticity of work effort with respect to the real wage in the disutility of work (see the appendix of Di Bartolomeo *et al.* (2003)).

2.2.2 Monetary policy targets and reaction functions

Optimal monetary policy at a generic time T is derived from the minimization of a quadratic expected loss function:

$$L_T = \frac{1}{2} E_T \left[\sum_{i=0}^{\infty} \delta^i \left((\Delta p_{T+i})^2 + b\widehat{y}_{T+i}^2 \right) \right] \tag{11}$$

subject to the above output-gap and inflation-rate equations.[8] In equation (11) b is the relative weight for output-gap stabilization[9] and $\delta \in (0,1)$ is the central bank's constant intertemporal discount factor. The minimization of (11) is often called 'flexible inflation targeting' in the literature (see Svensson (1999)). In addition, notice that $b = 0$ corresponds to strict inflation targeting.

The policy problem consists in choosing the path for the central bank's instrument, r_t, assuring the paths of the target variables, Δp_t and $\widehat{y}_t$, that minimize the expected loss function (11) subject to the constraints on output gap and inflation rate behavior implied by equations (3) and (4), *viz.* (6) and (7). We solve this policy problem in two stages. First, we determine the optimal relationship between the targets by minimizing (11) with respect to equation (4), *viz.* (7). Second, we use the optimal relationship, resulting from the first stage, and equation (3) (*viz.* (6)) to find the optimal path for the interest rate that supports the optimal condition. Using this two-stage specification of the policy problem, optimal monetary policy reduces to a sequence of static problems in the first stage. In fact, the central bank's problem can easily be solved in this first stage by deriving a minimax solution of the following Lagrangian:

$$\Gamma_T := L_T + \sum_{i=0}^{\infty} \delta^i \lambda_{T+i} \left\{ \beta E_T \left[\Delta p_{T+1+i} \right] + \gamma \widehat{y}_{T+i} + v_{T+i} - \Delta p_{T+i} \right\}$$

[8] Notice that the target value of the inflation rate can be set at zero, implying that the classical problem of inflation bias does not arise. Alternatively, we could also assume a constant inflation bias $\overline{\Delta p}$. Moreover, the output target level is set at the flexible-price output level.

[9] A socially optimal output gap $\widehat{y}^*$ may also be considered in (11) so that the second term can be replaced by $b(\widehat{y}_{T+i} - \widehat{y}^*)^2$. For reasons of simplicity, $\widehat{y}^*$ may be assumed to be constant and positive if potential output on average, due to some distortion, falls short of the socially optimal output level and negative in the opposite case.

to which corresponds the following first-order (minimizing) conditions with respect to the observable variables:[10]

$$\frac{\partial \Gamma_T}{\partial \Delta p_T} = \Delta p_T - \lambda_T = 0 \tag{12}$$

$$\frac{\partial \Gamma_T}{\partial \Delta p_{T+i}} = E_T\left[\delta\left(\Delta p_{T+i} - \lambda_{T+i}\right) + \beta\lambda_{T+i-1}\right] = 0 \qquad i = 1, 2, 3.. \tag{13}$$

$$\frac{\partial \Gamma_T}{\partial \widehat{y}_{T+i}} = E_T\left[b\widehat{y}_{T+i} + \gamma\lambda_{T+i}\right] = 0 \qquad i = 0, 1, 2... \tag{14}$$

We solve these FOCs under both the discretionary and commitment regimes. Under discretion, the central bank is assumed to re-optimize during each period. Under commitment, the central bank implements a state-contingent rule to which it can credibly commit. With forward-looking price setting and the underlying short-run output-inflation trade-off, there may be gains from commitment to a rule, as emphasized by Clarida *et al.* (1999) and others. The **discretionary policy** is obtained by considering equations (12) and (14) to which corresponds the following optimal general condition:

$$\Delta p_t = -\frac{b}{\gamma}\widehat{y}_t \tag{15}$$

As underlined by Clarida *et al.* (1999), this condition implies that the central bank follows a "lean against the wind policy". Whenever output is below capacity, the central bank reduces the interest rate to expand the demand (and inflation) and vice-versa when it is above target. Clearly, the more the central bank is then concerned about inflation, the less its reaction is. In a similar way, the monetary policy under the **commitment regime** must satisfy the following optimal general condition derived from equations (13) and (14):

$$\Delta p_t = -\frac{b}{\gamma}\left(\widehat{y}_t - \frac{\beta}{\delta}\widehat{y}_{t-1}\right) \tag{16}$$

This commitment regime is called the 'timeless perspective' regime by Woodford (1999b), which involves ignoring any conditions prevailing at the regime's inception by imagining that the decision to apply (13) and (14) had been made in the distant past (the start-up condition (12) is not used and condition (13) is applied in all periods). In general, a policy rule is called 'optimal from a timeless perspective' if it has a time-invariant form and if commitment to the rule from any date T onward determines an equilibrium that is optimal, subject to at most a finite number of constraints on the initial evolution of the endogenous variables. Contrary to the 'pure commitment solution' Nelson and McCallum (2000) show that in this timeless perspective case there is no dynamic inconsistency in terms of the central bank's own decision-making process. Nevertheless, many economists reject the idea of any commitment as, up to now, no central bank has made a 'once and for all commitment' to a monetary policy rule.

Equations of the kind of (15) and (16) are sometimes called 'specific targeting rules' in the literature. Moreover, we also remark that, if the central bank discounts the future at the same rate as the private sector ($\beta = \delta$), equations (15) and (16) provide the standard optimal conditions (compare with Clarida *et al.* (1999)).

Taken together, the optimal condition (15) and the core NKPC (4) form a difference equation system that, solved,[11] yields the *optimal (reduced form) targets under the discretionary regime* (D); hence, for Δp_t^D and $\widehat{y}_t^D$:

$$\Delta p_t^D = \frac{b}{\gamma^2 + b\left(1 - \beta\rho\right)}v_t \tag{17}$$

$$\widehat{y}_t^D = -\frac{\gamma}{\gamma^2 + b\left(1 - \beta\rho\right)}v_t \tag{18}$$

where it is assumed that the stochastic inflation shock v_t is observable at time t and follows a first-order autoregressive process: $v_t = \rho v_{t-1} + \tilde{v}_t$.[12]

[10] Notice that in the definition of the Lagrangean and in the first-order conditions (FOCs) we have used the law of iterated expectations: $E_T(E_t[x_{t+i}]) = E_T[x_{t+i}]$ for $t \geqslant T$.

[11] The difference equation system is solved by using the method of undetermined coefficients assuming rational expectations. In particular, we look for the minimal state variable solution that excludes bubbles and sunspots, as discussed by McCallum (1999).

[12] Where the (known) autocorrelation coefficient satisfies $0 < |\rho| < 1$ and $\tilde{v}_t \sim iid\left(0, \sigma_{\tilde{v}}^2\right)$ (see also before). Notice that in the presence

In the New Keynesian setup the inflation shock, v_t, can have two different interpretations (see Smets and Wouters (2002b)). One interpretation is that this shock is driven by a technology shock that also affects the appropriate target level of output since the central bank's objective is given by (11) and another interpretation is that this inflation shock captures a wage-push shock as in Clarida *et al.* (2002).[13]

Similarly, from equations (16) and (4), we derive the *optimal targets in the commitment regime* (C):

$$\Delta p_t^C = -\frac{b}{\gamma}\left(\theta_1 - \frac{\beta}{\delta}\right)\widehat{y}_{t-1} - \frac{1}{\theta_2}v_t \tag{19}$$

$$\widehat{y}_t^C = \theta_1 \widehat{y}_{t-1} - \frac{\gamma}{b\theta_2}v_t \tag{20}$$

where $\theta_1 \equiv \frac{1}{2}\frac{\left(1+\beta+\gamma^2 b^{-1}\right)-\sqrt{\left(1+\beta+\gamma^2 b^{-1}\right)^2-4\beta}}{\beta}$ and $\theta_2 \equiv 1+\beta\left(\frac{\beta}{\delta}-\rho\right)+\frac{\gamma^2}{b}-\theta_1\beta$. Notice that in the commitment regime output persistence is present whereas in the discretionary regime it is not (compare equations (17) and (18) with (19) and (20)).

By assuming that the stochastic shock u_t is observable at time t and may follow a first order autoregressive process: $u_t = \omega u_{t-1} + \tilde{u}_t$[14] and by plugging the reduced form expressions (17) and (18) in the aggregate demand (3) and, solving, we derive the *optimal (reduced form) feedback policy* for the interest rate (the central bank's (optimal) *reaction function*) in the *discretionary regime*:

$$r_t^D - rr_t^0 = \frac{1}{\pi_3}\left[\frac{\gamma(1-\rho)+\alpha b\rho}{\gamma^2+b(1-\beta\rho)}\right]v_t + \frac{1}{\pi_3}u_t \tag{21}$$

According to the optimal policy rule (21) the central bank adjusts the interest rate to stabilize demand and supply shocks subject to a trade-off between the output-gap volatility and the volatility of inflation. From (21) it becomes clear that the reaction of interest rates to demand shocks does not depend on the preference parameter b. Hence, any preference type of a central bank will choose the same reaction to demand shocks, which restores the optimal combination of a zero output gap and an inflation rate equal to the inflation target. The interest rate reaction to supply shocks on the contrary depends on central bank preferences. Hence, depending on the preference type each central bank will choose its preferred stabilization mix. This means that in situations with supply shocks the central bank faces a trade-off between stabilizing the inflation rate versus stabilizing the output gap (see before). Of course the deviation from baseline will only be one period long; hence, equation (21) is not able to display persistence.

By using equations (19) and (20) instead of equations (17) and (18), the central bank's (optimal) reaction function in the *commitment regime* becomes:[15]

$$r_t^C - rr_t^0 = \frac{1}{\theta_2}\left[\frac{\gamma}{b}\left(\frac{1+\theta_1-\rho}{\pi_3}\right) - \frac{\beta+\rho(\delta-\theta_1)}{\delta}\right]\widehat{y}_{t-1} + \theta_1\left[\frac{1+\theta_1}{\pi_3} + \frac{b(\delta\theta_1-\beta)}{\gamma\delta}\right]v_t + \frac{1}{\alpha}u_t \tag{22}$$

Again, equation (22) implies that the optimal response to demand shocks u_t does not depend on the preference parameter b. In other words, each preference type b will react identically to demand shocks, which is quite logical since our model does not exhibit any persistence (up to now) so that the central bank is able to restore its globally optimal outcome of an inflation rate equal to the inflation target and an output gap equal to zero.

of forward-looking private sector behavior discretionary optimization by a central bank generally results not only in average inflation bias when the output gap target is positive, but also in inefficient responses to shocks (that is called 'stabilization bias' by Clarida et al. (1999) and Woodford (1999a) and arises with a Calvo-type NKPC; see before), regardless of whether the output-gap target is positive or not.

[13] In Clarida *et al.* (2002) the inflation shock is modeled as a stochastic disturbance to the wage markup in a monopolistically competitive labor market. As this shock to the wage markup causes inefficient variations in output, a welfare-maximizing central bank would like to smooth out the output effects of such shocks. In that case the output gap in the central bank's quadratic risk function (11) is replaced by output alone. The cost-push shock will give rise to a trade-off between inflation and output-gap stabilization while a supply shock will not (see Gaspar and Smets (2002)).

[14] Where the (known) autocorrelation coefficient satisfies $0 < |\omega| < 1$ and the error terms are assumed to be mutually independently distributed as white noise processes, or $\tilde{u}_t \sim iid\left(0, \sigma_{\tilde{u}}^2\right)$ (see before for the process g_t').

[15] Again, by assuming that the central bank discounts the future at the same rate as the private sector, equations (21) and (22) yield the standard reaction functions after tedious algebra.

Notice that the above reaction functions do not assume the existence of a stable solution for all possible parameters (see Evans and Honkapohja (2002a) and (2002b)).

2.3 A hybrid closed-economy setup

The hybrid model is an alternative specification that is based on the presence of inertia in output prices and habit formation in consumption and tends to generate persistence in inflation and output.[16]

2.3.1 Discussion of the hybrid model

We present two possible ways to determine a hybrid New Keynesian macroeconomic model for closed economies.

First, a simple (*ad hoc*) approach to the hybrid closed-economy model is suggested by Clarida *et al.* (1999). They introduce two parameters χ and φ ($0 \leqq \chi \leqq 1$ and $0 \leqq \varphi \leqq 1$): χ measures the influence of the expected future output gap (versus the lagged output gap); $(1-\varphi)$ measures the importance of lagged inflation versus future inflation. Model (6) and (7) then becomes:

$$\begin{aligned} \widehat{y}_t &= \chi E_t\left[\widehat{y}_{t+1}\right] + (1-\chi)\,\widehat{y}_{t-1} - \frac{1}{\sigma}\left(r_t - E_t\left[\Delta p_{t+1}\right] - rr_t^0\right) + g_t' \qquad (23) \\ \Delta p_t &= \varphi\beta E_t\left[\Delta p_{t+1}\right] + (1-\varphi)\,\Delta p_{t-1} + \lambda\widehat{mc}_t + v_t' \qquad (24) \end{aligned}$$

Again $\lambda\widehat{mc}_t$ can be interpreted using either a Leontief or a Cobb-Douglas technology.

Second, explicit profit maximization under a generalized Calvo - price setting and explicit utility maximization in the presence of habit formation in consumption is considered. The staggered price setting according to Calvo (1983) is now re-interpreted in the sense that firms reset prices with probability $(1-\theta_p)$, but that now only a fraction $(1-\omega)$ of firms actually behave according to the Calvo model. The remaining fraction ω is assumed to follow a backward-looking rule. If a firm maximizes its real profits, it will choose the price of its good so that the adjustment price is determined by the projected path of marginal cost with resulting NKPC (see Gali *et al.* (2001)):

$$\Delta p_t = \Pi_1 E_t\left[\Delta p_{t+1}\right] + \Pi_2 \Delta p_{t-1} + \lambda\widehat{mc}_t + v_t' \quad , \qquad (25)$$

where, in the Cobb-Douglas case, we have:

$$\begin{aligned} \Pi_1 &\equiv \beta\theta_p\Gamma^{-1} \ ; \ \Pi_2 \equiv \omega\Gamma^{-1} \ ; \\ \text{and } \lambda &\equiv \frac{(1-\omega)\,(1-\theta_p)\,(1-\beta\theta_p)\,(1-\alpha)}{\Gamma\left[1+\alpha\,(\theta-1)\right]} \end{aligned}$$

with $\Gamma \equiv \theta_p + \omega(1-\theta_p(1-\beta))$.

Following the derivations in Caputo (2003), we obtain a hybrid output-gap equation from utility maximization under habit formation in consumption and application of equilibrium condition $\widehat{c}_t = \widehat{y}_t$. The resulting IS-curve is:

$$\widehat{y}_t = \Psi\beta E_t\left[\widehat{y}_{t+1}\right] + \Psi\widehat{y}_{t-1} - \Omega\left(r_t - E_t\left[\Delta p_{t+1}\right] - rr_t^0\right) + g_t' \qquad (26)$$

where τ is a constant rate-of-risk-aversion (CRRA) parameter, indicating the importance of habit formation in the utility function: $U(C_t, H_t) \equiv \frac{\left(C_t H_t^{-\tau}\right)^{(1-\sigma)}}{(1-\sigma)}$, with H_t an accustomed aspiration level which depends on past consumption so that it allows for habit formation in consumption (see Caputo (2003)), and

$$\begin{aligned} \Psi &\equiv \frac{\tau(\sigma-1)}{\sigma+\tau\beta(\tau(\sigma-1)-1)} \qquad (27) \\ \Omega &\equiv \frac{1-\tau\beta}{\sigma+\tau\beta(\tau(\sigma-1)-1)} \qquad (28) \end{aligned}$$

[16] An empirical justification for including lagged inflation rates is given by Fuhrer and Moore (1995).

2.3.2 Monetary policy targets

As in the above subsection, the optimal monetary policy reduces to a sequence of static problems in the first stage. In fact, the central bank's problem, at a generic time T, can be solved by minimizing the following Lagrangian in this first stage (again using the law of iterated expectations):

$$\begin{aligned}\Gamma_T \quad : \quad &= L_T + \sum_{i=0}^{\infty} \delta^i \lambda_{T+i} \left\{ \beta_1 E_T \left[\Delta p_{T+1+i} \right] + \beta_2 \left[\Delta p_{T-1+i} \right] + \gamma \widehat{y}_{T+i} + \upsilon_{T+i} + \right. \\ &\left. -\Delta p_{T+i} \right\}.\end{aligned}$$

The first order conditions turn out to be:

$$\begin{aligned} - \frac{\partial \Gamma_T}{\partial \Delta p_T} &= \Delta p_T - \lambda_T + \delta \beta_2 \lambda_{T+1} = 0 \quad ; \qquad (29) \\ - \text{ for } i &= \{1, 2, 3, ...\} : \\ \frac{\partial \Gamma_T}{\partial \Delta p_{T+i}} &= E_T \left[\delta (\Delta p_{T+i} - \lambda_{T+i}) + \delta^2 \beta_2 \lambda_{T+1+i} + \beta_1 \lambda_{T-1+i} \right] = 0 \ ; \qquad (30) \\ - \text{ for } i &= \{0, 1, 2, ...\} : \\ \frac{\partial \Gamma_T}{\partial \widehat{y}_{T+i}} &= E_T \left[b \widehat{y}_{T+i} + \gamma \lambda_{T+i} \right] = 0 \ . \qquad (31) \end{aligned}$$

The discretionary policy can be obtained by considering that the central bank uses equations (29) and (31) in period T and then plans to use equations (30) and (31) in the other periods ($t > T$),[17] but optimal policies derived in such a way are (again) dynamically inconsistent since for each current period it is always optimal for the central bank to use (29) instead of (30).

A different and dynamically consistent concept, proposed by e.g. Clarida *et al.* ((1999), p. 1692), is the following. The central bank recognizes at period T that in the future ($t > T$) it will behave just as it does during period T. Therefore, minimizing its (expected) loss the central bank considers $\rho_1 \Delta p_t$ instead of $E_t [\Delta p_{t+1}]$ in the NKPC (2), where ρ_1 is a parameter of the equilibrium-solution expression: $\Delta p_t = \rho_1 \Delta p_{t-1} + \rho_2 \varsigma_t$, with the white noise error term ς_t. By solving we achieve the following optimal general condition for monetary policy in the discretionary regime:

$$\Delta p_t^D = -\frac{b}{\gamma} \left[(1 - \beta_1 \rho_1) \widehat{y}_t - \beta_2 \delta E_t [\widehat{y}_{t+1}] \right] \qquad (32)$$

By contrast, according to the timeless perspective, optimal monetary policy under the commitment regime must satisfy the following condition derived from equations (30) and (31):

$$\Delta p_t^C = -\frac{b}{\gamma} \left(\widehat{y}_t - \frac{\beta_1}{\delta} \widehat{y}_{t-1} - \beta_2 \delta E_t [\widehat{y}_{t+1}] \right) \qquad (33)$$

By using equations (32) and (33) together with IS relation (1), we can derive both optimal output gap and inflation targets and the interest rate reaction function as in the previous subsection. However, the explicit algebraic (closed-form) solutions of those kinds of dynamic systems are rather difficult to obtain,[18] and, therefore, we limit our attention to the optimality conditions for price dynamics, i.e. equations (32) and (33).

2.4 A hybrid open-economy setup

For our propose it is intereresting to explicitly investigate the impact of the open economy on monetary policy. In this section we analyze the effects of introducing exchange rate channels of monetary policy in the closed-economy framework of the previous subsection.

[17] By solving the described problem the optimal condition is found to be $\Delta p_t = -\frac{b}{\gamma} (\widehat{y}_t - \beta_2 \delta E_t [\widehat{y}_{t+1}])$.

[18] Usually, numerical simulations are used; see, e.g., McCallum and Nelson (2000) and Jensen (2002).

2.4.1 Discussion of the hybrid open-economy model

A simple small open-economy framework is obtained by augmenting the hybrid equations (1) and (2) with the effects of the real exchange rate (see, e.g., Svensson (2000)). In addition, the Uncovered Interest rate Parity (UIP) hypothesis is considered as the rule that governs the flows of capital among the open economies. The hybrid open-economy model becomes:

$$\begin{aligned}
\widehat{y}_t &= \pi_1 E_t\left[\widehat{y}_{t+1}\right] + \pi_2 \widehat{y}_{t-1} - \pi_3 (r_t - E_t\left[\Delta p_{t+1}\right] - rr_t^0) + \zeta x_t + u_t && (34)\\
\Delta p_t &= \beta_1 E_t\left[\Delta p_{t+1}\right] + \beta_2 \Delta p_{t-1} + \gamma \widehat{y}_t + \eta x_t + v_t && (35)\\
r_t - E_t\left[\Delta p_{t+1}\right] &= E_t[x_{t+1}] - x_t + \varrho_t && (36)
\end{aligned}$$

where $x_t \equiv e_t + p_t^* - p_t$ is the (logarithmic) real exchange rate and ϱ_t is an exogenous noise term reflecting the sum of the real world interest rate, $r_t^* - E_t\left[\Delta p_{t+1}^*\right]$, and a risk premium.[19] Equation (34) is the simple extension of equation (1) to an open economy. As for the closed-economy case, it nests the open-economy demand obtained by the log-linear approximation to the Euler conditions for the optimal consumption path (see the appendix of Di Bartolomeo *et al.* (2003)). The real exchange rate appears because it determines the relative cost of foreign and domestic goods, and is therefore a proxy of competitiveness. Equation (35) is a hybrid open-economy NKPC based on staggered price setting, while equation (36) is a real UIP condition that relates the domestic real interest rate to the foreign real interest rate, the rate of real exchange rate depreciation and a risk premium.

The extent to which exchange rate changes are eventually reflected in import prices is commonly referred to as the degree of exchange rate 'pass-through'.[20] Imported goods are made up of a heterogeneous range of commodities and the pass-through may vary considerably across these different types of imports e.g. a (much) higher degree of pass-through for more homogeneous and widely-traded goods (as oil and raw materials), where the so-called 'law of one price' might hold, than for highly differentiated goods. It should be stressed that incomplete pass-through renders the analysis of monetary policy of an open economy fundamentally different from the one of a closed economy, unlike (canonical) models with perfect pass-through which emphasize a type of isomorphism.

According to Caputo (2003), the NKPC satisfies:

$$\Delta p_t = (1-\varphi)[\beta E\left[\Delta p_{t+1}\right] + k(\phi \widehat{y}_t + \vartheta x_t)] + \varphi \Delta p_{t-1} + v_t' \qquad (37)$$

where

$$k \equiv \frac{(1-\theta_p)(1-\beta\theta_p)}{\theta_p(1+\phi\theta_h)}$$

with θ_h the elasticty of demand for domestic output. The hybrid open-economy IS curve is given by (see (26)):

$$\widehat{y}_t = (1-\vartheta)E_t\{\Psi\beta\left[\widehat{y}_{t+1}\right] + \Psi\widehat{y}_{t-1} - \Omega\left(r_t - E_t\left[\Delta p_{t+1}\right] - rr_t^0\right)\} + \vartheta \widehat{y}_t^* + \zeta x_t + g_t' \qquad (38)$$

where Ψ and Ω are defined as in (27) and (28) x_t is the real exchange rate, ϑ is the degree of openness (share of consumption allocated to imported goods).and

$$\zeta \equiv \frac{\vartheta(\eta^* + \eta - \vartheta\eta)}{1-\vartheta}$$

[19] Notice that e_t is the logarithmic nominal exchange rate denoting the price of one unit of foreign currency in terms of the domestic currency, p_t^* the logarithmic foreign price level and p_t the logarithmic price level of domestically produced goods.

[20] This degree of exchange rate pass-through can be empirically estimated; see Campa and Goldberg (2001) for estimates of the exchange rate pass-through to import prices for 25 OECD countries over the period 1975 to 1999, Goldfajn and Werlang (2000) and Choudhri *et al.*(2001) for estimates of the exchange rate pass-through to domestic inflation in 71 countries in the period 1979 to 1998 (2000), and Darvas (2001) and Coricelli *et al.* (2003) for two studies on the pass-through from exchange rate changes to domestic inflation in four CEECs (the Czech Republic, Hungary, Poland, and Slovenia) for the period 1993 to 2000. The empirical analysis indicates that, especially for Slovenia and Hungary, there is a very large pass-through from exchange rates to domestic inflation (and to a somewhat lesser but still important extent for the Czech Republic and Poland).

with η^* and η the foreign and domestic elasticities of substitution between domestic and foreign goods.[21] Interpreting (38) we observe that the output gap in an open economy depends on its domestic expectation, the persistence in this domestic consumption (output gap), the long-term real interest rate, the real exchange rate, and the foreign real output. Furthermore, foreign consumption (output gap) also plays a crucial role, which depends on the degree of habit formation both domestically and abroad.

2.4.2 Monetary policy targets

In studying the optimal program under commitment relative to discretion we again show that the former entails a smoothing of the deviations from the law of one price.[22]

The discretionary optimization problem can be solved now as follows. First, in order to eliminate the nominal interest rate, we substitute the uncovered interest rate parity condition (36) in equation (34), and we solve for the real exchange rate:

$$x_t = \frac{\pi_1 E_t\left[\widehat{y}_{t+1}\right] + \pi_2 \widehat{y}_{t-1} - \pi_3 (E_t[x_{t+1}] + \varrho_t - E_t\left[\Delta p_{t+1}\right] - rr_t^0) - \widehat{y}_t + u_t}{(1+\eta)} \tag{39}$$

Substituting expression (39) in the open-economy NKPC (35) we obtain:

$$\begin{aligned} \Delta p_t \quad = \quad & \left(\beta_1 + \frac{\pi_3 \eta}{1+\eta}\right) E_t\left[\Delta p_{t+1}\right] + \beta_2 \Delta p_{t-1} + \left(\gamma - \frac{\eta}{1+\eta}\right)\widehat{y}_t + \\ & + \frac{\eta\left[\pi_1 E_t\left[\widehat{y}_{t+1}\right] + \pi_2 \widehat{y}_{t-1} - \pi_3 (E_t[x_{t+1}] + \varrho_t - rr_t^0) + u_t\right]}{1+\eta} + v_t \end{aligned} \tag{40}$$

which can be used to find the optimal general condition for discretionary monetary policy:

$$\Delta p_t^D = -\frac{b}{\gamma - \eta\left(1+\eta\right)^{-1}}\left[\left(1 - \beta_1 \rho_1 - \frac{\pi_3 \eta \rho_1}{1+\eta}\right)\widehat{y}_t - \beta_2 \delta E_t[\widehat{y}_{t+1}]\right] \tag{41}$$

Recall that under a discretionary regime, in which the central bank optimizes each period and is unconstrained by its previous choices, expectations about future outcomes are not affected by the current policy choice.

By contrast, according to the timeless perspective, optimal monetary policy under the commitment regime must satisfy the following condition:

$$\Delta p_t^C = -\frac{b}{\gamma - \eta\left(1+\eta\right)^{-1}}\left(\widehat{y}_t - \frac{1}{\delta}\left(1 - \beta_1 \rho_1 - \frac{\pi_3 \eta \rho_1}{1+\eta}\right)\widehat{y}_{t-1} - \beta_2 \delta E_t[\widehat{y}_{t+1}]\right) \tag{42}$$

Again, by using equations (41) and (42) together with IS equation (34), we can derive both optimal output-gap and inflation targets and the interest rate reaction function, but, for computational reasons, a closed-form expression can no longer be obtained so that we limit our attention to the optimal conditions for price dynamics, i.e. equations (41) and (42).

3 Estimations of the NKPC model for the accession countries

In this section we present estimates of the relationships discussed in the theoretical part for different EU-accession countries.

[21] See CES-aggregates in the appendix of Di Bartolomeo *et al.* (2003) for domestic and foreign consumption. If an economy has a non-diversifed export sector (i.e. faces a high η^*), the impact of the exchange rate fluctuations will be exacerbated (Caputo (2003)).

[22] Which is -it should be said again- in stark contrast with the established empirical evidence. In addition, an optimal commitment policy always requires, relative to discretion, more stable nominal and real exchange rates.

3.1 Data and methodology

It is widely known that the quality of the available data for the CEECs is limited, especially of those data from early in the transition phase. E.g., the decline in output is believed to be overestimated, because newly emerging activities were inadequately captured and existing firms had an incentive to underreport output and sales to avoid taxes (see e.g. Falcetti *et al.* (2002)). Moreover experiences in transition countries have been so different to date that it is questionable that one parameter set would fit the data of all countries equally well. We therefore present estimates country by country. We use quarterly data covering sample periods from the early 1990s until the end of 2002. Inflation is measured as the quarterly logarithmic change in the producer price index. Both the output gaps and the deviation of the interest rates from their steady-state values are approximated by removing a deterministic polynomial time trend from the corresponding level variables. Data are drawn from the IMF's International Financial Statistics database and from the OECD's Statistical Compendium. Clearly, because of the limited time period since the start of transition, and, consequently, because of the fairly limited number of observations, results should be interpreted with caution. Figure 1 plots GDP inflation (solid line, left hand scale) and the output gap (dashed line, right hand scale). As to be expected, it is not obvious to infer a close relationship from the graph (compare with figure 3 in Galí *et al.* (2001) for OECD countries). In most countries some correspondences can be detected however.

At the core of the theoretical framework behind the different versions of the NKPC lies its forward-looking nature. In order to be able to estimate the different versions of the NKPC, we need (conditional) expectations of future inflation (and output). Ideally, one would like to use survey data, where time series on inflation expectations have been collected. Unfortunately we do not have them, and, therefore, conditional expectations have to be formed based on the data set at hand. A possible empirical approach is to use some form of Generalized Method of Moments (GMM) method with linear rational expectations (LREs). Assuming no inflation bias and that $\Delta p_t - \beta_1 E_t [\Delta p_{t+1}] - \beta_2 \Delta p_{t-1} - \gamma \widehat{y}_t$ is orthogonal to a set of variables, collected in the information set of the agents at time t, the hybrid NKPC can be identified. Let z_{1t} denote a vector of instruments observed at time t. Then, under LREs, the following set of orthogonality conditions is assumed for the NKPC (2):

$$E_t \left[\left(\Delta p_t - \beta_1 E_t [\Delta p_{t+1}] - \beta_2 \Delta p_{t-1} - \gamma \widehat{y}_t \right) \; z_{1t} \right] = 0 \tag{43}$$

Likewise, it is possible to define a set of orthogonality conditions for the (hybrid) output-gap equation (1):

$$E_t[(\widehat{y}_t - \pi_1 E_t [\widehat{y}_{t+1}] - \pi_2 \widehat{y}_{t-1} + \pi_3(\widehat{r}_t - E_t [\Delta p_{t+1}])) \; z_{2t}] = 0 \tag{44}$$

with $\widehat{r}_t \equiv r_t - rr_t^0$.

Rewriting the above orthogonality conditions in vector form:

$$\mathbf{h}(\boldsymbol{\theta}, \mathbf{w}_t) \equiv \begin{bmatrix} E_t [(\Delta p_t - f_1(\boldsymbol{\theta}, \mathbf{x}_t))] \; \mathbf{z}_t = 0 \\ E_t [(\widehat{y}_t - f_2(\boldsymbol{\theta}, \mathbf{x}_t))] \; \mathbf{z}_t = 0 \end{bmatrix} \tag{45}$$

where $\boldsymbol{\theta}$ is the vector of parameters to be estimated, $\boldsymbol{\theta} \equiv [\boldsymbol{\theta}_1 = (\beta_1, \beta_2, \gamma)', \boldsymbol{\theta}_2 = (\pi_1, \pi_2, \pi_3)']'$ and $\mathbf{w}_t \equiv [\mathbf{v}_t', \mathbf{x}_t', \mathbf{z}_t']'$; $\mathbf{v}_t \equiv [\Delta p_t, \widehat{y}_t]'$; $\mathbf{x}_t \equiv [\mathbf{x}_{1t} = (\Delta p_{t+1}, \Delta p_{t-1}, \widehat{y}_t)', \mathbf{x}_{2t} = (\widehat{y}_{t+1}, \widehat{y}_{t-1}, \widehat{r}_t - \Delta p_{t+1})']'$, $\mathbf{z}_t$ is a vector with instruments $[\Delta p_{t-2}, \Delta p_{t-3}, \Delta p_{t-4}, \widehat{y}_{t-2}, \widehat{y}_{t-3}, \widehat{y}_{t-4}, \widehat{r}_{t-1}, \widehat{r}_{t-2}]'$ with $E_t [\mathbf{z}_t, \boldsymbol{\varepsilon}_t] = 0$, $\boldsymbol{\varepsilon}_t$ being the error vector belonging to (2) and (1), it is possible to estimate the model by GMM through the minimization of:

$$Q(\boldsymbol{\theta}) = \left[\frac{\sum_{t=1}^{T} \mathbf{h}(\boldsymbol{\theta}, \mathbf{w}_t)}{T} \right]' \widetilde{S}_T^{-1} \left[\frac{\sum_{t=1}^{T} \mathbf{h}(\boldsymbol{\theta}, \mathbf{w}_t)}{T} \right] \tag{46}$$

where $\widetilde{S}_T^{-1}$ is an estimate of the inverse sample covariance matrix.[23] We conduct Hansen's J-test to test the validity

[23] In order to obtain standard errors that are robust to heteroskedasticity and autocorrelation of unknown form we computed the

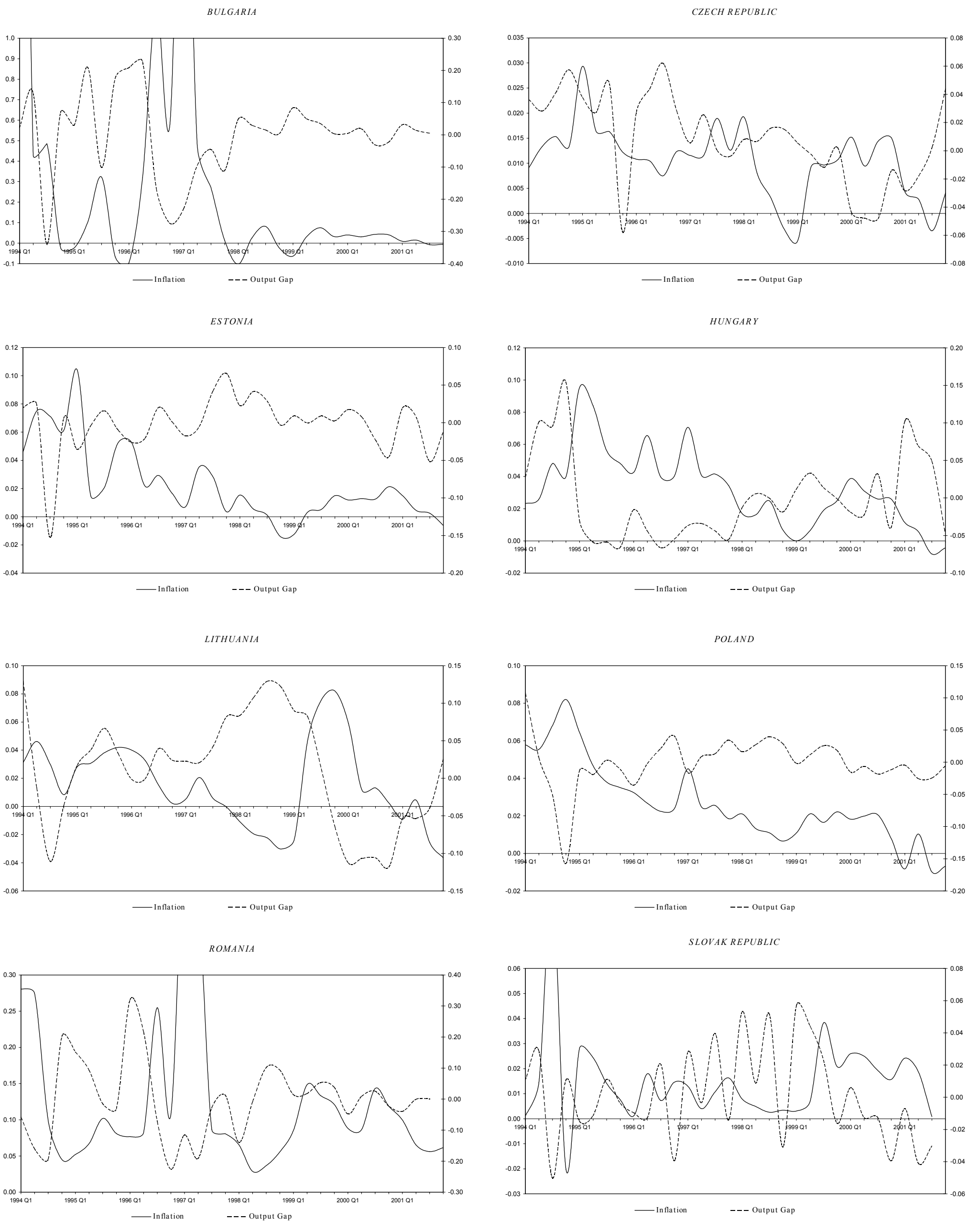


Figure 1: Inflation rates (LHS) and output gaps (RHS) in eight EU-accession countries: 1994 Q1 - 2001 Q4

of our overidentifying restrictions since we have more instruments than parameters to be estimated.[24] The agents' information set at time t thus consists of three lags of inflation (lags two to four), three lags of detrended output (lags two to four) and two lags of $\widehat{r}_t$.

In small samples GMM estimators are often found to be biased, widely dispersed, sensitive to the normalization of the orthogonality conditions and to the choice of the instrument set. In order to minimize the potential estimation bias that is known to arise in small samples with too many overidentifying restrictions, we opt for a relatively small number of lags for the instruments. The two-step GMM estimator used here is known to be less sensitive to these small-sample biases.[25] To control for serial correlation and heteroskedasticity in the error term, the standard errors presented in the tables are modified using a Newey-West correction, as noted before. Since sample sizes are fairly limited and the period covered is one of drastic changes, GMM results should be interpreted with caution.

Since the occurrence of the output gap in closed-economy NKPCs is quite debated in empirical contributions (see Galí and Gertler (1999), Galí *et al.* (2001), Gertler *et al.* (2001), Jondeau and Le Bihan (2001), Leith and Malley (2002), and Sbordone (2002)), and since also in the case of the CEECs the output gap turned out to be only a poor proxy of marginal costs, we estimated the (hybrid) NKPC (7) using the logarithmic deviation of the real unit labour cost (or, equivalently, the labour income share) from its mean as a measure for the deviation of the real marginal cost from its steady-state level (see also (9) under a Cobb-Douglas production function). This variable has a better empirical record in the literature on inflation dynamics in the Euro-area and the US (see e.g. Jondeau and Le Bihan (2001)). Real unit labour costs are constructed as the logarithmic ratio of (quarterly) compensation per employee times employment and GDP ($w+n-y$). Then, the agents' information set is extended with two lags of marginal costs $\widehat{mc}_{t-1}$ and $\widehat{mc}_{t-2}$. Figure 2 plots this variable against the inflation rate in the different countries. It is not obvious to infer a close relationship from the graph. Given that our sample period covers the transition phase, this should not come as a surprise. In most countries some correspondences can be detected however.

3.2 The purely forward-looking closed-economy model

By setting $\beta_2 = \pi_2 = 0$ in (1) and (2), respectively, we obtain the purely forward-looking closed-economy model. The remaining parameters β_1, π_1, γ and π_3 are convolutions of structural or deep parameters from the microeconomic theory behind the New Keynesian model. As a consequence of the joint optimal price and output-gap setting, specification ((3)-(4)) provides some immunity with respect to the Lucas critique. Parameters to be estimated are structural ones, so that they are not likely to change as the policy regime varies. GMM estimation under cross equation restrictions is performed for the above mentioned output-gap version and for the marginal cost (gap) version of the closed-economy NKPC (7).

Table 1 shows the results for the purely forward-looking closed-economy case described in ((6)-(7)) using the Leontief and the Cobb-Douglas production functions.The identifying assumptions used are $\theta_p = 0.75$ (i.e. prices are on average fixed for four quarters), $\alpha = 0.4$ and $\theta = 11$, implying a desired mark-up of 1.1 (cf. Leith and Malley (2002) and Caputo (2003)). An apparent fact is that the estimated private sector discount factor β is very high and even larger than 1 in some cases. Using the Cobb-Douglas production function βs are generally higher and nowhere significantly smaller than one. σ, the relative risk aversion parameter of households, varies between 5.7 and 16.3. Overidentifying restrictions are rejected in all cases by the J-statistic.

---

sample variance-covariance matrix $\widetilde{S}_T$ by utilizing the Newey and West (1987) estimator:

$$\widetilde{S}_T = \widetilde{\Gamma}_{0,T} + \sum_{i=1}^{q} \{1 - [i/(q+1)]\} \left(\widetilde{\Gamma}_{i,T} + \widetilde{\Gamma}'_{i,T}\right) \tag{47}$$

with

$$\widetilde{\Gamma}_{i,T} \equiv \frac{\sum_{t=i+1}^{T} \left[\mathbf{h}\left(\widetilde{\boldsymbol{\theta}}, \mathbf{w}_t\right)\right] \left[\mathbf{h}\left(\widetilde{\boldsymbol{\theta}}, \mathbf{w}_{t-i}\right)\right]'}{T}, \tag{48}$$

$s(i,q) \equiv \{1 - [i/(q+1)]\}$ the Bartlett kernel and q the bandwith parameter.

[24] Since the implied test statistic is distributed as $\chi^2(s-a)$, where s and a denote the number of orthogonality conditions and parameters, respectively, it may be possible to achieve more statistical power by (even) reducing the number of degrees of freedom (see Davidson and MacKinnon (see e.g. Davidson and MacKinnon (1993), p. 616). In our case, we can increase the statistical power by increasing the number of instruments in the z_t vector (so that we have already more instruments than parameters to be estimated).

[25] See e.g. the July 1996 special issue of the *Journal of Business and Economics Statistics*.

Figure 2: Inflation rates (LHS) and demeaned real unit labour costs (RHS) in eight EU-accession countries

	Leontief			Cobb-Douglas		
	β	σ	J-stat	β	σ	J-stat
Bulgaria	0.8795	7.4234	5.0103	0.8828	7.3781	5.0485
	(0.1203)	(1.0881)	(0.93)	(0.1217)	(1.1054)	(0.92)
Czech Republic	1.0229	11.3144	7.0626	0.9728	10.9254	7.1774
	(0.0546)	(4.4494)	(0.79)	(0.0584)	(4.2326)	(0.78)
Estonia	0.9397	7.6085	8.7676	1.0951	7.8415	7.3928
	(0.0574)	(1.6301)	(0.64)	(0.0881)	(2.0040)	(0.76)
Hungary	0.9938	8.3705	6.7701	0.9936	15.1696	6.4248
	(0.0349)	(3.5157)	(0.82)	(0.0342)	(17.0781)	(0.84)
Latvia	0.6954	6.0889	7.4514	1.2396	8.3825	7.6756
	(0.0925)	(1.2328)	(0.76)	(0.0873)	(2.5729)	(0.74)
Lithuania	0.9449	7.2536	8.6041	1.5197	16.3187	8.6840
	(0.0440)	(1.2978)	(0.66)	(0.1407)	(3.1160)	(0.65)
Poland	1.2177	11.7596	9.8140	1.3027	16.3252	8.8358
	(0.0315)	(4.2482)	(0.54)	(0.0132)	(7.9799)	(0.64)
Romania	1.0536	5.4828	7.4484	1.1071	10.4041	7.9370
	(0.0392)	(1.1748)	(0.76)	(0.0401)	(5.7370)	(0.72)
Slovak Republic	0.9317	5.1375	7.3521	1.0414	5.6871	6.6820
	(0.0887)	(2.4764)	(0.77)	(0.0853)	(2.5938)	(0.82)
Slovenia	1.0298	10.6713	7.8293	1.2079	14.0415	9.0746
	(0.0361)	(2.1390)	(0.73)	(0.0192)	(3.3071)	(0.61)

Table 1: GMM estimates for the purely forward-looking closed-economy model using demeaned marginal costs in the NKPC - Leontief vs Cobb-Douglas production function (Newey-West standard errors between parentheses)

3.3 The hybrid closed-economy models

The hybrid model adds backward-looking behavior to the forward-looking elements in the previous subsection. According to the hybrid model of Clarida *et al.* (1999) the parameters of equations (23) and (24) can be estimated according to GMM as in Table 2. The maintained assumptions with respect to θ_p, α and θ are the same as in the pure forward looking case.

With the exception of Latvia, this *ad hoc* model performs quite well. In most cases the estimated discount factor is smaller than one, especially in the Cobb-Douglas case. Leaving aside Latvia, we observe in the tables that the proportion or degree of forward-looking firm behavior in the NKPC (24) ranges from 0.42 (Hungary) to 0.80 (Slovak Republic) for the Leontief production function, so that the degree of forward-lookingness of firms strongly varies among CEECs. The Cobb-Douglas case also shows a dispersion across countries and the point estimates strongly differ (lowest is now Lithuania (0.44) and highest Romania (0.79). In a similar study, Gerberding (2001, p.23) argues that the estimated degree of forward-lookingness in a German Phillips curve is higher than in an Italian Phillips curve as German monetary policy was more credible.[26] If this argument carries over to transition countries, we observe that the Slovak Republic, Romania, Slovenia, and Poland have shown a more credible monetary policy than the other CEECs considered. By contrast, Lithuania, Hungary, and the Czech Rebublic seemed to perform (significantly) worse in terms of past credibility as far as a Leontief production function is appropriate. Under a Cobb-Douglas technology, Hungary shows a more credible monetary policy. Of course, results have to be interpreted with caution since Gerberding's argument might not be valid for transition economies, e.g. because of different liberalization degrees in the sample period.

Results of Table 2 are roughly in the same direction as the recent estimations for NKPCs in the United States that are reported in Table 3.

Table 4 shows the results of NKPC (25). The proportion ω of backward looking firms seems in line with the

[26] Notice that a large part of the observed nominal price inertia in Italy is also a result of the existing indexation mechanisms in that country, and is not directly linked to (the lack of) credibility of its monetary policy.

	Leontief					Cobb-Douglas				
	β	σ	χ	φ	J-stat	β	σ	χ	φ	J-stat
Bulgaria	0.8102 (0.1999)	2.1332 (0.2572)	0.3733 (0.1832)	0.6309 (0.1047)	6.5261 (0.84)	0.7246 (0.1403)	8.7410 (1.9781)	0.3299 (0.1299)	0.6403 (0.1598)	5.1542 (0.90)
Czech Republic	1.0251 (0.0583)	2.7197 (0.6706)	0.7976 (0.2944)	0.4634 (0.0628)	8.6618 (0.65)	0.9864 (0.0835)	5.7752 (2.2860)	0.7188 (0.2202)	0.4645 (0.0654)	8.7316 (0.65)
Estonia	1.0750 (0.1158)	2.3533 (0.4553)	0.2802 (0.1236)	0.5477 (0.1340)	6.8290 (0.81)	1.0441 (0.1206)	11.1729 (6.0773)	0.3783 (0.1309)	0.4568 (0.1157)	5.4120 (.88)
Hungary	0.9765 (0.0803)	2.4123 (0.4641)	0.2879 (0.1555)	0.4205 (0.0974)	7.6753 (0.74)	0.8933 (0.0725)	6.6812 (2.5016)	0.3839 (0.1672)	0.5505 (0.1120)	8.7915 (0.64)
Latvia	0.2133 (0.2005)	8.0612 (2.6919)	0.3119 (0.1130)	0.2652 (0.0833)	8.4648 (0.67)	0.8766 (0.1013)	12.4471 (4.0165)	0.5748 (0.0419)	1.1191 (0.1926)	12.5311 (0.32)
Lithuania	0.9633 (0.1557)	10.8965 (1.6859)	0.6057 (0.0878)	0.3911 (0.0704)	9.0468 (0.62)	0.6562 (0.0660)	13.8643 (2.8123)	0.6007 (0.0402)	0.4392 (0.0592)	8.2466 (0.69)
Poland	1.1093 (0.0331)	2.6466 (0.6079)	0.4288 (0.1136)	0.7319 (0.1241)	10.4797 (0.49)	0.8787 (0.1268)	12.7997 (3.8143)	0.5823 (0.1316)	0.5990 (0.1869)	7.9952 (0.71)
Romania	1.0300 (0.0613)	2.0724 (0.3014)	0.6608 (0.0673)	0.7807 (0.0510)	6.5396 (0.83)	0.9649 (0.0582)	10.9377 (3.7352)	0.6494 (0.0624)	0.7852 (0.0458)	6.5103 (0.84)
Slovak Republic	1.0811 (0.0690)	10.9054 (26.7033)	0.1950 (0.1782)	0.8047 (0.1350)	7.4210 (0.76)	1.0055 (0.1086)	5.6686 (2.8735)	0.2660 (0.1860)	0.5848 (0.1442)	7.7765 (0.73)
Slovenia	1.0038 (0.0332)	2.7835 (0.4924)	0.5845 (0.2192)	0.7433 (0.0249)	9.6451 (0.55)	0.9825 (0.0348)	22.7463 (5.0729)	0.6666 (0.0497)	0.7213 (0.0217)	11.4503 (0.40)

Table 2: GMM estimates for the hybrid closed-economy model with Leontief and Cobb-Douglas technology, based on Clarida et al. (1999), Leontief production function (Newey-West standard errors between parentheses)

Estimates of NKPCs for the United States		Per/Meth
Linde (2002)	$\Delta p_t = 0.46E_t\Delta p_{t+1} + 0.72\Delta p_{t-1} + 0.03\widehat{y}_t + \widetilde{\nu}_t$ $\Delta p_t = 0.28E_t\Delta p_{t+1} + 0.72\Delta p_{t-1} + 0.05\widehat{mc}_t + \widetilde{\nu}_t$	1960-97/ML
Söderlind et al. (2002)	$\Delta p_t = 0.1E_{t-1}\Delta p_{t+3} + 0.9[0.67\Delta p_{t-1} - 0.14\Delta p_{t-2}$ $+0.04\Delta p_{t-3} - 0.07\Delta p_{t-4}] + 0.13\widehat{y}_{t-1} + \widetilde{\nu}_t$	1987-99/calibration based on matching moments
Domenech et al. (2001)	$\Delta p_t = 0.54E_t\Delta p_{t+1} + 0.46\Delta p_{t-1} + 0.06\widehat{y}_{t-1} + \widetilde{\nu}_t$	1986-00/GMM
Jondeau and Le Bihan (2001)	$\Delta p_t = 0.53E_t\Delta p_{t+1} + 0.47\Delta p_{t-1} + 0.001 + \widetilde{\nu}_t$ $\Delta p_t = 0.54E_t\Delta p_{t+1} + 0.46\Delta p_{t-1} + 0.06\widehat{mc}_t + \widetilde{\nu}_t$	1970-99/ML
Galí et al. (2001)	$\Delta p_t = 0.36E_t\Delta p_{t+1} + 0.60\Delta p_{t-1} + 0.02\widehat{mc}_t + \widetilde{\nu}_t$	1960-94/GMM
Ruud and Whelan (2001)	$\Delta p_t = 0.61E_t\Delta p_{t+1} + 0.39\Delta p_{t-1} + \widetilde{\nu}_t$	1960-97/GMM
Rudebusch (2002)	$\Delta p_t = 0.29E_t\Delta p_{t+1} + 0.71\Delta p_{t-1} + 0.13\widehat{y}_t + \widetilde{\nu}_t$	1968-96/OLS
Galí and Gertler (1999)	$\Delta p_t = 0.68E_t\Delta p_{t+1} + 0.25\Delta p_{t-1} + 0.04\widehat{mc}_t + \widetilde{\nu}_t$	1960-94/GMM

Table 3: Estimates of NKPCs for the United States

	β	ω	γ	J-stat
Bulgaria	0.6017 (0.0977)	0.3775 (0.2000)	0.5620 (0.0704)	6.6586 (0.83)
Czech Republic	0.5701 (0.2698)	0.8753 (0.0714)	0.7741 (0.1638)	9.1612 (0.61)
Estonia	0.7211 (0.1454)	0.6785 (0.1595)	0.7902 (0.2196)	5.9258 (0.88)
Hungary	0.9047 (0.0761)	0.5244 (0.1565)	0.9117 (0.1045)	9.5328 (0.57)
Latvia	0.8635 (0.2307)	0.4608 (0.1934)	0.6717 (0.0733)	9.0124 (0.62)
Lithuania	- (-)	- (-)	- (-)	- (-)
Poland	0.8738 (0.0968)	0.4720 (0.1269)	0.6256 (0.2138)	7.6826 (0.74)
Romania	1.2012 (0.1150)	0.1951 (0.1066)	0.6212 (0.1096)	6.8506 (0.81)
Slovak Republic	0.8233 (0.2551)	0.8428 (0.4055)	0.2284 (0.0626)	8.1835 (0.70)
Slovenia	0.9929 (0.0891)	0.5391 (0.2775)	0.9220 (0.1372)	6.2133 (0.86)

Table 4: GMM estimates for the hybrid closed-economy model, based on Gali et al. (2001) and Caputo (2003) (Newey-West standard errors between parentheses)

parameters estimated in the *ad hoc* hybrid model above. The estimated discount factor is now smaller than one in almost all countries, though not always statistically signifcant below 1.

3.4 The hybrid open-economy New Keynesian model

GMM estimations of (38) and (37) are presented in table 5. Following Caputo (2003) additional identifying assumptions have been made to allow for reasonable identification. In addition to the earlier restriction with respect to $\theta_p = 0.75$, $\alpha = 0.4$ and $\theta = 11$, parameters are set as follows: $\eta = \eta^* = 1.5$; $\tau = 0.8$, $\phi = 0.6$ and $\sigma = 7.5$. With the exception of Bulgaria, the elasticity of the domestic output gap dependency on the EU output gap seems to be very low. Since the largest part of the period concerns the unstable transition period, this is not a surprising result. It is likely that in the future the dependency on the EU will increase. The share of backward looking firms seems to be considerable, particularly in Hungary, Lithuania and Bulgaria (over 50%). Taking the Gerberding (2001) argument into account for the CEECs, the high degree of forward-lookingness in the Czech and Slovak Republics, Latvia, Romania, Estonia, Poland and Slovenia implies more credible monetary policies than in the other CEECs considered. Comparing with the closed economy results in the previous subsection, we may conclude that monetary policy in the Slovak Republic, Romania, Poland and Slovenia seems to have been rather credible.

3.5 Simulation exercise

The workings of the estimated models can be further illustrated using simulations of the effects of macroeconomic shocks. The principal shocks in the models are demand and supply shocks. In the open-economy models one could in addition look at shocks to the three foreign variables, EU output, EU prices and the EU short-term interest rate. Here we concentrate our attention on the effects of supply shocks as they imply output-inflation trade-offs in a strict sense, thereby aggravating possible time-inconsistency problems. Demand shocks do not cause a direct trade-off between output and inflation as both move in the same direction after a demand shock; the only trade-offs that

	β	ϑ	φ	J-stat
Bulgaria	0.6727	0.6039	0.5888	9.0184
	(0.1720)	(0.0240)	(0.0664)	(0.62)
Czech Republic	0.9208	0.0179	0.2385	9.2072
	(0.0488)	(0.0052)	(0.0578)	(0.59)
Estonia	0.8373	0.0182	0.4099	8.1827
	(0.0796)	(0.0047)	(0.0495)	(0.70)
Hungary	0.8850	0.0150	0.6023	8.7152
	(0.4804)	(0.0061)	(0.1249)	(0.65)
Latvia	0.8149	0.0205	0.3191	8.5966
	(0.0990)	(0.0040)	(0.0664)	(0.66)
Lithuania	1.4331	0.0008	0.5923	9.4927
	(0.0604)	(0.0003)	(0.0431)	(0.58)
Poland	1.1312	0.0094	0.4307	10.3966
	(0.0619)	(0.0023)	(0.0833)	(0.49)
Romania	0.8672	0.1374	0.3681	8.0098
	(0.1426)	(0.0435)	(0.0676)	(0.71)
Slovak Republic	0.7808	0.1246	0.2986	9.8595
	(0.2428)	(0.0377)	(0.1099)	(0.54)
Slovenia	1.0118	0.0047	0.4829	8.9900
	(0.0494)	(0.0014)	(0.0515)	(0.62)

Table 5: GMM estimates for the hybrid open-economy New Keynesian model (Newey-West standard errors between parentheses)

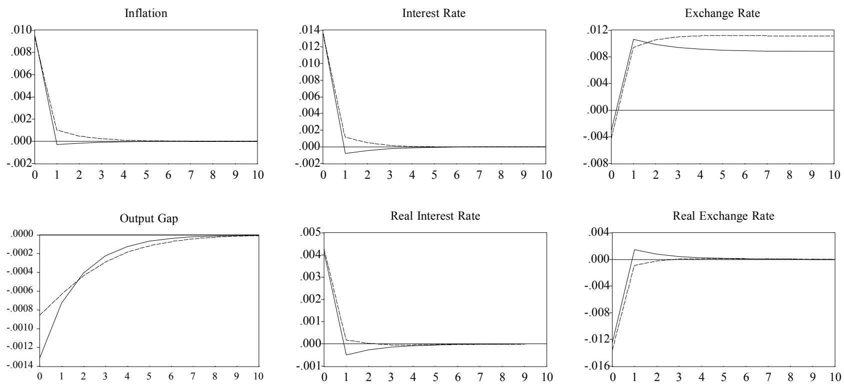
the policymaker faces in that case concerns how much stabilization now and how much at future points in time. A smaller adjustment effort today in that case is matched by more adjustment efforts during the remainder of the adjustment.

We analyze the effects induced by a temporary one percent supply shock in two cases: Hungary and Slovakia. To simulate, we take the estimates from the estimated hybrid open-economy models of Hungary and Slovakia, use the assumption mentioned above about the parameter values of a set of deep structural parameters. Finally, we assume a value for b (the important preference parameter of the monetary authority) of 0.5, implying as in much of the literature, a relatively inflation-averse monetary authority. From the empirical estimates in Table 5, it emerges that in Hungary price adjustments are probably more backward-looking than in Slovakia, whereas the Slovak economy is relatively more open.

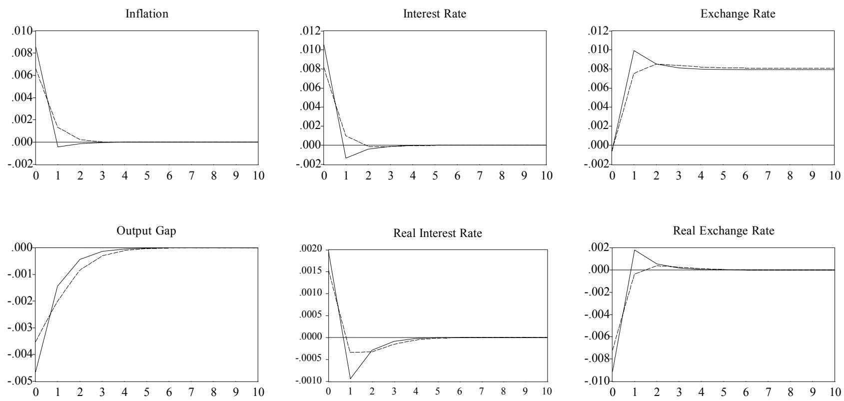
The supply shock takes the form of a transitory cost-push shock at t = 0, after which it dissipates, one could think of a temporary oil-price shock e.g. Figure 3 shows the effects of on the output gap, inflation, interest rates and the exchange rate.

The differences in outcomes between the discretionary regime and the commitment regime between countries are limited and only of a quantitative nature. The cost-push shock raises inflation, to which the monetary authorities react by setting a higher interest rate. Non-accommodation of the inflationary shock implies that also the real interest rate needs to be increased. In general, one expects that under discretion, policies are more aggressive, as a reflection of the "stabilization" bias, inherent to discretionary policymaking.[27] Here, the differences remain relatively small; in the Slovak case this effect is somewhat better discernible than in the Hungarian case. The

[27] Stochastic simulations of the models indicate that well-known results in the literature, necessarily also apply to our estimations. Lower output variability occurs under discretion than under commitment and higher inflation variability under discretion, reflecting the stabilization bias under discretion. Essentially, the ability of the monetary authority to commit to a future interest rate path, implies a delayed interest rate reaction in the future, inducing a smoother but also more protracted interest rate path under commitment than under discretion. The presence of such a short-run trade-off between output and inflation variability under cost-push inflation shocks also plays a decisive role in the final welfare comparison of both regimes. Lack of space prevented us from carrying out a more detailed analysis on these issues here.



(a) Hungary



(b) Slovakia

Figure 3: Cost-Push Shock in the Estimated Hybrid Open-Economy Model.(Note: solid lines denote the discretionary solution and dashed lines the commitment solution.)

uncovered interest parity condition implies that the exchange rate depreciates. As prices rise by more, the real exchange rate appreciates. Compared to the Hungarian case, the short-term output effects are more negative in Slovakia. On the other hand, its output recovers quicker in the medium run from the same shock than Hungary, partly because of a less strong real appreciation and lower real interest rate. The effects on nominal interest and exchange rates are relatively similar in both countries.

4 Concluding remarks

This paper studies different implications of alternative monetary policy regimes for small open economies as the EU-accession countries from Central and Eastern Europe, both from a theoretical and an empirical point of view. From a theoretical point of view, we studied dynamic versions of output gap and inflation equations based on direct generalizations of the standard closed-economy New Keynesian model with sticky (nominal) prices as described in Galí *et al.* (1999). The derivations of hybrid output gaps and inflation dynamics are presented as well in a closed-economy framework as in an open-economy one and implications of alternative monetary policy regimes as policy rules under discretion and commitment are discussed in such settings, where both forward- and backward-looking expectations are allowed.

From an empirical point of view, we consider each of the EU-accession CEECs as a small open economy being largely dependent on external shocks in an extended micro-founded New Keynesian setup. Our empirical estimations for the accession countries suggest that, during the transition phase, both forward- and backward-looking inflation expectations did significantly matter in these countries. Under a Leontief technology we observe that the proportion or degree of forward-looking firm behavior in the New Keynesian Phillips Curve ranges from 0.42 (Hungary) to 0.80 (Slovak Republic), so that the degree of forward-lookingness of firms strongly varies among CEECs. The Cobb-Douglas case also shows a dispersion across countries but the point estimates strongly differ (lowest is now Lithuania (0.44) and highest Romania (0.79)). The *ad hoc* hybrid model of Clarida *et al.* (1999) and the theoretically founded model of Galí *et al.* (2001) provide some robustness since the results are similar. In a related study, Gerberding (2001, p.23) argues that the estimated degree of forward-lookingness in a German Phillips curve is higher than in an Italian Phillips curve as German monetary policy was more credible. If this argument carries over to transition countries, we observe that the Slovak Republic, Romania, Slovenia, and Poland have shown a more credible monetary policy than the other CEECs considered. By contrast, Lithuania and the Czech Republic seemed to perform (significantly) worse in terms of past credibility. Of course, results have to be interpreted with caution since Gerberding's argument might not be valid for transition economies, e.g. because of different liberalization degrees during the sample period (1994-2002).

The open economy model revealed a very limited impact of EU-related variables. This result is likely to originate from the specific data-sample we use. The very specific nature of the transition period implies that macroeconomic performance in the countries under study were largely determined by the process of market installation and stabilization, rather than by external factors. As the relationship between these countries and the EU are both widening and deepening one can expect a rising quantitative impact of the EU. Related to this observation, there are not too large differences between the hybrid open-economy and closed-economy empirical results. This might imply that the estimated price-setting behavior is not strongly affected by changes in the terms of trade, introduced by considering open-economy aspects of firms' pricing decisions. This phenomenon reflects the existence of a sizeable degree of exchange rate pass-through implying a type of isomorphism between closed-economy and open-economy monetary policies. This observation is in agreement with recent empirical studies about the exchange rate pass-through in CEECs. A simulation exercise of the open-economy model for Hungary and the Slovak Republic suggests that the differences in outcomes both between regimes and between countries are limited and only of a quantitative nature.

Bearing in mind the limited sample and possible other data caveats relating to the transition context, we obtain a relatively robust impact of forward-looking expectations. This result is likely to become stronger as these countries are integrating in the EU and possibly become member of the EMU in the near future.

References

Arratibel, O., D. Rodríguez-Palenzuela and C. Thimann (2002), “Inflation Dynamics and Dual Inflation in Accession Countries: a ’New Keynesian’ Perspective”, ECB Working Paper no. 132

Calvo, G. (1983), “Staggered Prices in a Utility Maximizing Framework”, *Journal of Monetary Economics*, vol. 12, pp. 383-398

Caputo, R. (2003), “Habit Formation and its Implications for Small Open Economies”, mimeo, Cambridge University

Campa, M.J. and L.S. Goldberg (2002), "Exchange Rate Pass-Through into Import Prices: A Macro or Micro Phenomenon?"NBER Working Paper No. 8934

Choudhri, E.U., H. Faruqee, and D.S. Hakura (2002), "Explaining the Exchange Rate Pass-Through in Different Prices", IMF Working Paper No. 224

Clarida, R. (2001), “The Empirics of Monetary Policy Rules in Open Economies”, NBER Working Paper No. 8603

Clarida, R., J. Galí and M. Gertler (1999), “The Science of Monetary Policy: A New Keynesian Perspective”, *Journal of Economic Literature*, vol. 37, pp. 1661-1707

Clarida, R., J. Galí and M. Gertler (2001), “Optimal Monetary Policy in Open versus Closed Economies: An Integrated Approach”, *American Economic Review*, vol. 91, No. 2, pp. 248-252

Clarida, R., J. Galí and M. Gertler (2002), “A simple Framework for International Monetary Policy Analysis”, *Journal of Monetary Economics,* vol. 49, pp. 879-904

Coricelli, F., B. Jazbec, and I. Masten (2003), "Exchange Rate Pass-Through in Candidate Countries", CEPR Discussion Paper No. 3894

Darvas, Z. (2001), "Exchange Rate Pass-Through and Real Exchange Rate in EU Candidate Countries", Deutsche Bundesbank Discussion Paper No. 10

Davidson, R. and J. MacKinnon (1993), *Estimation and Inference in Econometrics*, Oxford University Press

Di Bartolomeo, G., B. Merlevede, J. Plasmans and B. Van Aarle (2003), “Monetary Policy Regimes with Hybrid Output Gap and Inflation Rates with an Application to EU-accession Countries”, mimeo

Domenech, R., L. Mayte, and T. David (2001), “A Small Forward-Looking Macroeconomic Model for EMU", Working Paper No. 0201, BBVA (Banco Bilbao Vizcaya Argentaria) Research Department.

Evans, G.W. and S. Honkapohja (2002a), “Expectations and the Stability Problem for Optimal Monetary Policies”, mimeo, Universities of Oregon and Helsinki, forthcoming in *Review of Economic Studies*

Evans, G.W. and S. Honkapohja (2002b), “Monetary Policy, Expectations and Commitment”, ECB Working Paper No. 124 and CEPR Discussion Paper No. 3434

Falcetti, E., Raiser, M. and P. Sanfey (2002), “Defying the Odds: Initial Conditions, Reforms, and Growth in the First Decade of Transition”, *Journal of Comparative Economics*, vol. 30, pp. 229-250

Fuhrer, J. and G. Moore (1995), ”Inflation Persistence”, *Quarterly Journal of Economics*, No. 440, p. 127-159

Galí, J. (2002), ”New Perspectives on Monetary Policy, Inflation, and the Business Cycle”, NBER Working Paper No. 8767

Galí, J. and M. Gertler (1999), “Inflation Dynamics: A Structural Economic Analysis”, *Journal of Monetary Economics*, vol. 44, pp. 195-222

Galí, J., M. Gertler and J.D. Lopez-Salido (2001), ”European Inflation Dynamics”, *European Economic Review*, vol. 45, pp. 1237-1270

Gaspar, V. and F. Smets (2002), "Monetary Policy, Price Stability and Output Gap Stabilisation", mimeo, ECB

Gerberding C. (2001), "The Information Content of Survey Data on Expected Price Developments for Monetary Policy", Discussion Paper No.9/01,Economic Research Centre of the Deutsche Bundesbank

Goldfajn, I. and S.R. Werlang (2000), "The Pass-Through from Depreciation to Inflation: A Panel Study", Banko Central do Brazil Working Paper No. 5

Jensen, H. (2002), "Targeting Nominal Income Growth or Inflation?", *American Economic Review*, vol. 92, pp. 928-956

Jondeau, E. and H. Le Bihan (2001), "Testing for a Forward-looking Phillips Curve. Additional Evidence from European and US Data", Notes d'Etudes et de Recherche, No. 86, Banque de France, Paris

Leith, C. and J. Malley (2002), ”Estimated General Equilibrium Models for the Evaluation of Monetary Policy in the US and Europe”, CESifo Working Paper No. 699(6)

Linde, J. (2002), "Estimating New-Keynesian Phillips Curves: A Full Information Maximum Likelihood Approach", Working Paper No 129, Central Bank of Sweden.

Lubik, T.A. and F. Schorfheide (2002), "Testing for Indeterminacy: An Application to U.S. Monetary Policy", mimeo, Johns Hopkins University and University of Pennsylvania

McCallum, B.T. (1999), “Issues in the Design of Monetary Policy Rules”, in *Handbook of Macroeconomics* edited by J.B. Taylor and M. Woodford, Amsterdam, North Holland

McCallum, B. and E. Nelson (1999), ”Nominal Income Targeting in an Open Economy”, *Journal of Monetary Economics*, vol. 43, pp. 553-578

Nelson, E. and B.T. McCallum (2000), "Timeless Perspective vs. Discretionary Monetary Policy in Forward-Looking Models", NBER Working Paper No. 7915

Newey, W. and K. West (1987), "A Simple Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix", *Econometrica*, vol. 55, pp. 703-708

Ruud, J. and K. Whelan (2001), "New Tests of the New-Keynesian Phillips Curve", Discussion Paper 2001-30, Federal Reserve Board.

Rudebusch, G. D. (2002), "Assessing Nominal Income Rules for Monetary Policy with Model and Data Uncertainty", *Economic Journal*, vol. 112, pp 402-432

Sbordone, A.M. (2002), “Prices and Unit Labor Costs: A New Test of Price Stickiness”, *Journal of Monetary Economics*, vol. 49, pp. 265-292

Smets, F. and R. Wouters (2002a), "Openness, Imperfect Exchange Rate Pass-Through and Monetary Policy", ECB Working Paper No. 128

Smets, F. and R. Wouters (2002b), "An estimated Stochastic Dynamic General Equilibrium Model of the Euro Area", ECB Working Paper No. 171

Smets, F. and R. Wouters (2003), "Output Gaps: Theory versus Practice", mimeo, ECB

Söderlind, P., U. Söderström, and A. Vredin (2002), "Can a Calibrated New-Keynesian Model of Monetary Policy Fit the Facts?", mimeo, Swiss Institute for Banking and Finance, St. Gallen

Svensson, L.E.O. (1999), "Inflation Targeting as a Monetary Policy Rule", *Journal of Monetary Economics,* vol. 43, pp. 607-654

Svensson, L.E.O. (2000), "Open Economy Inflation Targeting", *Journal of International Economics,* vol. 50, pp. 155-183

Taylor, J.B. (1993), "Discretion versus Policy Rules in Practice", *Carnegie-Rochester Conference Series of Public Policy*, vol. 39, pp. 195-214

Woodford, M. (1999a), "Optimal Monetary Policy Inertia", NBER Working Paper No. 7261

Woodford, M. (1999b), "Commentary: How should Monetary Policy be conducted in an Era of Price Stability?" in *New Challenges for Monetary Policy: A Symposium Sponsored by the Federal Reserve Bank of Kansas City*, Federal Reserve of Kansas City, pp. 277-316