FOR AGENDA

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July 31, 2008

To: Members of the Executive Board

From: The Secretary

Subject: **Hungary—Selected Issues**

This paper provides background information to the staff report on the 2008 Article IV consultation discussions with Hungary (SM/08/256, 7/30/08), which is tentatively scheduled for discussion on **Wednesday, September 17, 2008.** At the time of circulation of this paper to the Board, the Secretary's Department has received a communication from the authorities of Hungary indicating that they consent to the Fund's publication of this paper.

Questions may be referred to Mr. Joshi (ext. 34467) and Ms. Mitra (ext. 37056) in EUR.

Unless the Documents Section (ext. 36760) is otherwise notified, the document will be transmitted, in accordance with the procedures approved by the Executive Board and with the appropriate deletions, to the European Central Bank forthwith; to the WTO Secretariat on Friday, August 8, 2008; and to the European Bank for Reconstruction and Development, the European Commission, the European Investment Bank, the Food and Agriculture Organization, the Organisation for Economic Cooperation and Development, the United Nations Development Programme, and the World Food Programme, following its consideration by the Executive Board.

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INTERNATIONAL MONETARY FUND

HUNGARY

Selected Issues

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Approved by European Department

July 31, 2008

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A. Introduction

1. **Maintaining the recent progress in fiscal consolidation is an important challenge for Hungary**. The general government deficit has declined from 9¼ percent of GDP in 2006 to 5½ percent in 2007. Given Hungary's macroeconomic vulnerabilities, it remains critical that this consolidation continues apace and fiscal expansions that have characterized run-ups to elections in the past are avoided. Several important steps have indeed been taken to maintain the consolidation momentum, including improvements in budgetary procedures and management, and formal commitments in the context of the European Union's Excessive Deficit Procedure through successive Convergence Programs.

2. **The adoption of numerical fiscal rules such as those proposed in a draft fiscal responsibility package could be an important avenue to establish long-term fiscal discipline.** The package comprises three elements. A draft *Fiscal Responsibility Law* (FRL) sets numerical constraints on fiscal policy, including a requirement to stabilize central government debt in real terms, and the prohibition of primary deficits. The law also provides procedural guarantees (mandatory offsets of discretionary measures during the budget year), enhances transparency requirements, and specifies the tasks of a Legislative Budget Office entrusted to provide independent scrutiny of the budget. The law is backed by *constitutional changes* establishing fiscal sustainability as an overarching principle of government policy, guaranteeing the independence of the Legislative Budget Office, and giving the Office the responsibility to assess whether budget proposals are consistent with sustainability. Finally, amendments to the *Act on Local Governments* limit subnational entities' borrowing to a fraction of their capital expenditure. This new rules-based approach to budgetary policy follows the adoption of multi-year (indicative) expenditure ceilings with the 2008 budget.

3. **Recent literature has shown that the effectiveness of numerical fiscal rules ultimately depends on the existence of an underlying commitment to fiscal discipline.** Debrun and Kumar (2007) have argued that effective fiscal rules can be conceived either as *commitment devices* designed to tie policymakers' hands by increasing the cost of indiscipline (through an explicit enforcement mechanism), or as *signaling tools* meant to clarify policymakers' commitment (thereby rewarding a strong preference for fiscal discipline with lower risk premia). Hence, numerical fiscal rules could improve fiscal behavior not just because they penalize deviations from explicit targets (the "stick") but also because they

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[1] Prepared by Xavier Debrun (FAD) and Bikas Joshi (EUR). Without implication, thanks are due to Gábor Kiss (Magyar Nemzeti Bank), Balázs Romhányi (Hungarian Ministry of Finance), and IMF colleagues for insightful comments on earlier drafts of this paper.

reward discipline-minded policymakers (the "carrot"). In both cases, *effective* fiscal rules convey *credible* information on *future* fiscal policies, providing a distinct channel to affect borrowing costs beyond the direct impact of fiscal performance.

4. **This paper explores the impact of numerical fiscal rules on long-term interest rates, attempting to identify the effects of stronger fiscal performance and "pure" credibility.** A considerable but largely inconclusive literature has explored the relationship between fiscal performance and the level of interest rates. To the extent that numerical fiscal rules help improve current fiscal indicators, the adoption or the tightening of such rules may result in lower interest rates on government paper. The second effect arises because credible fiscal rules set explicit limits on *future* fiscal policies independently of contemporaneous fiscal performance. This effect could provide an *additional* channel for the decline in borrowing costs.

5. **The role of fiscal rules as a discipline-enhancing mechanism has triggered an extensive literature on the effectiveness of such arrangements**. A rapidly growing empirical literature has been looking at the effectiveness of *procedural rules*—i.e., rules that set out the legal framework for the preparation, execution, and ex post auditing of the budget—in enhancing fiscal discipline (e.g., Poterba and Von Hagen, 1999; von Hagen, 1992; Hallerberg et al. 2007; Fabrizio and Mody, 2006).[2] Sound budgetary procedures have been consistently found to be associated with stronger fiscal performance. Following the introduction of the Stability and Growth Pact, attention shifted to *numerical* fiscal rules, commonly defined as "a permanent constraint on fiscal policy, typically defined in terms of an indicator of overall fiscal performance" (Kopits and Symansky, 1998). Work on purely numerical rules remains limited due to the lack of comparable data across countries.[3] One exception is Debrun et al. (2008) who use a unique dataset of numerical fiscal rules based on a detailed survey among EU-25 member states (European Commission, 2006), and establish a strong and robust effect of fiscal rules on fiscal performance.

6. **The role of fiscal rules in determining long-term interest rates has received less attention**. Closest to the present analysis is the study by Hallerberg and Wolff (2006) examining the nexus between fiscal institutions and sovereign risk premia, with institutions very broadly defined. Focusing on the euro area, they find that the impact of conventional

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[2] The "fiscal rules" variables found in this literature are summary indices aimed at capturing the overall quality of budgetary procedures, including the role of numerical fiscal rules during the budget preparation stage (see, for instance, Fabrizio and Mody, 2006 and 2007).

[3] Indices measuring the quality of numerical vs. procedural rules partly overlap as the existence of numerical rules is a criterion for the quality of budget preparation.

fiscal indicators on sovereign spreads disappears once their institutional quality variable is introduced in the model. The latter has the expected negative sign and is statistically significant, suggesting that in the eyes of financial markets, good institutions are central in establishing the credibility of any commitment to fiscal discipline. Going beyond the Hallerberg and Wolff (2006) paper, this paper broadens the scope of the analysis to include ten new EU member states.[4] This paper also focuses on the credibility effect of *numerical fiscal rules*.

7. **The main findings of this paper are as follows**:

- The empirical analysis supports the view that introducing numerical fiscal rules (or tightening existing ones) tends to reduce yields on long-term government securities, either through a "pure" credibility effect, or through an induced improvement in fiscal indicators (cyclically adjusted primary balance and public debt).

- The credibility effect is more likely to be found in countries with a stronger record of good fiscal behavior and with budgetary procedures more conducive to an effective implementation of numerical fiscal rules. This suggests that financial markets do not take fiscal rules at face value, and that governments must demonstrate their willingness and ability to stick to the rules' objectives. Also, the existence of a strong credibility effect appears to weaken the relationship between current fiscal performance and interest rates, suggesting that credible rules convey more valuable information about fiscal policy than current fiscal indicators.

- No credibility effect could be identified in the full sample of EU-25 countries over the period 1990-2005. The adoption of a rules-based fiscal framework (or the tightening of existing rules) nevertheless affected long-term interest rates through its contribution to a stronger fiscal performance. On average, new or tighter fiscal rules led to an increase in the cyclically-adjusted primary balance (CAPB) by about 0.4 percent of GDP, yielding a reduction in the long-term interest rate by about 5 basis points on impact and 30 basis points in the longer term.

- Credibility effects could be identified in selected sub-samples. In these cases, the adoption of a rules-based fiscal framework (or the tightening of existing rules) yielded an average reduction in the long-term interest rate by 10 to 40 basis points on impact and by up to 65 basis points in the long run.

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[4] Reflecting limited data availability, the empirical model looks at the level of yields on long-term government paper instead of the sovereign spreads.

- Specific features of numerical fiscal rules appear essential for the strength of the credibility effect. They include a solid statutory basis, the presence of an independent body monitoring the rule's implementation, and an important role of the rule in the public debate on fiscal policy. There is also some evidence that the credibility of the enforcement procedure is stronger when the independent body plays an active role in the process.

8. **The paper is organized as follows**: The next section sets out the key features of the fiscal-rules indices used in this paper, and discusses stylized facts (Section B). The determinants of long-term government bond yields are then examined in Section C, replicating existing results in the current sample, and extending the analysis to test the robustness of the credibility effect to varying institutional and political fundamentals, and to some dimensions of budgetary procedures. To provide a consistent quantification of the fiscal-behavior and credibility effects, Section D provides simultaneous estimations of the interest rate equation along with a fiscal reaction function similar to Debrun et al. (2008). Section E concludes.

B. The Fiscal Rule Index

Construction of the Index

9. **Key to the present analysis is the availability of quantitative indices capturing the extent to which numerical fiscal rules are likely to promote fiscal discipline.** Constructing such indices raises a number of thorny issues. First, there is a great variety of numerical rules. They fall into four broad categories with potentially different effects of fiscal discipline: (i) *deficit rules*, which include balanced-budget rules, and deficit limits; (ii) *debt rules*, which place limits on gross or net public debt; (iii) *expenditure rules*, which impose ceilings on total spending (or spending growth in real or nominal terms) or on specific categories of spending; and (iv) *revenue rules*, which are generally meant to put a lid on the overall tax burden or to save unexpected revenue windfalls. Second, there is a need to identify precise criteria that allow discrimination between, for example, strict and loose enforcement procedures. Third, the scoring of individual dimensions and the aggregation of resulting scores are largely a matter of judgment.

10. **This paper uses a unique dataset focusing specifically on numerical fiscal rules at the national level in the European Union over the period 1990-2005.** Information comes from a survey conducted by the European Commission in 2006. National experts were asked to fill a detailed questionnaire for each fiscal rule introduced, changed or removed in their respective country between 1990 and 2005. On that basis, time-varying (annual frequency) quantitative fiscal rule indices were calculated.

11. **The database covers a wide range of numerical fiscal rules** with different characteristics in terms of the *fiscal target*, *legal status* (law or constitution, coalition agreement, etc.) and *sub-sector of general government* to which they apply (local and regional governments, central government, and social security). Hence, for each rule deemed consistent with the Kopits-Symansky definition (discussed in Section A), the database reflects information on (i) the fiscal aggregate targeted, the government sectors covered, the time frame, the statutory basis, the existence of escape clauses and the monitoring and enforcement procedures; (ii) the relevant dates for the elaboration and implementation of the rule and the main changes introduced over the period; (iii) assessment by national fiscal policy experts on the importance of the rule in the public debate (media visibility, public opinion impact). Information is available for 25 EU countries, although no numerical rule was found in Greece, Cyprus, and Malta.

12. **This paper uses a variant of the *Fiscal Rule Index (FRI)*** calculated by Debrun et al. (2008). The modified aggregate index used here does not incorporate information on expenditure and revenue rules because they are generally conceived as modalities for implementing objectives set out in terms of the budget balance or the public debt—such as a debt rule operationalized through multi-year expenditure ceilings. Doing so has the advantage that, unlike deficit caps, expenditure ceilings do not preclude the operation of automatic stabilizers on the revenue side, avoiding the pro-cyclical bent typically associated with deficit and debt rules (see Debrun, Epstein and Symansky, 2008). In this case, however, the motivation for introducing expenditure ceilings is not discipline per se, but the willingness to avoid destabilizing fiscal policies. Because the objective of this paper is to identify the potential impact of *numerical rules* on the perception of a credible commitment to fiscal discipline, it was felt important to narrow the focus on rules best able to convey such commitment is precise terms: budget balance and debt rules.

13. **Like the original FRI, the fiscal rule index used here—denoted FRI-2—combines the *coverage* of the rule** (i.e., the share of government budget subject to a certain rule, with each rule's weight proportional to the share of the general government it covers) **with an "index of strength"** summarizing the qualitative features of fiscal rules most likely to matter for their effectiveness. In the absence of obvious priors as to which types of rules have a greater influence on fiscal outcomes, the FRI-2 gives equal weight to all rules. The FRI-2 is also corrected for the possibility that different rules could apply to the same sub-sector of the general government, thereby avoiding a double-counting problem.

14. **The strength of the rule is assessed on the basis of four criteria.** The first is the *statutory basis* of the rule, the idea being that a legally binding or even constitutional rule will be less likely to be ignored or circumvented than a mere coalition agreement. The second relevant feature is the existence and nature of a specific *body in charge of monitoring* the rule. In that regard, it is often presumed that an independent agency could encourage compliance by raising the "reputational" or political costs of deviating from the rule. Third,

the existence and nature *of enforcement mechanisms*, including formal sanctions, should also matter. Finally, to the extent fiscal rules are public commitments on specific objectives, one would expect governments to be held accountable through the public debate on fiscal policy. In that regard, *media visibility* could play a significant role.

15. **Fiscal and macroeconomic data used in this paper come from various sources**. For data from the European Commission DG ECFIN AMECO database, Autumn 2006 vintage, only ESA95 fiscal numbers were considered to ensure consistency across countries (though at the cost of limiting the length of available time series in some of the newer member states). Other macroeconomic data are from the IMF's World Economic Outlook database. The long-term interest rate generally corresponds to the long-term government bond yield as reported in the IMF International Financial Statistics (line 61), whereas the short-term series mostly refers to the T-bill rate (IFS line 60c). When not available, the money market rate (IFS line 60b) was used in lieu of the T-bill rate. In some cases, the time series were lengthened using ratio-splicing of comparable series in IFS, AMECO and the OECD Economic Outlook database.

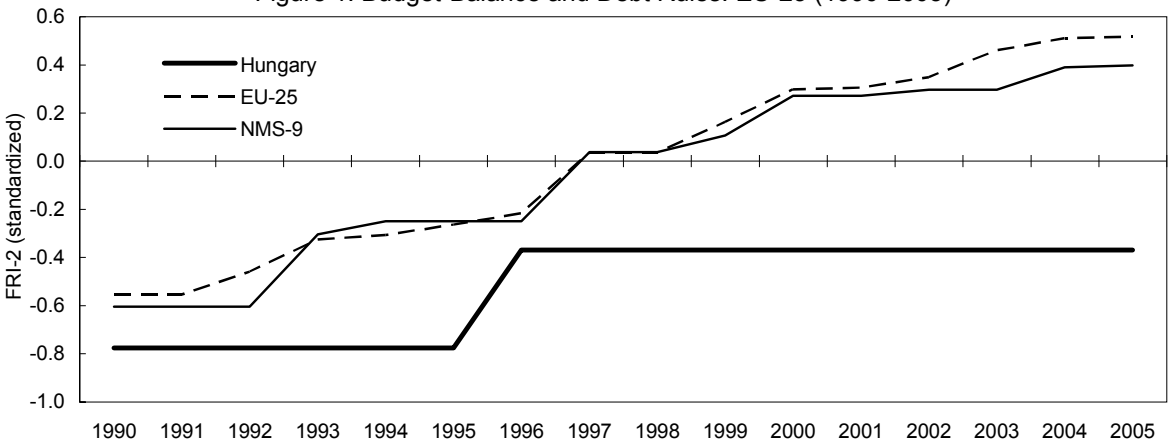
16. **The analysis also incorporates a number of political and institutional variables.** The political variables consist of an election dummy (set to equal 1 in years legislative elections take place), and a measure of the ideological range within a coalition, calculated as the difference between the two extreme ideological scores of parties in coalition governments (with a 0 if there is a single party government). The basic source for both variables is the World Bank Political Database (Beck et al., 2001; updated in 2005). To assess the extent to which a government is likely to give in to short term spending pressures, an index of government stability is also used; it spans between 0 and 12 and is compiled by the International Country Risk Guide (from the PRS Group, a consultancy). Finally, dummy variables capturing the model adopted for centralizing budgetary decisions—namely, "contract" and "delegation"[5]—are used from Annett (2006), who relies on Hallerberg (2004) and, for new EU member states, Ylaoutlinen (2004). Relevant data for Cyprus and Malta are not available, and since available data does not go beyond 2004, no change was assumed for 2005.

[5] The "delegation" model of budget centralization gives to the Finance Minister the power to bring demands from spending ministries in line with an overall budget envelope. In "contract" countries, centralization takes place through procedural rules. Political systems conducive to single-party (e.g., France, Spain, and the UK) or stable coalition governments are more likely to rely on delegation, whereas countries characterized by multiple-party coalitions (e.g., Belgium and the Netherlands) tend to rely on the contract approach to avoid endless bargaining over the budget. In general, the delegation model is thought to allow for greater leeway in the exercise of discretion.

Stylized Facts

17. **The appetite for numerical fiscal rules has increased dramatically since 1990.** Between 1990 and 2005, average fiscal rule indices for budget-balance and debt rules (the FRI-2) trended upward, in both the EU-25 as a whole and ten new member states. Hungary remained consistently below the average of the nine other new member states, and by 2005, the index for Hungary was about 1 standard deviation below that of the other new member states (Figure 1). The Hungary-specific index changed only once, in 1996, reflecting the introduction of a debt ceiling for local governments. It is likely that the adoption of the draft fiscal responsibility law would eliminate the gap with other EU countries.

Figure 1. Budget-Balance and Debt Rules: EU-25 (1990-2005)

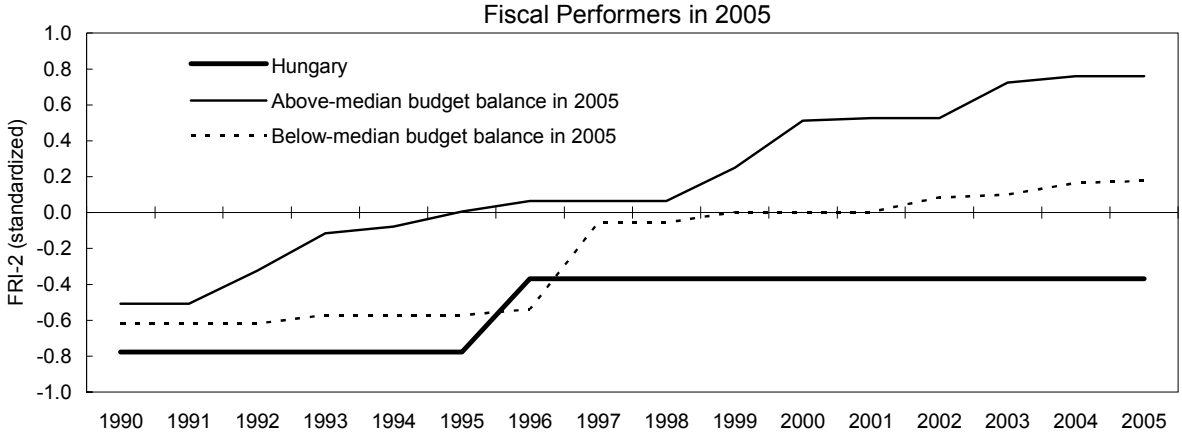


Sources: Debrun et al. (2008); and IMF staff calculations.

18. **In general, countries exhibiting a strong fiscal performance at the end of the period are those that have adopted more encompassing and stricter numerical rules since 1990**, as reflected in reflected in higher scores for the FRI-2 index. Figure 2 plots the time series of FRI-2 for two groups of countries: those with above-median and those with below-median fiscal balances at the end of 2005. Debrun et al. (2008) show a similar result for the original FRI (that includes revenue and expenditure rules).[6]

[6] Their econometric work suggests that beyond these simple correlations, stronger fiscal rules do *cause* stronger fiscal performance. However, they fail to establish a link between the strength of that relationship and specific dimensions of the rules that would be expected to increase the costs of violating the numerical targets. That puzzling result—which they attribute to the high correlation among individual sub-indices—could in part be due to the fact that the impact of numerical fiscal rules on fiscal behavior may also be related to the "carrot" of lower interest rates rather than to the "stick" of legal or political sanctions.

Figure 2. Budget-Balance and Debt Rules in Strong vs. Weak Fiscal Performers in 2005



Sources: Debrun et al. (2008); and IMF staff calculations.

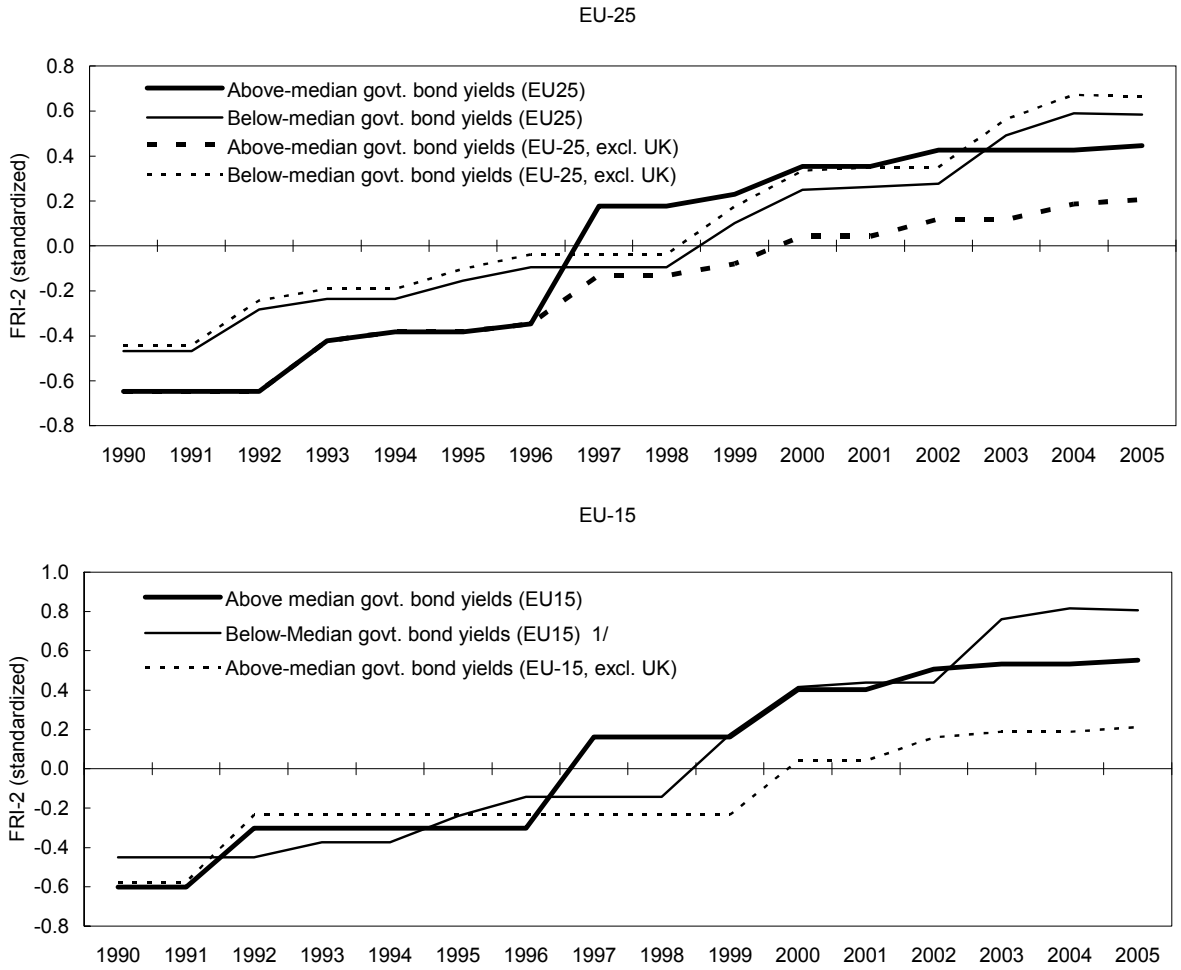
19. **In fact, governments facing lower borrowing costs at end-2005 were also those with the greater revealed preference for budget balance and debt rules over the period**. The group of countries with below-median long-term government bond in 2005 witnessed the sharpest increase in the FRI-2 index (Figure 3). That result holds for both EU-15 and EU-25 groups, and thus is not attributable to the lower credit ratings of many new member states in 2005.[7] The next section goes beyond these unconditional correlations, and investigates econometrically the link between government bond yields and numerical fiscal rules.

C. The Determinants of Long-Term Interest Rates

20. **This section uses econometric methods to quantify the fiscal-behavior and credibility effects on long-term government bond yields.** This is done by introducing a contemporaneous fiscal indicator and a fiscal rule index jointly in a conventional model of interest rate determination. After a brief discussion of the methodology (including its limitations), the basic results are presented. Overall, the credibility effect is found to be weak and imprecisely estimated. Re-estimating the model on selected sub-samples, the section then explores the possible determinants of credibility effect, pointing to a set of conditions under which it is more likely to exist.

[7] This correlation is much stronger when the UK is excluded.

Figure 3. Budget-Balance and Debt Rules in Countries with
High- vs. Low Long-Term Government Bond Yields in 2005



Sources: Debrun et al. (2008); and IMF staff calculations.
1/ The exclusion of the UK does not affect the median bond yield.

Methodology

21. **To assess the response of long-term interest rates to fiscal behavior and fiscal rules,** this paper postulates a single-equation model linking the yield on long-term government paper to fiscal policy indicators and conventional macroeconomic determinants of interest rates (Faini, 2006; and Ardagna, Caselli and Lane, 2007). The estimated coefficients of the fiscal indicators will identify the fiscal-behavior effect, whereas the credibility effect will be captured by the estimated coefficient of the fiscal rule index.

22. **The key economic assumption underlying the model is that the real interest rate moves to balance aggregate savings and investment**. The reduced-form specification derived from this assumption implies that the nominal interest rate depends on (expected)

inflation, economic activity, and fiscal policy indicators. To the extent that economic agents do not expect to repay the existing public debt in full with their own future tax money,[8] public debt should be retained as a fiscal indicator in the model, as it is partly perceived as private wealth and thus affects private saving decisions. Faini (2006) has argued that a flow indicator should also be present, primarily because forward-looking agents understand (i) the existence of a certain degree of persistence in the fiscal balance, and (ii) the link between the fiscal balance and public debt. This paper thus retains both the public debt and the cyclically adjusted primary balance (CAPB) as fiscal indicators affecting the level of long-term interest rates. To control for the effect of monetary policy and other financial developments, the short-term nominal interest rate is also used as an explanatory variable of long term rates. This is consistent with the expectations theory of interest rates—that long-term rates are determined by future expected short rates—and helps enhance the reduced-form interpretation of the model, ensuring that the estimated effects are properly identified and unbiased.

23. **The interest rate equations are estimated on a panel of 25 European Union member states described in Section B.** Standard statistical tests indicate that country-specific dummies (fixed effects) are required, as they help alleviate concerns about omitted cross-country determinants of long-term interest rates. Time dummies reflecting specific EU-integration related events (such as accession of new member states and introduction of the Stability and Growth Pact) and parliamentary elections are also introduced.[9] Finally, all estimated equations include one lag of the dependent variable, as the long-term interest rates exhibit significant persistence in this sample.

Results

24. **Baseline results for the fiscal behavior effect are broadly in line with existing literature**, showing a small but significant effect of the CAPB on long-term interest rates. The first column of Table 1 replicates the parsimonious, linear specification proposed by Ardagna, Caselli and Lane (2007). It indicates that, all else equal, an improvement in the CAPB by one percentage point of potential GDP entails an instantaneous cut in long term interest rates by about 10 basis points. Factoring in persistence, the same permanent improvement in the CAPB will ultimately yield a reduction of long-term rates by 17 basis

[8] The assumption that economic agents are not perfectly Ricardian is a routine feature of macroeconomic analysis of fiscal policy.

[9] Panel unit root tests—reported in the Appendix—indicate that only a subset of explanatory variables are I(1) whereas long-term interest rates are found to be stationary, precluding the existence of a cointegrating vector.

points.[10] In contrast, public debt does not appear to have any direct impact on long-term yields (Table 1, columns 1 and 2). However, the fiscal-behavior effect appears to vanish when political variables (government stability and the ideological range of the governing coalition) are taken into account (Table 1, column 3). This is a strong indication that financial markets participants look beyond observed fiscal performance and consider deeper factors likely to influence the commitment to fiscal discipline.[11] To focus on the original contribution of this paper, the rest of the analysis in this section looks only at the credibility effect.

25. **The pure credibility effect is found to be quantitatively small and imprecisely estimated.** An average increase in the FRI-2—pointing to more encompassing and stricter fiscal rules—entails a reduction in long-term government bond yields in the range of 5 to 15 basis points on impact (15 to 35 basis points in the long run), all else being equal. To understand these results, it is important to note that the panel fixed effect estimation assumes that the same statistical model can explain the evolution of long-term rates over time in all countries in the sample. The lack of statistical precision thus suggests either that the credibility effect associated with fiscal rules is indeed weak or non-existent in the EU, or that it is contingent on factors and condition that may vary across countries and/or over time.

26. **While EU-related developments did not seem to affect long-term rates, domestic politics have had a statistically significant and quantitatively large impact on long-term government bond yields.** In particular, indicators of perceived government stability and ideological cohesion of governing coalitions—an indicator of enduring government stability—are valued by financial markets. For instance, an average improvement in the government stability index yields a 25 basis points reduction on impact (50 basis points in the long-run if the improvement is permanent). In contrast, long-term interest rates do not seem to respond to elections, which is be expected because their impact on fiscal performance is only temporary.

27. **This analysis is, of course, subject to a number of caveats**. The underlying assumption that the same model of interest rate determination is valid for all countries in the panel can obviously be questioned. Also, the likelihood of structural breaks during 1990-2005, the most notable one being the introduction of the euro, appears elevated. The next sub-section explores the impact of cross-country heterogeneity on the results by re-estimating the model on selected sub-samples. This exercise provides useful information on elements likely to affect the strength of the credibility effect.

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[10] The long-term effect is equal to the estimated coefficient of the CAPB divided by one minus the estimated coefficient of the lagged dependent variable.

[11] The results are similar across two conventional estimators: panel fixed effects, and Generalized Method of Moments (Arellano-Bond). The latter estimator (Columns 4 to 6 in Table 1) addresses a possible bias present in fixed-effects estimation of dynamic models.

Table 1. Determinants of Long-Term Interest Rates in the EU-25 (1990–2005)

Estimator:	Fixed effects			Arellano-Bond		
	(1)	(2)	(3)	(4)	(5)	(6)
Long-term interest rate (lagged)	0.46 ***	0.45 ***	0.53 ***	0.45 ***	0.45 ***	0.56 ***
	(5.81)	(5.45)	(6.63)	(5.31)	(5.17)	(8.43)
Short-term interest rate	0.42 ***	0.41 ***	0.28 ***	0.42 ***	0.41 ***	0.22 ***
	(5.46)	(5.44)	(4.43)	(4.75)	(4.73)	(3.44)
Cyclically-adjusted primary balance	-0.09 ***	-0.09 **	-0.04	-0.09 ***	-0.09 **	-0.02
	(-2.77)	(-2.49)	(-1.07)	(-2.61)	(-2.33)	(-0.51)
Public debt (lagged)	0.00	0.00	0.00	0.01	0.00	0.00
	(0.70)	(0.79)	(0.80)	(0.73)	(0.56)	(0.32)
Real GDP growth	0.09 **	0.09 **	0.09 ***	0.10 **	0.00	0.13 ***
	(2.54)	(2.56)	(2.89)	(2.38)	(0.09)	(2.94)
Inflation	0.05	0.06	0.14	0.08	0.08	0.23 **
	(0.84)	(0.91)	(1.52)	(0.96)	(1.00)	(2.28)
Enlargement (dummy)	…	…	0.18	…	…	0.08
			(0.56)			(0.23)
Election year (dummy)	…	…	0.24	…	…	0.28
			(1.18)			(1.38)
Stability and Growth Pact (dummy)	…	…	0.19	…	…	0.29
			(0.92)			(1.29)
Government stability	…	…	-0.14 **	…	…	-0.16 **
			(-2.49)			(-2.35)
Ideological range of governing coalition	…	…	0.07 **	…	…	0.07
			(2.13)			(1.26)
Fiscal Rule Index	…	**-0.08**	**-0.06**	…	**-0.07**	**-0.15**
		(-0.92)	**(-0.70)**		**(-0.58)**	**(-1.29)**
R squared (within)	0.89	0.89	0.89	…	…	…
Number of observations	285	285	252	260	260	227
Number of countries	25	25	25	25	25	25
Test for 2nd order autocorrelation (p-value) 1/	…	…	…	0.14	0.13	0.37
Sargan test (p-value) 2/	…	…	…	1.00	1.00	1.00

Note: The t-statistics are reported in parentheses (with superscripts *, **, and *** denoting statistical significance at the 10, 5 and 1 percent levels respectively). They are robust to cross-sectional heteroskedasticity. All models include a constant and country effects (not reported). The latter are jointly significant at conventional confidence levels in all equations. The enlargement dummy is equal to 1 for new member states, after they joined the EU. The SGP dummy is equal to 1 for euro area member states after 1998.

1/ Arellano-Bond test of the null hypothesis of no autocorrelation of residuals.

2/ Test of the null hypothesis that identifying restrictions are valid.

Sensitivity Analysis: Exploring the Determinants of the Credibility Effect

28. **Running econometric regressions on different sub-samples allows examinations of the sensitivity of the estimated coefficients (and in particular the credibility effect) to different dimensions of the panel**. The overall sample was split into various sets of two sub-samples: EU-15 and new member states, euro area observations (starting in 1999 for the 11 original member states plus Greece) and non-euro area observations, high-debt (above 60 percent of GDP) and low-debt observations, and "delegation" model of budget centralization and other models (mostly "commitment").

29. **The credibility effect seems to be contingent on a number of factors**—country-specific ones, such as the nature of the budget centralization model; and fundamental regime shifts, such as joining the euro area (Table 2). The estimated coefficient on the fiscal rules index is indeed statistically significant in a fair number of sub-samples.[12] The immediate negative impact of an average "tightening" of the fiscal rules framework on the long-term interest rate varies between 10 and 40 basis points, while in the long run, a permanent shift to stricter and more encompassing fiscal rules indicates a reduction in long-term government bond yields of up to 65 basis points.

30. **Looking more specifically at the conditions that appear conducive to a significant credibility effect,** the results in Table 2 point to the following conclusions:

- ***There is some evidence that credibility effects are more likely among older EU member states (EU 15) and members of the euro area.*** [13] This may point to the fact that countries with a longer record of fiscal behavior and generally stronger institutional fundamentals are more likely enjoy a credibility effect when introducing numerical fiscal rules at the national level. However, that effect does not exceed 10 basis points and is only marginally significant in statistical terms. This may reflect a realization that euro area member states are subject to the full extent of the corrective arm of the Stability and Growth Pact; for these countries, the Pact would tend to overshadow the effect of national rules.

- ***Countries with excessive public debt do not seem to experience any credibility effect associated with numerical fiscal rules.*** Again, this may be indicating that numerical rules at the national level are less likely to be credible in countries with a significant record of past fiscal profligacy (as reflected in their high debt ratio). Such record

[12] Although the specification of column 6 in Table 1 is used as a baseline, some control variables had to be dropped in a number of cases, reflecting either perfect collinearity or aberrant results.

[13] Cyprus, Malta, and Slovenia were not members of the euro area during the period covered by our sample.

Table 2. Determinants of Long-Term Interest Rates in the EU-25 (1990–2005): Selected Sub-Samples

Estimator:	Arellano-Bond								Fixed effects 1/	
	EU-15	Non-EU15	Euro	Non-euro	High debt	Low debt	Delegation	No delegation	Stable gov.	Unstable gov.
Long-term interest rate (lagged)	0.55 ***	0.35 ***	-0.11	0.53 ***	0.47 ***	0.31 ***	0.39 ***	0.39 ***	0.56 ***	0.13
	(8.77)	(4.26)	(-1.44)	(5.67)	(9.98)	(6.35)	(4.52)	(4.58)	(6.41)	(1.53)
Short-term interest rate	0.26 ***	0.58 ***	0.50 ***	0.23 ***	0.26 ***	0.50 ***	0.40 ***	0.23 ***	0.12	0.43 ***
	(4.23)	(16.99)	(10.52)	(3.07)	(11.32)	(13.49)	(4.29)	(2.56)	(0.92)	(6.93)
Cyclically-adjusted primary balance	-0.08 **	-0.01	0.00	-0.03	-0.07 *	-0.04	-0.07	-0.05	0.03	-0.04
	(-2.44)	(-0.03)	(-0.26)	(-0.39)	(-1.77)	(-0.82)	(-1.34)	(-0.88)	(0.56)	(-0.72)
Public debt (lagged)	0.01	0.00	-0.01	0.00	0.01	0.00	0.02 **	0.01	0.00	0.01
	(0.73)	(0.22)	(-0.85)	(0.27)	(0.46)	(0.08)	(2.04)	(0.61)	(-0.29)	(0.88)
Real GDP growth	0.13 ***	-0.01	0.04 **	0.11 **	0.26 ***	0.04	0.06 **	0.09	0.07	0.11 *
	(3.04)	(-0.06)	(2.14)	(2.38)	(4.29)	(0.91)	(1.93)	(1.39)	(1.63)	(1.80)
Inflation	0.22 **	-0.07 *	0.11 **	0.22 *	0.45 ***	-0.04	0.01	0.33 ***	0.26 *	0.09
	(2.10)	(-1.77)	(2.12)	(1.92)	(4.22)	(-1.07)	(0.17)	(2.70)	(1.88)	(1.18)
Enlargement (dummy)	…	…	…	0.03	…	…	…	-0.61	…	…
				(0.07)				(-1.40)		
Election year (dummy)	…	…	0.08 **	0.38	…	…	0.26	0.28	0.47 *	0.02
			(2.17)	(1.40)			(1.48)	(1.00)	(1.76)	(0.11)
Stability and Growth Pact (dummy)	…	…	…	…	…	…	…	-0.29	0.13	-0.96 **
								(-1.30)	(0.56)	(-2.13)
Government stability	…	…	-0.03 **	-0.17 *	-0.21 ***	0.03	-0.18 ***	-0.16	0.14	-0.08
			(-1.89)	(-1.85)	(-3.75)	(0.24)	(-3.69)	(-1.61)	(0.59)	(-1.19)
Ideological range of governing coalition	…	…	-0.02	0.13 *	…	…	-0.14	0.11 ***	0.10	0.15
			(-1.53)	(1.90)			(-1.42)	(2.71)	(1.52)	(1.65)
Fiscal Rule Index	**-0.16**	**0.10**	**-0.09 ***	**-0.16**	**-0.17**	**-0.31 ** **	**-0.10**	**-0.41 ** **	**-0.06**	**-0.43**
	(-1.58)	**(0.10)**	**(-1.63)**	**(-0.93)**	**(-1.37)**	**(-2.48)**	**(-1.06)**	**(-2.03)**	**(-0.50)**	**(-1.59)**
Number of observations	213	47	72	155	107	153	72	148	148	104
Number of countries	15	10	12	25	15	22	9	19	24	21
Test for 2nd order autocorrelation (p-value) 2/	0.93	0.16	0.10	0.38	0.25	0.21	0.55	0.45	…	…
Sargan test (p-value) 3/	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	…	…

Note: The t-statistics are reported in parentheses (with superscripts *, **, and *** denoting statistical significance at the 10, 5 and 1 percent levels respectively). They are robust to cross-sectional heteroskedasticity. All models include a constant and country effects (not reported). The latter are jointly significant at conventional confidence levels in all equations. The enlargement dummy is equal to 1 for new member states, after they joined the EU. The SGP dummy is equal to 1 for euro area member states after 1998.
1/ Arellano-Bond estimation could not be obtained for one of the subsamples (lagged dependent variable highly insignificant and evidence of second-order autocorrelation). The comparison is thus based on fixed-effects estimates.
2/ Arellano-Bond test of the null hypothesis of no autocorrelation of residuals.
3/ Test of the null hypothesis that identifying restrictions are valid.

could reflect an absence of genuine commitment to discipline. In contrast, countries that maintain public debt ratios below 60 percent of GDP enjoy a fairly significant credibility effect: 30 basis points on impact and 45 basis points in the long run for an average tightening of the fiscal rule index observed over the period.

The model of budget centralization seems to play a determining role in the existence of a credibility effect. Specifically, countries that do not rely on the delegation model of centralization experience a particularly large credibility effect. This would suggest that when the finance minister is given discretion in setting the overall budgetary envelope, numerical fiscal rules are not believed to provide a credible anchor. Indeed, the delegation approach leaves substantial room for discretion and political bargaining during budget preparation, which may ultimately weaken the influence of pre-set numerical targets on fiscal behavior. By contrast, countries using procedural rules for budget preparation (the so-called commitment model) may find it easier to enforce numerical targets.

- ***There is some evidence that the adoption of numerical fiscal rules contributes to lower long-term interest rates in politically less stable countries.***[14] The last column of Table 2 shows that both the SGP (for euro area member states) and the fiscal rule index (capturing national rules only) have a negative effect on long-term rates. The latter is not precisely estimated, but omitting the SGP dummy in the regression makes the fiscal rule index highly significant. Hence, in the euro area, the SGP may overshadow the disciplinary effect of national fiscal rules. More broadly, the large credibility effect of fiscal rules in countries with less stable governments could be related to the importance of the budgetary centralization model. In the same way as countries with coalition governments prefer procedural rules to enforce discipline on spending ministries (avoiding paralyzing negotiations), numerical fiscal rules may be perceived as more likely to be effective anchors of fiscal discipline in politically less stable countries. One reason is that rules, especially if they have a statutory or constitutional basis, can tie all political parties to a certain standard of fiscal discipline regardless of the turnover rate of cabinets.

Does the Credibility Effect Depend on the Design of Fiscal Rules?

31. **The observed heterogeneity in the estimates of the credibility effect could also be because only specific dimensions of the rules matter** so that the use of aggregate indices may mask these effects. As already discussed in Section B, numerical fiscal rules may differ

[14] The median value of the government stability index is used to discriminate between observations corresponding to episodes with more or with less government stability.

in critical dimensions potentially affecting their effectiveness, such as their statutory basis, or features of the enforcement procedure. Debrun et al. (2008) have calculated a variety of meaningful sub-indices giving a greater weight to these specific dimensions, but these indices exist only for the overall fiscal rule index (which includes expenditure and revenue rules). Table 3 below shows the credibility effect associated with sub-indices of the overall fiscal rule index for a sub-sample including observations corresponding to a public debt of less than 60 percent of GDP.[15] The specification of column 6 in Table 1 was again used as the baseline, this time including an expenditure rule index to try to take into account the adverse impact of the latter on estimates of the credibility effect (see memorandum items).

Table 3. Impact of the Fiscal Rules on Long-Term Interest Rates: Specific Features of the Rule (EU-25, 1990–2005, Non-Excessive Public Debt)

Specific dimensions of fiscal rules as captured by sub-indices:	
Statutory basis	-0.47 **
	(-2.07)
Independent body monitoring the rule's implementation	-0.48 **
	(-2.07)
Independent body contributing to rule's enforcement	-0.52 **
	(-2.01)
Strength of enforcement procedure	-0.40 **
	(-2.03)
Media impact of the rule	-0.47 **
	(-2.23)
Memorandum items:	
Overall fiscal rule index	-0.45 **
	(-2.09)
Expenditure rule index	0.05
	(0.29)

Notes: The t-statistics are reported in parentheses (with superscripts *, **, and *** denoting statistical significance at the 10, 5 and 1 percent levels respectively). Given that subindices are only available for the overall fiscal rule index and the expenditure rule index, the results, obtained with model (6) in Table 1, use the overall index but control for the effect of expenditure rules.

32. **The credibility effect appears to respond with equal strength to each of the key features of the fiscal framework.** In particular, credibility depends on the statutory basis of the rule, with a rule enshrined in the Constitution contributing more to credibility than a coalition agreement, its impact on the public debate (through the media), and the presence of an independent body in charge of monitoring its implementation. The possibility for such independent body to also play a role in the enforcement procedure seems to have a somewhat

[15] Similar results were obtained using alternative sub-samples for which the credibility effect was found to be significant.

greater impact on credibility than other dimensions of the enforcement procedure, although the difference ($0.12 = 0.52 - 0.40$) remains within the margin of error.

D. Fiscal Behavior Effect

33. **This section provides a quantitative estimate of the fiscal behavior effect and assesses its sensitivity to the presence of a credibility effect.** The evidence so far points to two key results. First, in the absence of any credibility effect, fiscal rules could still influence long-term rates through their impact on fiscal behavior. Specifically, lower public debt and higher primary balance could contribute to lower interest rates. The second result is that the existence of a credibility effect is generally associated with an insignificant impact of current fiscal indicators on long-term interest rates.

34. **One issue is that the estimation techniques used so far do not specifically address the possibility of a statistical bias that could underestimate the role of fiscal indicators**. The potential problem arises from the fact that interest rate shocks may trigger a systematic fiscal policy response, e.g., to stabilize public debt dynamics and contain interest payments. Such reverse causality—running from interest rates to fiscal policy—would lead to an underestimation of the coefficients on fiscal indicators in the interest rate equation, making the discovery of both credibility and fiscal behavior effects less likely. To explore this, the interest rate model is estimated jointly with a fiscal "reaction function" similar to Debrun et al. (2008). Joint estimation should not only increase the precision of estimated coefficients—because it uses information on the shocks that may simultaneously affect interest rates and the fiscal indicators (CAPB and public debt)—but also address the simultaneity bias discussed above.

35. **These estimates allow quantification of the fiscal behavior effect** (Table 4, columns 1 and 2). Using the full sample, the adoption of a rules-based fiscal framework (or the tightening of existing rules) is associated with an average improvement in the CAPB by about 0.4 percent of potential GDP in the short-term and by about 1 percent in the long term. As the CAPB is found to affect long-term interest rates, the fiscal behavior effect is about 5 basis points ($0.42 \times (-0.13)$) on impact, and rising to about 30 basis points in the long term.

36. **Focusing on non-excessive debt observations (a sub-sample in which a credibility effect seems to exist), the fiscal rule index is also found to exert a strong positive influence on the CAPB.** Column 4 of Table 4 indicates that an average increase in the fiscal rule index is associated with a ½ percent of GDP improvement in the cyclically adjusted primary balance. The role of parliamentary elections in worsening fiscal performance is also remarkable. The results are generally robust to various econometric techniques that account for simultaneous shocks affecting interest rates and fiscal behavior (seemingly unrelated

Table 4: Determinants of Long-Term Interest Rates and Cyclically Adjusted Primary Balances (EU-25, 1990–2005)

	Full sample		Non-excessive public debt					
	3SLS, FE		Panel, FE		SURE, FE		3SLS, FE	
	Long-term interest rate	Cyclically adj. primary balance	Long-term interest rate	Cyclically adj. primary balance	Long-term interest rate	Cyclically adj. primary balance	Long-term interest rate	Cyclically adj. primary balance
	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)
Long-term interest rate (lagged)	0.57 ***	…	0.31 **	…	0.34 ***	…	0.34 ***	…
	(10.90)		(2.18)		(2.83)		(2.86)	
Short-term interest rate	0.21 ***	...	0.36 ***	...	0.31 ***	...	0.32 ***	...
	(5.23)		(3.19)		(3.96)		(3.94)	
Cyclically-adjusted primary balance	-0.13 **	…	0.01	...	-0.04	...	-0.13	...
	(-2.17)		(0.15)		(-0.63)		(-1.13)	
Public debt (lagged)	0.01 *	0.03 ***	0.01 *	0.05 **	0.02	0.05 ***	0.03 *	0.06 ***
	(1.77)	(3.68)	(1.75)	(2.41)	(1.52)	(2.84)	(1.68)	(3.19)
Real GDP growth	0.07 ***	...	0.04 **	...	0.02	...	0.02	0.01
	(2.53)		(0.91)		(0.55)		(0.60)	(0.21)
Real GDP growth (lagged)	…	0.03	…	0.01	…	0.00		0.00
		(0.78)		(0.30)		(0.08)		(0.21)
Inflation	0.15 ***	...	0.08	...	0.09	...	0.08	…
	(3.13)		(0.73)		(1.23)		(1.19)	
Enlargement (dummy)	0.25	0.86 *	-0.11	0.80	-0.14	0.81	-0.02	0.72
	(0.65)	(1.70)	(-0.24)	(1.60)	(-0.26)	(1.41)	(-0.04)	(1.26)
Election year (dummy)	0.2	-0.57 ***	0.38	-0.59 ***	0.32	-0.61 ***	0.27	-0.61 ***
	(1.49)	(-3.18)	(1.07)	(-2.66)	(1.61)	(2.61)	(1.30)	(-2.59)
Stability and Growth Pact (dummy)	0.18	-0.27	-0.48	0.08	-0.42	0.07	-0.39	-0.25
	(0.91)	(-1.03)	(-1.33)	(0.16)	(-1.14)	(0.16)	(-1.06)	(-0.72)
Government stability	-0.12 **	0.09	-0.06	0.04	-0.07	-0.01	-0.06	-0.06
	(-2.32)	(1.44)	(0.53)	(0.43)	(-0.88)	(-0.13)	(-0.74)	(-0.63)
Ideological range of governing coalition	0.05	-0.08	0.14	0.29 *	0.08	0.28	0.13	0.28
	(0.81)	(-0.94)	(0.70)	(1.87)	(0.41)	(1.30)	(0.64)	(1.31)
Lagged Cyclically adjusted primary balance	…	0.59 ***	...	0.50 ***	...	0.52	…	0.50 ***
		(12.45)		(6.90)		(7.71)		(7.51)
Fiscal Rule Index	**0.04**	**0.42 *** **	**-0.37 ** **	**0.54 *** **	**-0.30 ** **	**0.56 *** **	**-0.22**	**0.53 *** **
	(0.40)	**(3.06)**	**(-2.22)**	**(2.85)**	**(-1.95)**	**(3.25)**	**(-1.26)**	**(3.07)**
R-squared	0.91	0.82	0.79	0.51	0.85	0.80	0.85	0.80
Number of observations	239	239	146	156	138	138	138	138
Number of countries	25	25	22	22	22	22	22	22

Note: The t-statistics are reported in parentheses (* denotes significance at 10%, ** significance at 5%, and *** significance at 1%). All models include a constant (not reported).

regressions—SURE—proposed by Zellner, 1962), and for the possibility of causality running from interest rates to fiscal behavior (three-stage least squares, 3SLS).

37. **Turning to the determinants of interest rates determinants, fiscal indicators seem to have a greater influence when simultaneous shocks and reverse causality are taken into account** (using the 3SLS methodology). The coefficient on the CAPB is quantitatively larger—pointing to some reverse causality—but remains statistically insignificant. The public debt now also has some influence on long-term interest rates (about 3 basis points for each percentage point of GDP). However, the 3SLS estimate of the credibility effect is now imprecise and quantitatively smaller.

38. **On balance, these additional results suggest that long-term interest rates could respond to both current performance and expected future behavior**—as guided by numerical fiscal rules. The sample used here, however, does not allow disentangling the two effects. This difficulty may reflect the fact numerical fiscal rules are relatively recent in many European countries, and that, as other results in this paper suggests, credibility builds on a track record consistent with an underlying commitment to fiscal discipline.

E. Conclusions

39. **Fiscal rules do not unconditionally deliver lower interest rates.** The introduction of new numerical fiscal rules (or tightening of existing ones) reduces yields on long-term government bonds, either through a credibility effect, or through the influence of rules on current fiscal performance. These effects are hard to disentangle and sensitive to country-specific conditions, including features of existing fiscal institutions and budgetary procedures, and the level of the public debt. This suggests that financial markets do not take rules at face value, and that governments must demonstrate their ability and willingness to stick to the rules.

40. **The econometric evidence shows that the existence of a credibility effect weakens the influence of current fiscal indicators on long-term interest rates.** Some estimates discussed in this paper imply that a credible tightening of fiscal rules can on average yield an immediate reduction in long-term government bond yields by 10 to 40 basis points. Taking into account interest rate persistence and assuming a permanent tightening of fiscal rules, that number could reach 65 basis points in the long run.

41. **While no uniform credibility effect could be identified across EU-25 countries, fiscal rules at the national level could affect long-term interest rates through stronger fiscal performance.** On average, new or tighter fiscal rules are estimated to lead to an increase in the cyclically-adjusted primary balance (CAPB) by about 0.4 percent of potential GDP in the short term and 1 percent over the longer term. This would result in an average

reduction in long-term interest rates by about 5 basis points on impact and 30 basis points in the longer term.

42. **A number of specific features of a fiscal rule are key for its credibility**. They include a solid statutory basis, an important role of the rule in shaping the public debate on fiscal policy, and the presence of an independent body monitoring the rule's implementation. The credibility of the enforcement procedure also seems to be stronger when the independent body plays an active role in the process.

APPENDIX

Table A1. Panel Unit Root Tests

(p-value of Fisher test for unbalanced panel; H0=unit root)	
Long-term interest rate	0.007 ***
Short-term interest rate	0.000 ***
Cyclically-adjusted primary balance	0.005 ***
Fiscal rule index (overall)	0.451
Fiscal rule index (budget balance and debt)	1.000
Fiscal rule index (expenditure only)	1.000
Real GDP growth	0.000 ***
Government stability	0.157
Public debt-to-GDP ratio	0.941
Inflation	0.000 ***

REFERENCES

Annett, Anthony, 2006, "Enforcement and the Stability and Growth Pact: How fiscal policy did and did not change under Europe's fiscal framework," IMF Working Paper No. 06/116 (Washington: International Monetary Fund).

Ardagna, Silvia, Francesco Caselli, and Timothy Lane, 2007, "Fiscal Discipline and the Cost of Public Debt Service: Some Estimates for OECD Countries," *The B.E. Journal of Macroeconomics*, Vol. 7, Issue 1, Article 28, available online at http://www.bepress.com/bejm/vol7/iss1/art28.

Beck, Thorsten, George Clarke, Alberto Groff, Philip Keefer and Patrick Walsh, 2001, "New tools in comparative political economy: The Database of Political Institutions," *World Bank Economic Review*, Vol. 15, Issue 1, pp. 165-176.

Debrun, Xavier, and Manmohan S. Kumar, 2007, "Fiscal Rules, Fiscal Councils and All That: Commitment Devices, Signaling Tools or Smokescreens?" Proceedings of the 9th Banca d'Italia Workshop on Public Finance, Perugia, March 2007.

Debrun, Xavier, Natan Epstein and Steven Symansky, 2008, "A New Fiscal Rule: Should Israel 'Go Swiss'?" IMF Working Paper, No 08/87, (Washington: International Monetary Fund).

Debrun, Xavier, Laurent Moulin, Alessandro Turrini, Joaquim Ayuso-i-Casals, and Manmohan S. Kumar, 2008, "Tied to the Mast? National Fiscal Rules in the European Union," *Economic Policy*, Vol. 23, Issue 54, pp. 297–362.

European Commission, 2006, "Public Finances in EMU," European Economy, No. 3.

Fabrizio, Stefania, and Ashoka Mody, 2006, "Can Budget Institutions Counteract Political Indiscipline?" *Economic Policy*, Vol. 21, Issue 48, pp. 689–739.

Fabrizio, Stefania, and Ashoka Mody, 2007, "Breaking the Impediments to Budgetary Reform: Evidence from Europe," manuscript.

Faini, Riccardo, 2006, "Fiscal Policy and Interest Rates in Europe," *Economic Policy*, No. 47, pp. 443–89.

Hallerberg, Mark, 2004, *Domestic Budgets in a United Europe: Fiscal Governance from the End of Bretton Woods to EMU* (Ithaca: Cornell University Press).

Hallerberg, Mark, Rolf Strauch, and Jürgen von Hagen, 2007, "The Design of Fiscal Rules and Forms of Governance in European Union Countries," *European Journal of Political Economy*, Vol. 23, Issue 2, pp. 338–59.

Hallerberg, Mark, and Guntram Wolff, 2006, "Fiscal Institutions, Fiscal Policy and Sovereign Premia," *Deutsche Bundesbank Discussion Paper* No. 35.

Kopits, George, and Steven Symansky, 1998, "Fiscal Policy Rules," Occasional Paper No. 162 (Washington: International Monetary Fund).

Poterba, James, and Jürgen von Hagen, eds., 1999, *Fiscal Institutions and Fiscal Performance* (Cambridge and Chicago: National Bureau of Economic Research and University of Chicago Press).

von Hagen, Jürgen, 1992, "Budgetary Procedures and Fiscal Performance in European Communities," Economic Papers No. 96 (Brussels: European Commission).

Ylaoutinen, Sami, 2004, "Fiscal frameworks in the central and Eastern European countries, Finnish Ministry of Finance," Discussion paper No. 72 (Helsinki: Ministry of Finance of Finland).

Zellner, Arnold, 1962, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," *Journal of American Statistical Association*, No. 57, pp. 348–68.

II. Monetary Policy Responses to Real and Portfolio Shocks in Hungary[1]

A. Introduction

1. **Monetary policy making in Hungary faces important uncertainties related to the impact of the ongoing turbulence in global financial markets on the outlook for inflation**. Specifically, two risks are significant: a sharper-than-projected decline in partner-country GDP growth, and an increase in the risk premium on forint-denominated assets, leading to a large depreciation of the forint. This paper develops a small macroeconomic model to show the impact of these shocks on output, inflation, the real exchange rate, and the policy interest rate. In addition, the paper illustrates the impact of gains in central bank's inflation-fighting credibility.

2. **The macroeconomic model provides explicit roles for inflation expectations and external shocks**. The model has two economies (Hungary and the euro area) and four main equations: an output gap equation (a forward-looking IS curve), an inflation equation (expectations-augmented Phillips Curve), an interest-parity exchange rate relationship, and a forward-looking monetary policy reaction function. Although the set up is simple, the model captures the standard channels of monetary transmission transparently, including the monetary policy response to euro area shocks by the European Central Bank and its effects on Hungary. However, the parsimony of the model has some shortcomings. For example, the model is not well suited to handle supply shocks, such as food and energy price shocks.

3. **Subject to the usual caveats, the results of this paper illustrate that substantial policy responses may be needed if the risks considered are realized**:

- Should external demand fall by more than currently envisaged, the central bank may need to cut interest rates, with a ½-percentage point fall in the euro area aggregate demand implying a cut in the policy rate in Hungary over time of as much as 125 basis points.

- An increase in the risk premium on forint-denominated assets, leading to a 10-percent depreciation of the exchange rate, could require a higher policy rate over time of as much as 300 basis points, depending on the size of the pass-through of exchange rate depreciation to inflation.

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- In addition, the paper finds salutary effects of gains in the central bank's inflation-fighting credibility, defined as more forward-looking inflation expectations and lower second-round effects on inflation. Results suggest that an improvement in credibility would deliver a quicker reduction in inflation with lower interest rates over the adjustment period.

4. **The paper is organized as follows**. Section B gives background on the monetary policy framework in Hungary and the models used by the central bank (MNB). Section C describes the macroeconomic model used in the paper, while Section D discusses the data and baseline projections. Section E analyzes the policy responses to the two shocks, with benefits to enhancing credibility discussed in Section F. Section G concludes. The calibration of the model to Hungary is described in the Appendix.

B. Background

5. **Hungary adopted inflation targeting in 2001, but until recently also had an exchange rate band**. The MNB's key policy instrument is the interest rate on its two-week bill auctioned to credit institutions. In August 2005, the government and the MNB jointly adopted an explicit medium-term inflation target for the period starting in 2007, defined as a 3±1 percent increase in the Consumer Price Index at the 5-8 quarters horizon. Hungary eliminated the ±15 percent band for the forint-euro exchange rate in February 2008, allowing for a full fledged inflation targeting regime. Although the exchange rate is no longer a direct policy objective, it is considered to be an important channel of the monetary transmission mechanism, operating both through aggregate demand and import prices. Thus, the MNB pays attention to the exchange rate to the extent it influences inflation projections.

6. **The MNB's Quarterly Projection Model combines neo-Keynesian features in the short-run with neoclassical features in the long-run** (Benk and others, 2006). It consists of a set of equations estimated equation by equation and not as a system. The short-run version of the model is in error-correction form, and the long run is determined by a supply block with a production function that has capital and labor as inputs. The demand side has consumption determined by housing and wealth, demand for labor and capital influenced by profit maximization conditions, exports and imports by relative export and import prices among other things. Prices and wages are set such that the output and unemployment gaps close in the long run. Fiscal policy is modeled using various revenue and expenditure items. The model is a backward-looking one without a role for expectations. The nominal interest rate and the exchange rate are treated as exogenous variables. Thus, it is not amenable to questions on monetary policy responses to various shocks.

7. **The MNB staff have recently developed a dynamic stochastic general equilibrium (DSGE) model** (Jakab and Vilagi, 2007). It is a two-sector (namely, domestic and exported final goods) small-open-economy model, estimated by Bayesian methods.

Unlike the quarterly projection model, it has an interest rate rule and an uncovered interest parity condition to endogenize the nominal interest rate and exchange rate paths. A special feature of this model includes an assumption that price and wage setters index their prices to perceptions of inflation in the past, inherently generating a backward-looking component in inflation expectations. Rich in sectoral details and structural shocks, the model generates impulse responses of different variables to the structural shocks. But it does not include a block with partner-country dynamics.

C. FPAS Model

8. **The Forecasting and Policy Analysis System (FPAS) model used in this paper comprises four core equations for Hungary** (Box 1):[2]

- an aggregate demand (IS) equation that relates the level of real activity to expected and past real activity, the gap between the real interest rate and the neutral rate of interest, and the deviation of the real exchange rate from its equilibrium;
- a price-setting equation in the form of an expectations-augmented Phillips curve (PC) relating inflation to past and expected inflation, the output gap, the change in the real exchange rate, and real oil price inflation;
- a monetary policy (MP) rule that sets the policy interest rate as a function of the output gap and deviation of expected inflation from the target; and,
- an uncovered interest parity condition (UIP) for the real exchange rate allowing for both backward- and forward-looking expectations.

9. **The monetary transmission mechanism works in the following way**: a deviation (an increase, to be more precise) of projected inflation from the target prompts an increase in the policy rate by more than one-for-one so as to increase the real interest rate (Clarida, Galí and Gertler, 1999). As the real rate deviates from its neutral rate and influences long-term real rates through the term structure, consumption, through intertemporal substitution effects, and investment, through a change in the cost of borrowing, fall. In addition, the increase in the real rate prompts an appreciation of the currency that also reduces aggregate demand. Overheating pressures decline as the output gap falls, and inflation slowly returns to target. The speed with which it does so depends upon several factors: the sensitivity of the output gap to real interest rate and the real exchange rate gaps, the relative importance of backward

[2] For background on FPAS models, see Berg, Karam, and Laxton (2006a and 2006b). For applications of FPAS models to other European countries, see Epstein, Karam, Laxton and Rose (2006), Tiffin (2007), and Iakova (2007), among others. Appendix I describes each of the equations in detail and the calibration of the model.

and forward looking expectations in the Phillips curve, perceived inflation in wage setting behavior affecting core inflation, and the sensitivity of inflation to output gap.

Box 1. Summary of Equations and Variables

Behavioral equations 1/

(1) $IS: \quad y_t = \beta_1 y_{t+1} + \beta_2 y_{t-1} - \beta_3[r_{t-1} - r^*_{t-1}] + \beta_4[z_{t-1} - z^*_{t-1}] + \beta_5 y^{EA}_t + \varepsilon^y_t$

(2a) $PC(headline): \quad \pi_t = \alpha_1 \pi 4_{t+4} + (1-\alpha_1)\pi 4_{t-1} + \alpha_2 y_{t-1} + \alpha_3[z_t - z_{t-1}] + \alpha_4 \pi^{roil}_t + \alpha_5 \pi^{roil}_{t-1} + \varepsilon^\pi_t$

(2b) $PC(core): \quad \pi_{c,t} = \alpha_{c1}\pi 4_{c,t+4} + (1-\alpha_{c1})\pi 4_{c,t-1} + \alpha_{c2} y_{t-1} + \alpha_{c3}[z_t - z_{t-1}] + \alpha_{c4}[\pi 4_{t-1} - \pi 4_{c,t-1}] + \varepsilon^{\pi c}_t$

(3) $MP: \quad i_t = \gamma_1 i_{t-1} + (1-\gamma_1) * (r^*_t + \pi 4_t + \gamma_2[(\frac{1}{2}\pi 4_{t+4} + \frac{1}{2}\pi 4_{c,t+4}) - \pi^*_{t+4}] + \gamma_3 y_t) + \varepsilon^i_t$

(4) $UIP: \quad z_t = \delta_z z_{t+1} + (1-\delta_z) z_{t-1} - [r_t - r^{EA}_t - \rho^*_t]/4 + \varepsilon^z_t$

Variable definitions

y	Output gap, percentage points
y^{EA}	Output gap in the euro area, percentage points
π (π_c)	CPI (core CPI) inflation, quarterly at annualized rate, percentage points
$\pi 4$ ($\pi 4_c$)	4-quarter change in the CPI (core CPI), annualized rate, percentage points
π^*	Target inflation rate, annualized rate, percentage points
π^{roil}	Change in the relative price of oil, quarterly at annualized rate, percentage points
r	Real interest rate, in percent
r^*	Equilibrium real interest rate, in percent
z	Log of the real exchange rate (increase implies depreciation)
z^*	Log of the equilibrium real exchange rate (increase implies depreciation)
i	Short term nominal interest rate, in percent
ρ^*	Equilibrium risk premium, in percentage points

1/ A similar set of equations apply to the euro area block, but without the exchange rate and partner country output gap terms.

D. Model Consistency of Baseline Projections

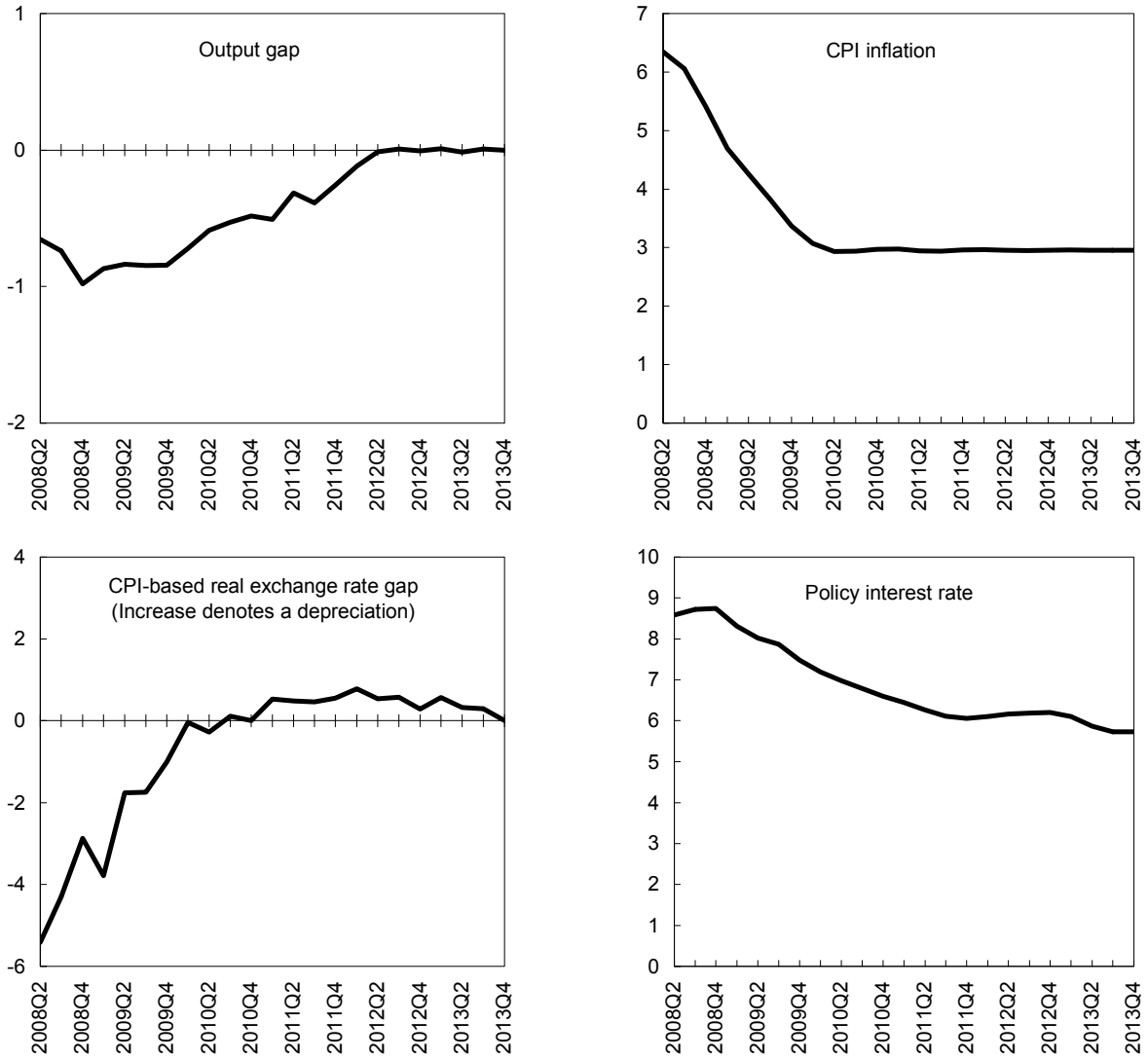
10. **In the staff's baseline projections for Hungary**, CPI inflation falls gradually, reflecting the opening of a negative output gap in 2008-09 and the fading impact of higher global food and energy prices (Figure 1).[3] Although Hungary's and the euro area's output

[3] The Laxton-Rose-Xi (LRX) filter (Berg and others, 2006) is used to estimate the output gap. The LRX filter uses historical and projected output data. It is similar to the HP filter but includes an additional term that

(continued…)

gaps were only weakly correlated during 2005-07, the projections assume a stronger correlation going forward, reflecting the spillover effects of U.S. GDP growth on euro area GDP growth, and from the latter to European emerging markets. CPI inflation is expected to be above target but falling toward the 3 percent target by 2010. Given these projections for the output gap and CPI inflation, the policy interest rate is projected to start falling gradually starting in early 2009. By 2013 the policy rate is assumed to reach approximately 5½ percent, consistent with the inflation target of 3 percent and a neutral real interest rate of 2½ percent.

Figure 1: Hungary: Baseline Projections, 2008–13



Source: IMF staff calculations.

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penalizes the objective function for deviations of the equilibrium from a prior. In this case, the prior specifies the closing of the output gap by 2013Q4.

11. **The FPAS model can be used to evaluate the consistency of the baseline projections**. This is done by feeding the judgmental forecasts of the endogenous variables into the model, and then calculating the residuals. For example, the model-consistent interest rate path can be derived consistent with the judgmental forecast for inflation, the output gap, and the real exchange rate. The difference between the model-consistent path and the judgmental path is the residual. In the case of the staff's baseline projections, the residuals are small, suggesting that the baseline forecast is broadly consistent with the model. By contrast, in a forecast where the interest rate is held constant (and the other variables are the same as before), the residuals are large and serially correlated, suggesting that such a forecast is not model-consistent.

E. Policy Responses to Shocks

12. **The FPAS model can also be used to assess the economy's response to various shocks**, such as a weaker-than-projected external demand or a higher-than-expected risk premium on forint-denominated assets. In general, it would be optimal for the policy interest rate to change as well. In this section, the economy's responses to shocks are contrasted with the baseline forecasts of the previous section.

External Demand Shock

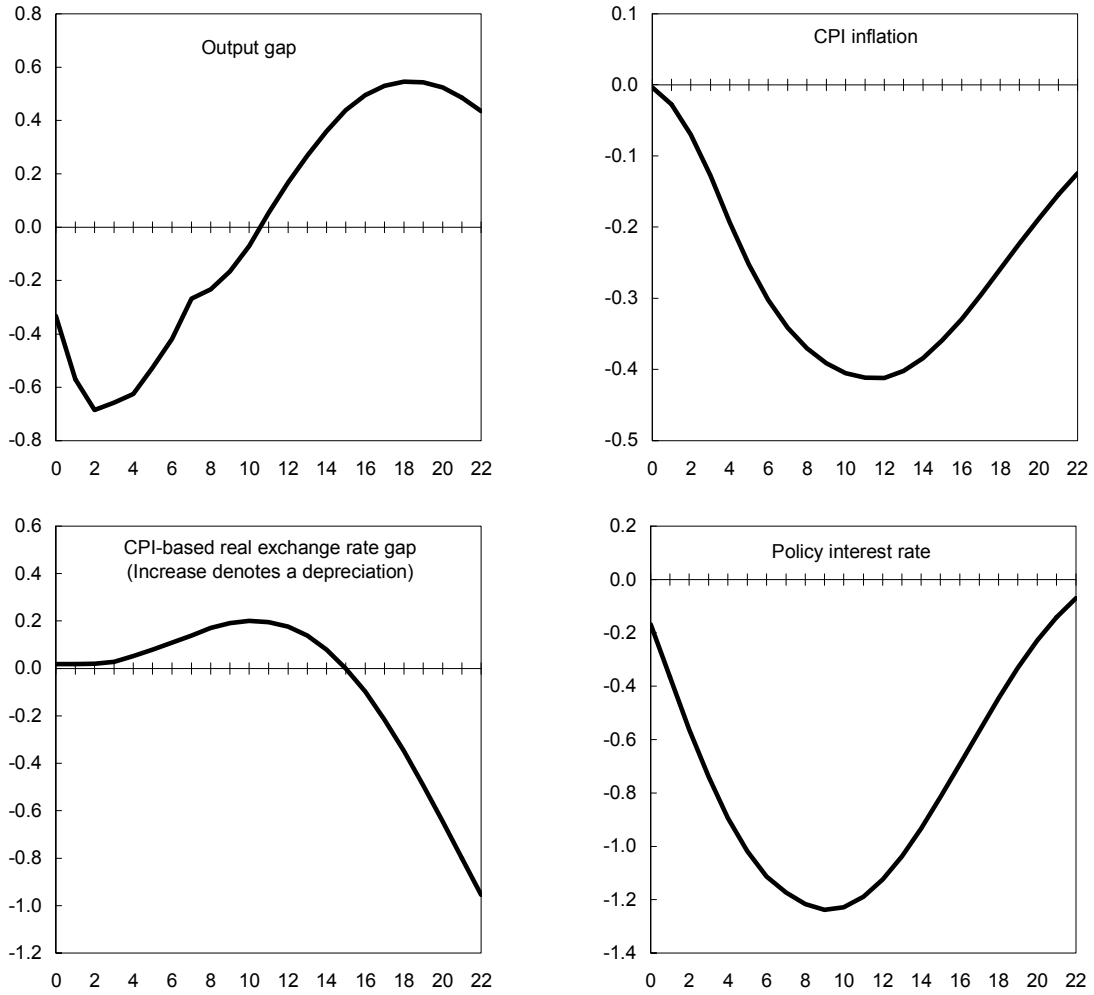
13. **The model suggests that a decrease in the euro area output gap by ½ percentage points could prompt a loosening of monetary policy in Hungary for a long period** (Figure 2). Given the persistence built into the output gap equation, an immediate fall in euro area aggregate demand implies a cumulative decrease in the average annual euro area GDP growth by ⅓ percentage points from the baseline in the first year.

14. **The negative shock to euro area growth reduces demand for Hungarian exports**, shaving ⅓ percentage point from the output gap immediately, and ⅓ percentage point from annual GDP growth in the first year. The output gap follows an oscillatory path and returns to baseline beyond the forecast horizon. The real exchange rate depreciates a little to lower the negative real exchange rate gap, but does not contribute significantly either toward putting higher pressures on inflation or toward increasing output growth. The lower output gap reduces both headline and core inflation that continues to fall to 2.6 percent over two years that necessitates further cuts in the policy rate. As a result, the policy rate would come down by about 50 basis points from the baseline immediately following the shock, and continue falling to as much as 125 basis points from the baseline over two years.

15. **The response of inflation to the external demand shock in the FPAS model is slightly different than in the MNB's DSGE model**. The DSGE has a separate export sector that keeps the disinflationary impact of external demand shock within the sector. The FPAS, which does not distinguish between the domestic and export sectors, builds in a somewhat

larger disinflationary impact of the external demand shock. However, difference is small over the first four quarters and the largest difference in inflation in the two models at any horizon is not more than 35 basis points.

Figure 2. Hungary: External Demand Shock 1/
(Number of quarters after shock)

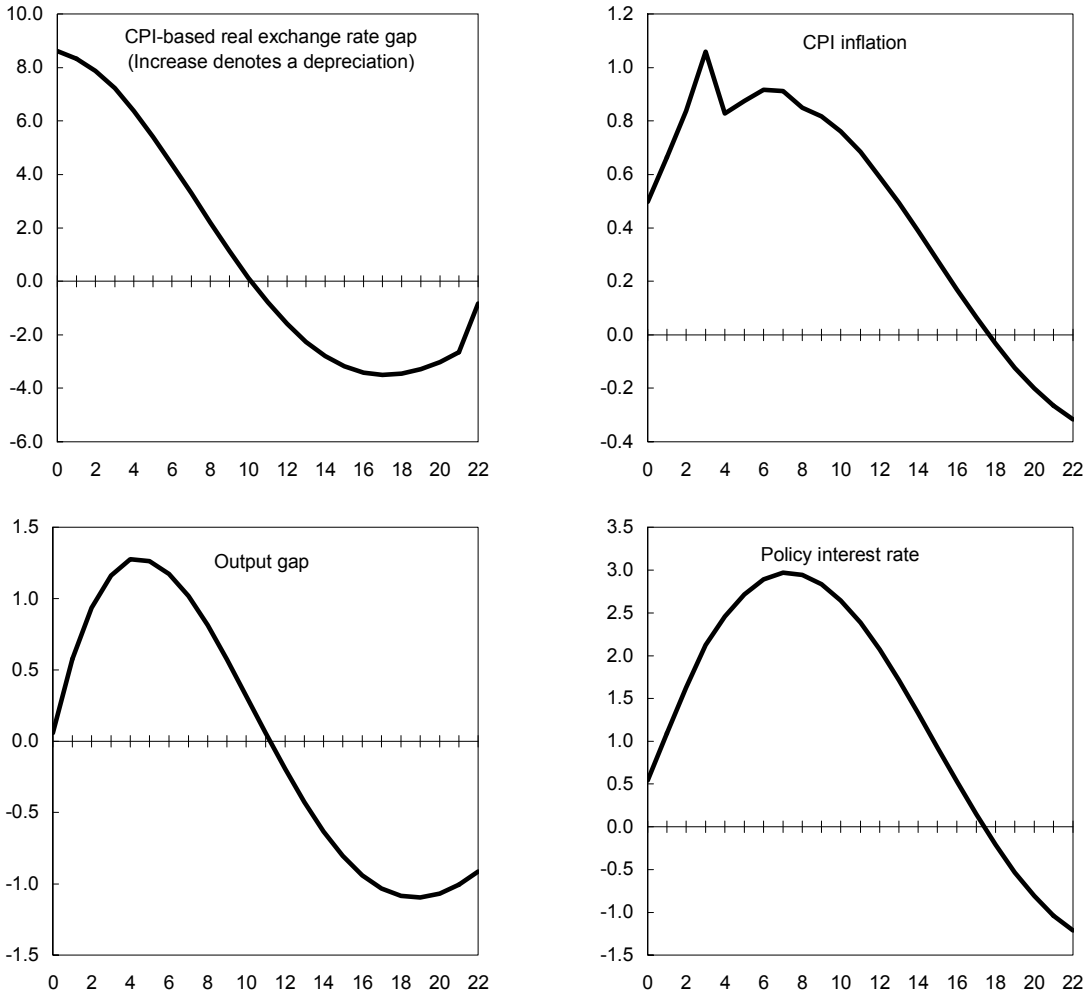


Source: IMF staff calculations.
1/ Deviations from baseline projections.

Risk Premium Shock

16. **The model suggest that a shock to the risk premium on forint-denominated assets that depreciates the nominal exchange rate by about 10 percent** (and the real exchange rate by about 8 percent) **could prompt a sharp increase in the policy rate** (Figure 3). The risk premium shock prompts an immediate sharp depreciation of the real exchange rate. Although the shock is temporary, its effects are persistent, with the real exchange rate returning to trend only after about three years.

Figure 3. Hungary: Risk Premium Shock 1/
(Number of quarters after shock)



Source: IMF staff calculations.
1/ Deviations from baseline projections.

17. **The importance of the exchange rate channel in the model suggests large pass-through effects on inflation**. In addition to a direct effect on import prices, there is an indirect effect on inflation through aggregate demand and the output gap. An exchange rate depreciation reduces the price of Hungary's exports, which stimulates euro area demand for Hungary's exports, which increases the output gap and feeds into inflation. As a result of the direct and indirect effects, CPI inflation is 1.5 percentage points above target after 1½ years. The direct impact on core inflation is only about a third of the impact on headline inflation, due to lesser importance of imported goods in the core CPI bundle. However, second round effects of private sector expectations on wage setting—modeled here by the coefficient (α_{c4}) on the past difference between CPI and core inflation on current core inflation—increase core inflation by one percentage point by 2½ years. The effects on key variables are similar to the ones in the MNB's DSGE model.

18. **The simulations suggest that the policy interest rate could be raised rapidly in response to the effects of the shock on inflation and the output gap**. The rate could go up by about 300 basis points relative to the baseline after two years, before starting to fall gradually. The large increase in the policy interest rate reduces aggregate demand directly and indirectly, by causing the exchange rate to appreciate. The opening of a negative output gap gradually brings down inflation toward the target. As inflation returns to target, the policy interest rate could fall.

F. Benefits to Enhancing Inflation-Fighting Credibility

19. **Regardless of the type of shock, the amount by which the policy interest rate needs to change following a shock depends in part on the central bank's inflation-fighting credibility**. The higher is the central bank's credibility, the smaller the change in the policy rate needed to achieve the inflation target. Smaller changes in the policy rate are less disruptive to economic activity, in part because they prompt smaller balance sheet effects for the private sector and banks. Inflation-fighting credibility is difficult to measure, but is likely related to a central bank's recent track record in controlling inflation. In this regard, the MNB is relatively new to inflation targeting and has a record of higher average inflation and inflation variability than central banks with more inflation targeting experience (Text table).

Text table. CPI Inflation: average and variability
(2001Q4 - 2007Q4)

	Inflation	
	mean	s.d.
Australia	2.79	0.53
Canada	2.16	0.76
Euro Area	2.17	0.27
Hungary	**5.42**	**1.80**
New Zealand	2.55	0.67
Sweden	1.61	0.69
Switzerland	0.82	0.43

20. **The FPAS model can be used to illustrate the benefits of higher inflation-fighting credibility**. Specifically, the experiment is to analyze the impact of the MNB gaining a level of credibility similar to that of central banks with more inflation targeting experience. There are three key parameters in the model that capture the central bank's credibility: the extent to which inflationary expectations are forward-looking (higher α_1 and α_{c1}); the degree of second-round effects on core inflation (lower α_{c4}); and the effect of the output gap on inflation (higher α_2 and α_{c2}).[4] To show how higher credibility affects the response of the policy interest rate, two inflation equations are considered: an inflation equation with central values of the parameters and a higher-credibility inflation equation with the relevant parameter values similar to those in the euro area (Appendix Table C). Starting from a situation of above-target inflation, the model is allowed to simulate the paths of the policy interest rate, the output gap, inflation, and the real exchange rate.

[4] For the third effect, see Berg and others (2006a).

21. **The simulations show that higher inflation-fighting credibility allows inflation to reach the target more quickly with a smaller change in the policy interest rate**. Inflation in the higher credibility regime is lower than in the lower credibility regime throughout the five-year projection period, with the difference increasing over time. Similarly, the policy interest rate is lower in the higher credibility regime, by up to 200 basis points. As a result, the output loss associated with reducing inflation is lower in the higher credibility regime. The sacrifice ratio is about 1 percentage point lower in the higher credibility regime.

G. Conclusion

22. **This paper develops a simple macroeconomic model that incorporates inflation expectations and partner-country dynamics to analyze the monetary policy response to shocks related to the global financial turbulence**. In particular, a ½ percentage point decline in euro area GDP relative to baseline is found to imply a cut in the policy interest rate in Hungary over time of as much as 125 basis points. An increase in the risk premium on forint-denominated assets, leading to an immediate 10-percent depreciation of the exchange rate, could require a higher policy rate over time of as much as 300 basis points, depending on the size of the pass-through of exchange rate depreciation to inflation.

23. **In addition, the model is used to illustrate the macroeconomic impact of higher inflation-fighting credibility**. If Hungary's central bank is able to increase its credibility, then the benefits could be significant. Specifically, starting from a situation of above-target inflation, a smaller increase in the policy interest rate would be needed, inflation would fall more rapidly to target, and the output loss associated with disinflation would be smaller.

APPENDIX: CALIBRATION OF THE FPAS MODEL TO HUNGARY

A. Calibration of Core Equations

Output gap (IS) equation

1. The output gap depends upon both expected and past output gaps, the real interest rate gap and real exchange rate gap. In addition, the output gap in the euro area—as the largest trading partner—influences Hungarian output gap through trade channels.

$$(1)\quad IS: \quad y_t = \beta_1 y_{t+1} + \beta_2 y_{t-1} - \beta_3[r_{t-1} - r^*_{t-1}] + \beta_4[z_{t-1} - z^*_{t-1}] + \beta_5 y^{EA}_t + \varepsilon^y_t$$

The values of the parameters are shown in Section C. Because of significant lags in the transmission mechanism, the sum of β_3 and β_4 is expected to be small relative to the lagged gap parameter, β_2 (Berg and others, 2006b). In fact, for most countries, $\beta_3 + \beta_4$ tend to lie between 0.10 and 0.20. The baseline model for Hungary assumes β_3 to be 0.08, lower than the euro area's, and β_4 to be 0.05. This implies that a 100 basis points tightening in the real interest rate is equivalent to a 1.6 percent appreciation in the real exchange rate, affecting output by lowering competitiveness. Compared to the euro area, a larger value on the lagged output gap (β_2=0.75) and a smaller β_3 imply a relatively slow transmission mechanism of monetary policy—widespread euroization of bank loans and deposits is expected to lower the effectiveness of policy. The demand shock, ε^y, could be interpreted as a shock to foreign demand or a fiscal policy shock. Although Hungary's business cycle has recently decoupled from the euro area's, net exports have been its main growth engine. Thus, the coefficient on trade linkages with the euro area is assumed to be very high (β_5=0.5).

Phillips Curve (PC) equation

2. Headline inflation depends upon expected and lagged inflation, the output gap, real exchange rate changes and real oil price increases. Core inflation follows similar dynamics, but includes a term that captures wage setting behavior.

$$(2a)\, PC(headline): \quad \pi_t = \alpha_1 \pi 4_{t+4} + (1-\alpha_1)\pi 4_{t-1} + \alpha_2 y_{t-1} + \alpha_3[z_t - z_{t-1}] + \alpha_4 \pi^{roil}_t + \alpha_5 \pi^{roil}_{t-1} + \varepsilon^{\pi}_t$$

$$(2b)\, PC(core): \quad \pi_{c,t} = \alpha_{c1}\pi 4_{c,t+4} + (1-\alpha_{c1})\pi 4_{c,t-1} + \alpha_{c2} y_{t-1} + \alpha_{c3}[z_t - z_{t-1}] + \alpha_{c4}[\pi 4_{t-1} - \pi 4_{c,t-1}] + \varepsilon^{\pi c}_t$$

Prices are adjusted according to expected inflation ($\pi 4_{t+4}$) and the markup of prices over marginal cost (proxied by the output gap, y_{t-1}). But backward-looking expectations also play a key role through indexation of wages and prices, and the extent of such expectations could be related to the lack of monetary policy credibility. As the importance of backward-looking

expectations increases, α_2 and α_{c2} are expected to decrease in magnitude. With rising importance of forward-looking expectations, the interest rate response needed to bring inflation back to the target decreases. For Hungary, the lead inflation term has a lower coefficient (α_1=0.10) than the euro area, given the recent history of persistently high inflation and missing the inflation target. Correspondingly, the coefficient on the output gap is also relatively low (α_2=0.20). Given the evidence of relatively high pass-through of exchange rate changes to domestic inflation, the coefficient for real exchange rate changes, α_3 is taken as 0.20—a one percent depreciation of the exchange rate results in 0.20 percent increase in inflation in the short run (Benk and others, 2006; Ca' Zorzi and others, 2007). The related coefficient in the core inflation equation is much smaller (α_{c3}=0.07) due to a lesser direct role for imported goods prices in this measure of inflation. An extra coefficient, α_{c4}, measures the extent of catch-up in terms of past movements in headline CPI inflation, capturing the second round effects of supply shocks such as oil and food prices feeding into core inflation. The second-round effects have been set higher than the euro area's, (α_{c4}=0.30) to denote somewhat lesser credibility of the MNB compared to the ECB.

Monetary Policy Rule

3. A forward-looking Taylor rule with interest rate smoothing underpins monetary policy in the model. Since Hungary adopted full-fledged inflation targeting as recently as February 2008, the rule is not assumed to have a precedent. Instead, the paper assumes that MNB pays equal attention to inflation and the output gap while setting the short term interest rate, and has the same parameters as the ECB's rule.

$$(3)\quad MP:\quad i_t = \gamma_1 i_{t-1} + (1-\gamma_1)*(r_t^* + \pi 4_t + \gamma_2[(\frac{1}{2}\pi 4_{t+4} + \frac{1}{2}\pi 4_{c,t+4}) - \pi_{t+4}^*] + \gamma_3 y_t) + \varepsilon_t^i$$

Equation (3) does not assume optimality of the interest rate rule. The central bank reacts to deviation of inflation from the target, four-quarters ahead. Although the MNB targets headline inflation, the paper assumes that it pays equal attention to core CPI inflation as well. In particular, it takes the average of the 4-quarter ahead core and headline inflation as a measure of inflation. This assumption allows for variation in second round effects on headline inflation. For any inflationary deviation, the central bank changes interest rate by more than one-for-one so as to move real rates. While γ_2>1 is the Taylor principle, the paper assumes γ_2 to be 2. The principle also contributes toward the mathematical stability of the model.

4. Berg and others (2006b) caution against potential losses arising from making the wrong set of assumptions about the nature of the economy. If inflation expectations are highly forward looking and the monetary authorities assume otherwise and react aggressively

to inflation deviations, the credibility costs may not be too high. If the economy is not that forward looking but the central bank assumes it to be so and reacts modestly, then credibility costs could be high. It may be better, therefore, to assume that the economy is not very forward-looking to be on the safe side of credibility.

Exchange rate in the modified UIP equation

5. Interest parity is assumed to hold. The CPI-based real exchange rate—an increase denotes a depreciation—moves one-for-one with the real interest rate differential, $r_t - r_t^{EA}$, with the euro area.

$$(4)\quad UIP: \quad z_t = \delta_z z_{t+1} + (1-\delta_z) z_{t-1} - [r_t - r_t^{EA} - \rho_t^*]/4 + \varepsilon_t^z$$

An increase in ρ_t^*, the equilibrium risk premium—comprised of the trend real exchange rate and the equilibrium real interest rate differential—depreciates the real exchange rate. In addition, the parameter, δ_z, allows for rational expectations but is (realistically) assumed to be much less than 1 (δ_z=0.25). The neutral rate of interest for Hungary, $r*$=2.5, is assumed to be higher than the euro area's (2.0), taking into account country risk premium.

B. Complete model equations

6. The following are the key equations for the Hungarian economy. The equations for the euro area have similar structure, but without the open-economy linkages. The behavioral equations are replicated from Box 1. The steady state conditions and other identities are added here.

Behavioral Equations

$$(1)\quad IS: \quad y_t = \beta_1 y_{t+1} + \beta_2 y_{t-1} - \beta_3 [r_{t-1} - r_{t-1}^*] + \beta_4 [z_{t-1} - z_{t-1}^*] + \beta_5 y_t^{EA} + \varepsilon_t^y$$

$$(2a)\, PC(headline): \quad \pi_t = \alpha_1 \pi 4_{t+4} + (1-\alpha_1)\pi 4_{t-1} + \alpha_2 y_{t-1} + \alpha_3 [z_t - z_{t-1}] + \alpha_4 \pi_t^{roil} + \alpha_5 \pi_{t-1}^{roil} + \varepsilon_t^{\pi}$$

$$(2b)\, PC(core): \quad \pi_{c,t} = \alpha_{c1} \pi 4_{c,t+4} + (1-\alpha_{c1})\pi 4_{c,t-1} + \alpha_{c2} y_{t-1} + \alpha_{c3} [z_t - z_{t-1}] + \alpha_{c4} [\pi 4_{t-1} - \pi 4_{c,t-1}] + \varepsilon_t^{\pi c}$$

$$(3)\quad MP: \quad i_t = \gamma_1 i_{t-1} + (1-\gamma_1) * (r_t^* + \pi 4_t + \gamma_2 [(\frac{1}{2}\pi 4_{t+4} + \frac{1}{2}\pi 4_{c,t+4}) - \pi_{t+4}^*] + \gamma_3 y_t) + \varepsilon_t^i$$

$$(4)\quad UIP: \quad z_t = \delta_z z_{t+1} + (1-\delta_z) z_{t-1} - [r_t - r_t^{EA} - \rho_t^*]/4 + \varepsilon_t^z$$

Steady State and Equilibrium Conditions

$$400[y_t^* - y_{t-1}^*] = g_t^* - \upsilon_{roil}\pi 4_t^{roil} + \varepsilon_t^{y^*}$$
$$g_t^* = (1-\lambda_{g^*})\overline{g}_t + \lambda_{g^*} g_{t-1}^* + \varepsilon_t^{g^*}$$
$$\pi_t^* = (1-\lambda_{\pi^*})\overline{\pi} + \lambda_{\pi^*}\pi_{t-1}^* + \varepsilon_t^{\pi^*}$$
$$r_t^* = (1-\lambda_{r^*})\overline{r}_t + \lambda_{r^*} r_{t-1}^* + \varepsilon_t^{r^*}$$
$$\rho_t^* = 4(z_t^* - z_{t-1}^*) + (r_t^* - r_{t-1}^{*EA})$$

Identities

$$y_t = 100(Y_t - y_t^*)$$
$$\pi_t = 400[\log(CPI_t) - \log(CPI_{t-1})]$$
$$\pi 4_t = 100[\log(CPI_t) - \log(CPI_{t-4})]$$
$$r_t = i_t - \pi_{t+1}$$
$$z_t = 100 * \log(S_t * CPI_t^{EA} / CPI_t)$$

Variable definitions

y	Output gap, percentage points
y^*	Log of potential real GDP
Y	Log of real GDP
g^*	Growth rate of potential GDP, quarterly at annual rate, percentage point
$\overline{g}$	Steady state growth rate of potential GDP, quarterly at annual rate, percentage point
y^{EA}	Output gap in the euro area, percentage points
π (π_c)	CPI (core CPI) inflation, quarterly at annualized rate, percentage points
$\pi 4$ ($\pi 4_c$)	4-quarter change in the CPI (core CPI), annualized rate, percentage points
π^*	Target inflation rate, annualized rate, percentage points
$\overline{\pi}$	Steady state inflation target, annualized rate, percentage points
π^{roil} ($\pi 4^{roil}$)	Change in the relative price of oil, quarterly at annualized rate (annual), percentage points
r	Real interest rate, in percent
r^*	Equilibrium real interest rate, in percent
$\overline{r}$	Steady state equilibrium real interest rate, in percent
z	Log of the real exchange rate (increase implies depreciation)
S	Nominal exchange rate, HUF/EUR.
z^*	Log of the equilibrium real exchange rate (increase implies depreciation)
i	Short term nominal interest rate, in percent
ρ^*	Equilibrium risk premium, in percentage points

C. Parameter values[20]

	Parameters	Hungary Central	Hungary Higher credibility--more forward-looking PC	Euro Area (EA) Central
(1) The IS Curve (Beta)				
lead output gap	β_1	0.10		0.10
lagged output gap	β_2	0.75		0.60
real interest gap	β_3	0.08		0.10
real exchange rate gap	β_4	0.05		…
EA output gap	β_5	0.50		…
(2a) Headline CPI Inflation (Alpha)				
lead headline CPI inflation	$\alpha 1$	0.10	0.20	0.20
lagged output gap	$\alpha 2$	0.20	0.30	0.30
real exchange rate change	$\alpha 3$	0.20		…
change in real oil price	$\alpha 4$	0.01		0.01
lagged change in real oil price	$\alpha 5$	0.01		0.01
(2a) Core Inflation (Alpha_c)				
lead core inflation	α_{c1}	0.10	0.25	0.25
lagged output gap	α_{c2}	0.20	0.30	0.30
real exchange rate change	α_{c3}	0.07		…
lagged diff. between CPI and core inflation	α_{c4}	0.30	0.25	0.25
(3) Monetary Policy Rule (Gamma)				
lagged interest rate	γ_1	0.70		0.70
4-quarter ahead inflation	γ_2	2.00		2.00
output gap	γ_3	0.50		0.50
(4) Modified UIP equation				
lead bilateral HUF/EUR exchange	δ_z	0.25		…
Stochastic processes				
Potential output growth--oil price	υ_{roil}	0.01		0.02
Persistence parameters (Lambda)				
potential output growth	λ_g *	0.95		0.70
equilibrium interest rate	λ_r *	0.00		0.00
inflation target	λ_π*	0.00		0.00

[20] The "central" parameters refer to the structure of the economy upon which the baseline in Section D and the two shocks in section E are based. The "Higher credibility" values refer to the structure of the Hungarian economy as it approaches the higher credibility of the ECB. Parameter values left blank in the "Higher credibility" column imply that the "Central" values apply for Hungary.

REFERENCES

Benk, Szilárd, Zoltán M Jakab, Mihály A Kovács, Balázs Párkányi, Zoltán Reppa, and Gábor Vadas, 2006, "The Hungarian Quarterly Projection Model (NEM)," MNB Occasional Papers 60, 2006.

Berg, Andrew, Phillippe Karam, and Douglas Laxton, 2006a, "Practical Model-Based Monetary Policy Analysis—Overview," IMF Working Paper 06/80, Washington: International Monetary Fund.

_____, 2006b, "Practical Model-Based Monetary Policy Analysis—A How-to Guide," IMF Working Paper 06/81, Washington: International Monetary Fund.

Ca' Zorzi, Michele, Elke Hahn and Marcelo Sánchez, 2007, "Exchange Rate Pass-through in Emerging Markets," European Central Bank Working Paper No. 739, March.

Clarida, Richard, Jordi Galí, and M. Gertler, 1999, "The Science of Monetary Policy: A New Keynesian Perspective," Journal of Economic Literature, Vol. 37, No. 4, pp. 1661-1707.

Epstein, Natan, Phillippe Karam, Douglas Laxton, and David Rose, 2006, "A Simple Forecasting and Policy Analysis System for Israel: Structure and Applications," in *Israel: Selected Issues*, IMF Country Report 06/121, Washington: International Monetary Fund.

Iakova, Dora, 2007, "Flattening of the Phillips Curve: Implications for Monetary Policy," IMF Working Paper 07/76, Washington: International Monetary Fund.

Jakab, Zoltán M and Balázs Világi, 2007, "An Estimated DSGE Model of the Hungarian Economy," Magyar Nemzeti Bank, mimeo.

Tiffin, Andrew, 2007, "Modeling Monetary Policy in Romania," in *Romania: Selected Issues*, IMF Country Report 07/220, Washington: International Monetary Fund.