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Monetary Policy Analysis with a Quarterly Projection Model

Hungary

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ABSTRACT: The calibration of monetary policy is particularly challenging at a time of large shocks. Interest rates in Hungary rose sharply in response a significant increase in inflation and depreciation in the forint in 2022. As inflationary pressures have eased, the base rate has been reduced but remains restrictive. Balancing the risks of loosening too quickly and inflation taking longer to return to target against those of loosening too slowly with larger costs to output requires careful calibration. This paper uses a Quarterly Projection Model to provide a quantitative guide to the calibration of monetary policy in Hungary. As underlying inflation remains elevated and second-round effects continue to push up services inflation, the model suggests that further cuts in interest rates should proceed cautiously and gradually.

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SELECTED ISSUES PAPERS

Monetary Policy Analysis with a Quarterly Projection Model

Hungary

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MONETARY POLICY ANALYSIS WITH A QUARTERLY PROJECTION MODEL[1]

A. Introduction

1. **The calibration of monetary policy is particularly challenging at a time of large shocks to inflation and output.** Interest rates in Hungary rose sharply in response the significant increase in inflation to above 25 percent y/y in 2023-Q1 and large depreciation in the forint. As inflationary pressures have eased and the exchange rate has stabilized, the base rate has been reduced to 7.0 percent in June 2024 but remains restrictive. The Reuters survey of economists' forecasts indicates that the policy rate is expected to fall further to around 6¼ percent by the end of 2024.[2] Balancing the risks of loosening too quickly and inflation taking longer to sustainably return to target against those of loosening too slowly with larger costs to output requires careful calibration. The pace and extent of future easing depends on the drivers of recent inflation, the state of the economy, and lags in the transmission mechanism.

2. **Models such as the IMF's Quarterly Projection Model (QPM) provide a quantitative guide to the calibration of monetary policy.** While easing inflation pressures suggest that qualitatively the monetary policy stance should be loosened over time, models provide a quantitative indication of the appropriate pace and extent. The QPM offers important features useful for monetary policy and scenario analysis. Interest rates are endogenous, reacting to changes in economic conditions. The projections for monetary policy and the economy are therefore internally consistent. The model is also forward-looking. So what matters is the expected paths for interest rates and inflation, not just rates today. The model can also be used to assess how large supply shocks to one sector – such as energy and other goods – spill over to sectors such as services. Such models are of course subject to uncertainties, particularly when the shocks are large and there are structural breaks. Nonetheless, they provide a useful quantitative benchmark, alongside judgement and other analysis, to inform the monetary policymaking process.

B. Overview of the Quarterly Projection Model

3. **The Quarterly Projection Model is one of the IMF's workhorse models for macroeconomic forecasting and monetary policy analysis.** It is a semi-structural new-Keynesian model, incorporating nominal rigidities and rational expectations. It therefore benefits from some of the theoretical insights of structural models but retains more flexibility, closeness to the data and simplicity than a fully micro-founded dynamic stochastic general equilibrium model (Carabenciov et al, 2008). It filters key macroeconomic variables into trends and gaps. Identifying appropriate trends, with the use of some judgement, is key to the performance of the model.

[1] Prepared by Chris Jackson (RES).

[2] Median value of economists' responses to the Reuters survey conducted in June 2024.

4. The standard QPM is comprised of four key equations, which are described in greater detail in Section E:

1) **An IS curve** that relates aggregate demand to real interest rates, credit conditions, and the exchange rate;
2) **A Phillips curve** that relates inflation to the output gap, exchange rate and relative prices;
3) **A policy or Taylor rule** that determines how interest rates respond to deviations in expected inflation from target and the output gap;
4) **An uncovered interest parity (UIP) condition** that relates the exchange rate to expected interest rate differentials and a risk premium.

5. The standard QPM is adapted to reflect some specific features of the Hungarian economy and post-Covid set of shocks. Inflation is modelled in greater sectoral detail, including the separation of core goods and services, to capture differences in their drivers and dynamics and to model spillovers of shocks from one sector to another. In a multi-sector model, each sector's inflation dynamics depend not only on the aggregate output gap but also its price level relative to aggregate prices. The exchange rate risk premium is explicitly included in the policy rule given the importance of exchange rate fluctuations for monetary and financial stability.[3] The model also includes changes in credit spreads, as well as risk-free rates, which may be positive in the case of a credit supply shock or negative in the case of interest rate caps. The latter are particularly important in the case of Hungary given their widespread use since 2022 which hinders the transmission mechanism.

C. The QPM and Monetary Policy in the Baseline

6. The projections from the QPM are shown in Figure 1 under two assumptions. The "baseline" projection is conditioned on a path for interest rates consistent with market participants' expectations for the first year of the forecast, as measured by the median of the Reuters poll of economists.[4] That implies that average quarterly interest rates fall to 6¼ percent in 2024-Q4 and 5¾ percent by 2025-Q2. The "unconstrained policy rule" projection instead allows interest rates to respond endogenously using the model's Taylor rule.

7. Conditioned on the market path for interest rates, the model projects that inflation picks up from 3.7 percent y/y in 2024 Q1 to 4.2 percent by the end of 2024, above the tolerance band of the target. Part of this reflects the impact of increases in indirect taxes on fuel. But it also reflects a pickup in core inflationary pressures. Over the forecast, the current disinflationary impulses of falling commodity prices and the appreciation in the forint fade. This reveals an elevated rate of services inflation, which has slowed less than goods inflation. In addition to inherent price persistence, services inflation remains strong because prices are low relative to

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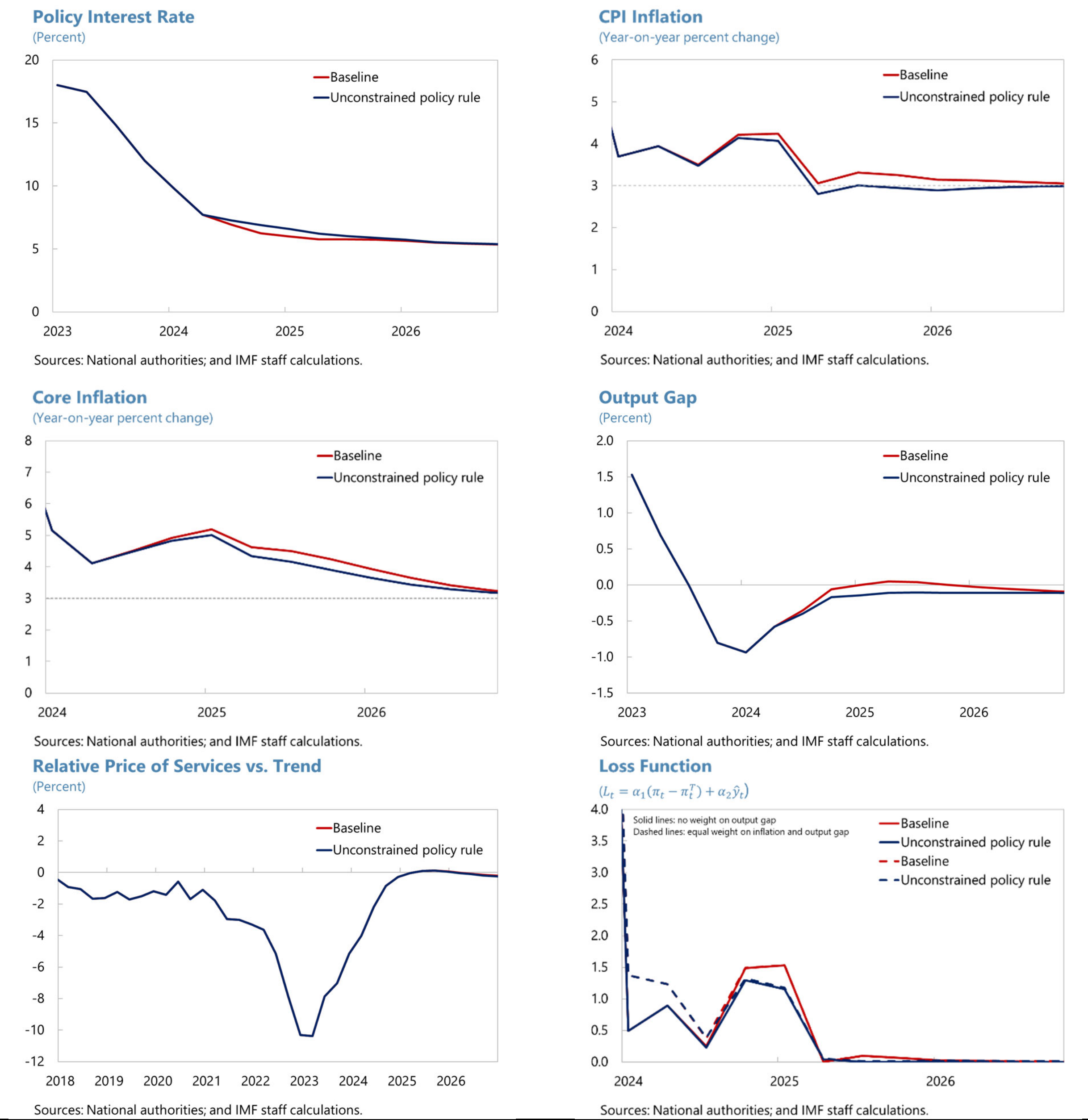
[3] A similar approach is used in Szilagyi et al (2013), although the current monetary policy model (Békési et al, 2016) does not include the exchange rate risk premium in the policy rule.

[4] The path for monetary policy is implemented using unanticipated shocks as anticipated shocks have a large effect on inflation and output, a version of the forward-guidance puzzle.

elevated real marginal costs. It implicitly reflects two mechanisms: past increases in goods and commodities prices feeding through to services as intermediate inputs, but also the delayed response of nominal wages to higher past inflation (Guerrieri, Marcussen, Reichlin and Tenreyro, 2023). These forces are captured by the low level of relative services prices. Despite weak aggregate output, services inflation therefore needs to remain elevated to bring relative prices back to trend.

Figure 1. QPM Projections Under the Baseline Monetary Policy Path and an Unconstrained Policy Rule



8. **Beyond 2025-Q2, the path for interest rates switches to the model's policy rule.** As inflation remains above target, policy is somewhat restrictive through 2025 but significantly less so than in the previous year. By 2026, the ex-ante real policy rate settles at its neutral level of around 2 percent.

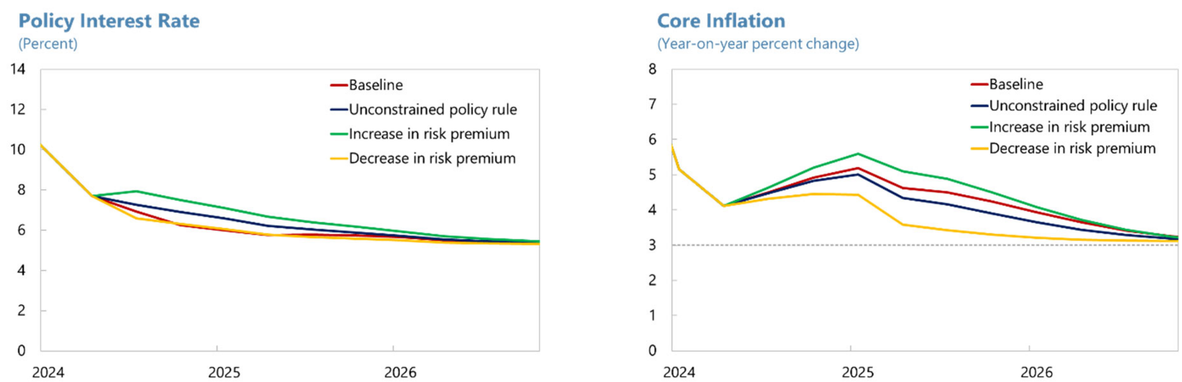
9. The model's policy rule suggests that further interest rates should proceed cautiously and somewhat more gradually than the current market path. This is because the model anticipates that inflation will remain somewhat elevated once the external disinflationary forces fade. Policy is therefore slightly more restrictive than the baseline to bring down inflation more quickly, producing a path for headline and core inflation that is closer to target on average in 2024-25. This comes at the cost of a slightly more gradual recovery. But even under a loss function with equal weights on deviations in inflation from target and the output gap, welfare is improved under the unconstrained policy rule path relative to baseline path for interest rates.

D. Alternative Scenarios

10. The model can also be used to assess the sensitivity of the path of interest rates to additional shocks to the economy and to the underlying behavior of inflation and output.

11. The behavior of the exchange rate is a key binding constraint on the path for interest rates given the sensitivity of inflation to the exchange rate. While the forint has appreciated since its material depreciation in 2022, thanks in part to restrictive monetary policy, it remains sensitive to changes in risk sentiment. Figure 2 shows the model-implied paths for monetary policy if the exchange rate risk premium were to increase or fall temporarily. If the risk premium were to rise temporarily by 2½pp, weakening the currency, the model suggests that interest rates ought to stay elevated for longer. This partially mitigates the increase in inflation from the depreciation but at the cost of weaker growth. Likewise, if the risk premium were to normalize faster than projected it would allow interest rates to fall toward their neutral rate more quickly.

Figure 2. Sensitivity of the Projections to Changes in the Exchange Rate Risk Premium

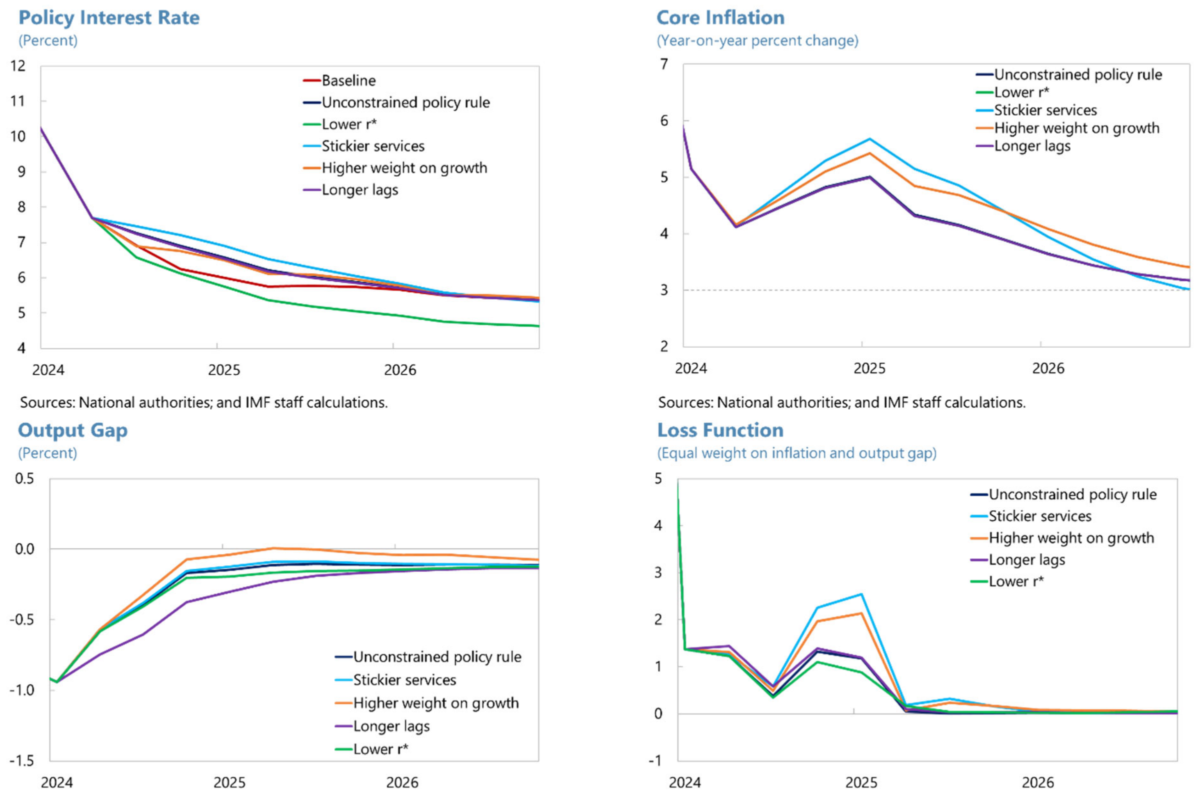


Sources: National authorities; and IMF staff calculations.

Sources: National authorities; and IMF staff calculations.

12. A range of alternative model calibrations also suggest only a gradual reduction in interest rates. The charts in Figure 3 illustrate how the policy path in the model would deviate under three different sensitivities: (i) stickier services inflation, potentially due to second-round effects of high inflation on wage growth and price indexation; (ii) a larger weight on output in the policy rule; (iii) longer lags of interest rates to activity (which may reflect weaker transmission through the housing market in Hungary than in other economies[5]); and (iv) a lower estimate of the trend real interest rate.

Figure 3. Sensitivity of the Projections to Changes in Model Parameters



Sources: National authorities; and IMF staff calculations.

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- In the first scenario, the persistence of services inflation is increased by 50 percent to reflect the potential for unusually strong second-round effects of high inflation via price indexation or high wage growth. Given current services inflation is elevated, this results in a higher inflation forecast. As a result, interest rates remain tighter through 2024-25 and do not reach their neutral level until 2026.

- The second scenario assumes that the policymaker places a higher weight on growth in the policy rule (equal to inflation). It also assumes that there is little interest rate smoothing. In this case, interest rates initially fall faster in 2024 than in the baseline, closing the output gap slightly faster. But it comes at the cost of higher inflation. And expectations of higher inflation ultimately mean that interest rates remain more restrictive than the baseline. Welfare is lower, despite stronger growth, even when weighing inflation and output deviations equally.

- The third scenario considers a model with longer lags of monetary policy to output. In this scenario, output takes longer to recover as the past high level of interest rates continues to

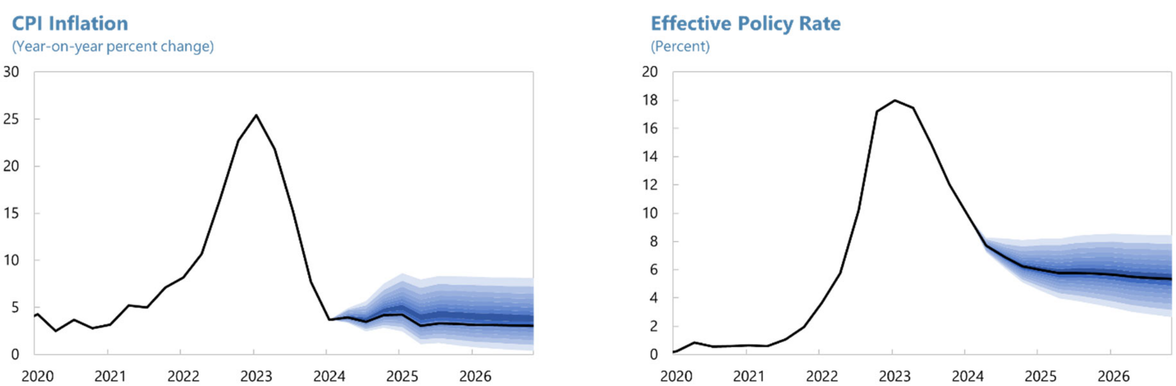
[5] April WEO 2024, 'Feeling the Pinch? Tracing the Effects of Monetary Policy Through Housing Markets'.

weigh on output. This produces little change in the path for the policy rate because the slope of the Phillips curve in the model is low. As a result, the projection for inflation is little changed.

- The final scenario assumes that the trend real rate, or r*, is 1 percent lower than estimated by the model. This produces a lower path for interest rates over the projection but with little change to the paths for the output gap or inflation.

13. **Given the incidence of large shocks in the recent past, it is also useful to consider the uncertainty around the central projections.** Figure 4 shows fan charts around the baseline projections for inflation and the policy rate. The bands around the forecast are created using a bootstrap approach. Residuals from the model's equations are sampled randomly with replacement and then used to shock the model in successive quarters of the projection.[6] Observations during 2020-21 are not sampled given the large changes in GDP and shocks during the peak Covid period. The fan chart for interest rates, however, is produced assuming no shocks to the future policy rate. Instead, monetary policy reacts only endogenously to the draw of shocks each period.[7]

Figure 4. Fan Charts



Sources: National authorities; Haver Analytics; and IMF staff calculations.

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Note: the fan chart shows the distribution of projected outcomes based on random draws of past shocks and an endogenous monetary policy response to those shocks. Each band represents five per cent of the distribution. The outer bands show the tenth and ninetieth percent of the distribution.

14. **The fan charts are wide, suggesting that uncertainty around the projections is high. Communication around the likely future path of interest rates should convey this uncertainty.** The fan chart for inflation is also asymmetric, with the mean projection lying above the baseline. This reflects the incidence of large supply shocks increasing inflation in the recent data. To extent that the risk of such supply shocks remains, this implies that risks to the baseline inflation may be somewhat skewed to the upside. This suggests that monetary policy ought to loosen but cautiously while there is some chance that these shocks could persist or reoccur.

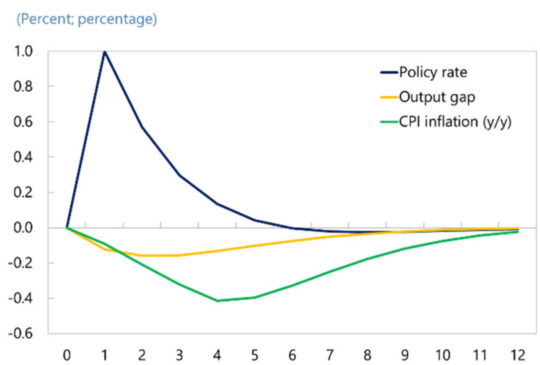
[6] The residuals therefore capture any correlations across equations but are independent over time.

[7] The fan charts are also conditioned on the set of shocks underlying the baseline including those needed to deliver the market path for interest rates.

E. Impulse Response Functions

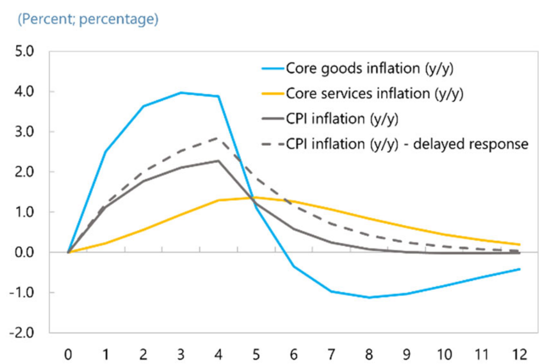
15. The model is calibrated to be broadly similar to external estimates. Figure 5 shows the impulse responses from a monetary policy shock. A 1pp temporary but persistent increase in the policy rate reduces the level of output by around 0.15 percent and reduces inflation by a peak of 0.4pp, implying a low sacrifice ratio. Inflation also falls quite quickly, with the peak impact under a year. Both these features reflect the importance of the exchange rate channel in Hungary, consistent with the findings of Szilágyi et al (2013) and Vonnák (2007). In part, that is due to the large share of tradables in the CPI: 74 percent of the basket is goods compared to 55 percent in the euro area.

Figure 5. Monetary Policy Shock



Sources: IMF staff calculations.

Figure 6. Core Goods Inflation Shock



Sources: IMF staff calculations.

16. An important feature of the model is sectoral spillovers, which mean that temporary shocks in one sector affect inflation in other sectors. Figure 6 illustrates the role of sectoral spillovers in the model. A cost-push shock in the core goods sector, such as those from supply bottlenecks, temporarily increases core goods inflation. But by increasing the overall price level, the shock to goods prices also implicitly leads nominal wages to increase as workers bid up their wages to restore their purchasing power. This increases marginal costs in the services sector, requiring services prices to increase. As a result, a temporary shock to the goods sector ultimately induces a smaller but persistent increase in services inflation, delaying the return of inflation to target. Despite it being a relative price shock, tighter monetary policy ultimately helps bring inflation back to target faster. With a monetary policy response, CPI inflation returns to target two years. If the policy response is delayed by a year, however, then inflation takes an additional year to return to target.

F. Conclusion

17. Following a period of large interest rate reductions, the projections from the QPM suggest that the next phase of monetary policy normalization should proceed cautiously and more gradually. This is because the model expects the pace of disinflation to slow as external disinflation forces fade and second-round effects continue to push up services inflation. A more gradual reduction in interest rates than embedded in recent market expectations would deliver a slightly smaller pick-up in inflation at the end of 2024 and inflation closer to target in 2025. There are, of course, caveats around these projections, particularly when the outlook is uncertain. For instance, the model may misidentify the size of key "gaps" such as the output or real rate gaps. While the model has been adapted to capture some distinct features of the post-Covid inflation surge, it is unlikely to capture all of them, particularly given the model's reduced form. As such, results from the model should be used alongside other forms of analysis and expert judgement in determining the optimal path of monetary policy. Data should be watched keenly to assess the realism of the model's projections.

G. Model Equations

18. The model consists of four main sets of behavioral equations:

- **Aggregate demand and supply**

The output gap ($\hat{y}_t$) is a function of its lag and its expected value, a monetary conditions index (mci_t), the foreign output gap ($\hat{y}_t^*$) and aggregate demand shocks ($\epsilon_t^{\hat{y}}$). The monetary conditions index is comprised of the real interest rate gap ($\hat{r}_t$), a credit risk premium ($cprem_t$) and deviations in the real exchange rate from its trend ($\hat{z}_t$). The credit risk premium is an exchange rate or country-specific risk premium and a domestic premium. The country risk premium explains deviations in the trend real exchange rate from relative interest rate differentials. The domestic premium reflects the difference between interbank interest rates and bank lending rates charged to the real economy.

$$\hat{y}_t = b_{1a}\hat{y}_{t-1} + b_{1b}E_t\hat{y}_{t+1} - b_2 mci_t + b_3\hat{y}_t^* + \epsilon_t^{\hat{y}}$$

$$mci_t = b_4(\hat{r}_t + cprem_t) + (1 - b_4)(-\hat{z}_t)$$

- **The Phillips curve and relative prices**

Inflation is disaggregated into five sectors: core services, core goods, unprocessed food, fuel, and regulated prices (including gas and electricity). Each sector differs in its degree of price stickiness and sensitivity to the output gap and external costs. In addition, in a multi-sector model each sector's inflation dynamics depend not only on the aggregate output gap but also its relative price gap (Woodford, 2003). A shock to marginal costs in the goods sector pushes up aggregate inflation, which in turn increases nominal wages (to restore real wages) and marginal costs in the services sector. This allows for second-order spillovers of shocks in one sector to another through relative price adjustments.

Quarterly annualized inflation in each sector *j* is modelled using a new-Keynesian hybrid Phillips curve, in which inflation depends on past and expected inflation, real marginal costs and cost-push shocks:

$$\pi_t^j = \alpha_{j1}\pi_{t-1}^j + (1 - \alpha_{j1})E_t\pi_{t+1}^j + \alpha_{j2}rmc_t^j + \epsilon_t^j$$

The real marginal cost in sector *j* is given by:

$$rmc_t^j = \alpha_{j3}\hat{y}_t + (1 - \alpha_{j3})\hat{z}_t - \widehat{rp}_t^j \qquad \text{for } j = services$$

$$rmc_t^j = \alpha_{j3}\hat{y}_t + (1 - \alpha_{j3})((1 - \alpha_{j4})\hat{z}_t + \alpha_{j4}\widehat{rp}_t^{noncore}) - \widehat{rp}_t^j \qquad \text{for } j = core\ goods$$

$$rmc_t^j = \alpha_{j3}\hat{y}_t + (1 - \alpha_{j3})(\hat{z}_t + \widehat{rwfood}_t) - \widehat{rp}_t^j \qquad \text{for } j = unprocessed\ food$$

$$rmc_t^j = \alpha_{j3}\hat{y}_t + (1-\alpha_{j3})(\hat{z}_t + \widehat{rwoil_t}) - \widehat{rp}_t^j \qquad \text{for } j = fuel$$

$$rmc_t^j = \alpha_{j3}\hat{y}_t + (1-\alpha_{j3})(\hat{z}_t + \widehat{rwnatgas_t}) - \widehat{rp}_t^j \qquad \text{for } j = regulated$$

In the core sectors, real marginal costs are determined by the output gap, the real exchange rate gap and relative prices. Real marginal costs for core goods includes the relative price of non-core CPI to capture food and energy prices as key direct inputs. Real marginal costs for non-core sectors also include gaps in the relevant real commodity prices.

The price series are aggregated together using their respective CPI weights, allowing for some persistent measurement error η_t:

$$p_t = w^S p_t^S + w^{CG} p_t^{CG} + w^F p_t^F + w^{Fuel} p_t^{Fuel} + w^{Reg} p_t^{Reg} + \eta_t$$

The relative price gaps are constrained to sum to zero:

$$0 = w^S \widehat{rp_t^S} + w^{CG} \widehat{rp_t^{CG}} + w^F rp_t^F + w^{Fuel} \widehat{rp_t^{Fuel}} + w^{Reg} \widehat{rp_t^{Reg}} + \eta_t$$

- **Interest rates and the policy rule**

Monetary policy is set according to a Taylor rule:

$$i_t = g_1 i_{t-1} + (1-g_1)(i_t^n + g_2(E_t \pi_{t+4}^{CT} - \bar{\pi}_{t+4}) + g_3 \hat{y}_t + h_1 \Delta prem_t) + \epsilon_t^i$$

$$i_t^n = \bar{r}_t + E_t \pi_{t+4}^{CT}$$

$$\bar{r}_t = \rho^{\bar{r}} \bar{r}_{t-1} + (1-\rho^{\bar{r}})(10Y_t^{BUBOR} - \pi_t^T) + \epsilon_t^{\bar{r}}$$

The Taylor rule is standard exception for the inclusion of the term $h_1 \Delta\, prem_t$ which reflects the fact that the central bank may place some weight on the stabilization of the exchange rate, as well as inflation and output. Large fluctuations in the currency may pose financial stability as well as price stability risks. The trend real interest rate is pinned down using the 10-year BUBOR interest swaps rate. The policy rule also uses a measure of inflation that strips out indirect taxes, π^{CT}, given these have only a temporary effect on inflation.

- **Uncovered interest rate parity and the exchange rate**

The nominal exchange rate (s_t) is determined by a UIP condition with a backward-looking element to capture stickiness in the adjustment of the exchange rate. A more positive value indicates a depreciation. Growth in the trend real exchange rate ($\Delta\bar{z}_t$) is a weighted average of its lag and a steady-state value. The exchange rate premium is additional premium investors for holding the currency over and above the returns from the real interest rate differential.

$$s_t = (1-e_1)E_t s_{t+1} + e_1\left(s_{t-1} + \frac{2(\bar{\pi}_t - \bar{\pi}_t^* + \bar{z}_t)}{4} + (i_t - i_t^* + prem_t) + \epsilon_t^s\right.$$

$$\Delta\bar{z}_t = \rho^z \Delta\bar{z}_{t-1} + (1-\rho^z)\Delta\bar{z}^{ss} + \epsilon_t^{\bar{z}}$$

- **Foreign variables**

The world block consists of global real commodity prices – food, oil and natural gas. Trends are estimated for each real commodity price, with the gaps relevant for domestic price pressures. The world economy is assumed to be summarized by variables for the euro area given Hungary's close trading links with the block. These variables include GDP, headline inflation, the ECB's policy rate and an output gap and are conditioned on the projections for these variables in the April 2024 WEO. The dynamics of the world variable gaps are generally modelled as AR(1) processes.

H. Calibration and Impulse Responses

19. The model is calibrated to produce plausible impulse responses that also correspond with those from the literature, including Szilágyi et al (2013) and Békési et al (2016). The main parameters are summarized in **Table 1**. The baseline projections use the calibrated model. But as a cross-check select important parameters are estimated over 2006-2024 Q1 using Bayesian techniques, using the calibrated values as priors. These are reported in the adjacent column and in most cases are close to the calibrated values.

Table 1. Hungary: QPM Parameters

Parameter		Value	Estimated	Parameter		Value	Estimated
IS curve				**Policy rule**			
Persistence	b_{1a}	0.5	0.43	Interest rate smoothing	g_1	0.7	0.73
Expected output	b_{1b}	0.05	0.05	Weight on inflation deviation	g_2	1.2	1.06
Interest rate channel	b_2	0.1	0.10	Weight on output gap	g_3	0.25	0.31
External demand	b_3	0.3	0.40	Weight on exchange rate premium	h_1	0.2	
Weight on real rate gap in monetary conditions index	b_4	0.8					
Core services Phillips curve				**Core goods Phillips curve**			
Persistence	α_{11}	0.4	0.37	Persistence	α_{21}	0.4	0.52
Real marginal costs	α_{12}	0.1	0.07	Real marginal costs	α_{22}	0.1	0.09
Loading on output gap in real marginal costs	α_{13}	0.75		Loading on output gap in real marginal costs	α_{23}	0.2	
				Loading on non-core costs	α_{24}	0.75	0.83
Unprocessed food Phillips curve				**Fuel Phillips curve**			
Persistence	α_{41}	0.5	0.27	Persistence	α_{41}	0.3	0.29
Real marginal costs	α_{42}	0.1	0.15	Real marginal costs	α_{42}	0.4	0.13
Weight on output gap in real marginal costs	α_{43}	0.3		Loading on output gap in real marginal costs	α_{43}	0.0	
Regulated prices Phillips curve				**Exchange rate**			
Persistence	α_{15}	0.1		Exchange rate persistence	e_1	0.3	
Real marginal costs	α_{25}	0.2					
Loading on output gap in real marginal costs	α_{35}	0.9					

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