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Monetary policy credibility, avoiding dark corners, and risk management: a response to Ben Bernanke's review of monetary policy-making at the Bank of England

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Abstract

Ben Bernanke's *Forecasting for Monetary Policy Making and Communication at the Bank of England: A Review* provides a stimulus for central banks worldwide to rethink their approach to monetary policy-making. In this paper we present an analytical framework which is designed to guide this re-evaluation. We agree with Bernanke that central banks need to adopt a scenario-based approach to monetary policy. And we also agree that there is the need for policy-makers to make clear how their policy is likely to respond to whatever scenario is being considered within the policy discussion. But—in addition—we emphasize the need to build a strategy to maintain credibility of monetary policy. In particular, we present the Forecasting and Policy Analysis System (FPAS), a scenario-based approach which has been adopted by the central banks of Armenia and Georgia. We show how using such a system can help policy-makers avoid 'dark corners'—conditions where inflation destabilizes monetary goals. This FPAS system integrates Alan Greenspan's principles of risk management with a transparent and accountable structure. A cornerstone of this system is the Endogenous Policy Credibility (ENDOCRED) model, a multi-country gap model. This model focuses on key nonlinearities that capture how monetary policy credibility might be gained, or lost, through policy action. We describe the application of the ENDOCRED model to the US and euro area during the Covid pandemic. The ENDOCRED model's insights highlight the critical interplay between credibility, risk management, and macroeconomic stability in crafting an effective monetary policy framework.

Keywords: central banking, monetary policy, credibility, macroeconomic models.
JEL codes: E47, E52, E58, E61, E66

I. Introduction

'We need models in which the credibility of a central bank is endogenous to its actions, (King 2024)".

The summer of 2021 vividly illustrated the dangers of relying too heavily on baseline assumptions under high uncertainty. Central banks, including the Federal Reserve System (Fed), adhered for too long to the narrative that inflation was 'transitory', delaying decisive policy actions that could have mitigated inflation persistence. Critics such as Larry Summers highlighted these missteps at the time, emphasizing that the reluctance to respond to growing evidence of persistent inflation risks allowed inflation pressures to build, and the costs of inaction would likely exceed the risks of over-tightening. These warnings foreshadowed the difficulties central banks later faced in re-anchoring medium-term inflation expectations and combating inflation premiums embedded in sticky prices and wage-setting behaviour.

Ben Bernanke's review of monetary policy-making at the Bank of England was a response to these events. He recommended that the Bank of England adopt a scenarios-based approach to monetary policy that tackles uncertainty in a more open and transparent manner. And he recommended that, when doing this, central banks must make clear the way in which their policy instrument will need to respond depending on the scenario that is being considered. In our view, central banks must move their analytical frameworks in the direction which Bernanke has suggested. This will—in our view—represent an important structural change in the way in which monetary policy is made.

In this paper we discuss how to implement such a framework. In addition to discussing the Bernanke proposals we add to the discussion a treatment of monetary policy credibility. We show how much easier it will be to deal with the circumstances which different scenarios present if the central bank has gained credibility for its policy-making. We discuss in some detail the difficult task of building such credibility. And we discuss what happens when this credibility is lost.

To address these challenges, the authors have contributed to the development of a transparent risk management approach referred to as the Forecasting and Policy Analysis System (FPAS) Mark II, originally described in Archer *et al.* (2022). This approach emphasizes constructing case scenarios—such as one in which inflation proves transitory and another in which inflation is persistent—to prepare policy-makers and financial markets for potential adverse outcomes. By evaluating the costs of delayed responses under each scenario, the approach ensures that central banks are positioned to act decisively depending on how the data evolve. Preparing financial markets for such possibilities enables faster adjustments and reduces the risks of losing credibility. As we show, the central banks of Armenia (CBA) and Georgia (NBG) have proposed a formal change to their analytical policy-making framework to make use of this system (Laxton *et al.* 2024).

A useful tool for implementing this strategy is the Endogenous Policy Credibility Model (ENDOCRED). Kostanyan *et al.* (2022a) applied a closed US economy version of the model to the summer of 2021, that demonstrated how an insufficiently aggressive response to inflation allowed inflationary pressures to become embedded in sticky prices and wages, complicating the task of re-anchoring medium-term inflation expectations, something the Fed and other central banks have continued to grapple with years later. Unlike long-term inflation expectations measured in financial markets—which have remained relatively anchored—medium-term expectations, embodied in the pricing of infrequently adjusted goods and wages, have drifted upward. This divergence highlights the importance of distinguishing between different inflation expectations and addressing persistent inflation premiums with timely policy responses. The open-economy ENDOCRED model (Kostanyan *et al.* 2022*b*) extends this analysis to include exchange rate dynamics and risk premia, addressing the vulnerabilities of small open economies. Together, these models form the analytical backbone of the CBA's FPAS Mark II framework, which integrates scenario-based decision-making and non-linear modelling to manage uncertainty.

The structure of the paper is as follows. Section II is a brief historical overview of monetary policy credibility. Section III introduces a linear, canonical multi-country gap model for constructing macroeconomically consistent projections. Section IV presents additional elements, including the endogenous policy credibility process that turns the canonical model into ENDOCRED and provides a simulation for the US and the euro area during the pandemic. The simulations illustrate the mechanics of the model and the implications that a lack of monetary policy credibility can have on the transmission of monetary policy. However, since monetary policy credibility encompasses much more than what can exist in a model, Section V discusses the broader design of monetary policy frameworks that piggybacks off Ben Bernanke's recommendations to the Bank of England to adopt a scenarios-based approach to monetary policy. Section VI simulates an FPAS Mark II exercise for the US using ENDOCRED to produce case scenarios we believe are pertinent for risk management in current day. Section VII wraps up the analytical discussion by returning to small open economies such as the United Kingdom and Israel and contrasting how credibility has evolved in each country and the implications for the future. Section VIII concludes.

II. Development of credibility-focused models

The development of credibility-focused models has been transformative for central banks, reshaping inflation-targeting frameworks. This evolution began with the work of Laxton *et al*. (1994b) at the Bank of Canada and was further advanced in subsequent research, including Isard *et al*. (2001), Laxton and N'Diaye (2002), Argov *et al*. (2007), and Alichi *et al*. (2009). These studies make the point that a central bank that pursues an inflation targeting regime should adopt a strategy that explicitly incorporates credibility into their analytical framework to ensure monetary policy is working properly. Monetary policy credibility evolves dynamically in this framework and has the following dimensions:

(1.) Are long-term inflation expectations in bond markets anchored to the target?
(2.) Are medium-term inflation expectations among wage and price setters anchored to the target?
(3.) And perhaps most importantly, is the monetary policy transmission mechanism operating as it was designed to do? Do long-term real interest rates, the exchange rate, and asset prices work as shock absorbers or amplifiers? For instance, when the economy is hit with a negative demand shock, do long-term real interest rates fall and the exchange rate depreciate to absorb the shock and help steer the economy back towards the inflation target?

Later in the paper we derive a specific measure of monetary policy credibility that is based purely on the view held in bond markets, but it should be clear that evaluating monetary policy credibility goes well beyond this single dimension. Furthermore, these studies on monetary policy credibility highlight the significant economic costs associated with losing and regaining credibility. When inflation premiums become embedded in sticky prices and wages, they are inherently persistent, making delayed policy responses costly both economically and reputationally.

While advanced economies benefitted from a period of relative tranquillity during the Great Moderation period following the 1970s, emerging market economies were not as lucky. Monetary policy credibility has proven to be helpful for understanding and managing the trade-offs between inflation stabilization and economic slack as credibility evolves. For instance, the Reserve Bank of India (RBI) has applied such a framework as described in chapter 11 of *Advancing the Frontiers of Monetary Policy* by Al-Mashat *et al*. (2018). The RBI employs dual quarterly projection models (QPMs). The first is a linear QPM used for quantitative forecasts that mirror the canonical model in Section III. The second is an ENDOCRED model with nonlinearities as described in Section IV. The combination of these models has enhanced the RBI's policy analysis by identifying risks and providing tools to simulate alternate scenarios. This approach has helped the RBI identify potential errors that might arise from reliance on simpler linear models, underscoring the importance of integrating different analytical tools in policy formulation.

Similarly, the Reserve Bank of New Zealand's (RBNZ) experience underscores the risks of inadequate modelling frameworks. Before adopting a model-based forecasting and policy analysis framework in 1998, as documented by Drew and Hunt (1998), the RBNZ relied on rigid approaches to target inflation on a period-by-period basis that failed to manage trade-offs effectively. During this period, the approach was likened to 'trying to brush your teeth through your ear'—a method that might achieve the goal but with unnecessary pain and inefficiency. As highlighted by Haworth *et al*. (2020), the RBNZ relied heavily on the exchange rate channel to manage inflation, imposing significant self-inflicted economic costs. Compounding these issues, the RBNZ lacked an FPAS to guide their inflation-targeting efforts. This approach led the RBNZ to tighten monetary policy significantly, resulting in substantial economic slack and a sharp appreciation of the New Zealand dollar. The exchange rate appreciation had devastating effects on the tradable goods sector, particularly on farmers, who bore the brunt of the downturn. Following this experience, the RBNZ transitioned to a more flexible inflation-targeting framework, acknowledging the importance of managing inflation and output through a balanced approach that considers both short- and medium-term objectives. These lessons remain central to discussions on inflation targeting frameworks globally. The introduction of an FPAS allowed the RBNZ to integrate judgment with model-based forecasts, improving policy coherence and communication.

These examples highlight how models serve dual purposes for central banks. First, as thinking devices, they help policy-makers conceptualize the economy's dynamics and the evolution of trade-offs under varying levels of credibility. Second, as projection tools, they organize the forecasting process and integrate empirical evidence with judgment. The shift from opaque, ad hoc, judgment-driven approaches to transparent and structured systems like an FPAS demonstrates the importance of advanced modelling frameworks in enhancing credibility, anchoring inflation expectations, and managing economic trade-offs more effectively. These innovations reflect the broader trend towards flexible, data-driven inflation-targeting frameworks that balance short-term fluctuations with long-term objectives.

While credibility is often lost quickly and regained slowly, there are exceptions. The UK's experience in May 1997 provides a compelling example. As documented in chapter 3 of *Advancing the Frontiers of Monetary Policy* (Al-Mashat *et al*. 2018), the Bank of England gained credibility rapidly after it was granted independence with a clearly defined inflation target. Within 9 months, long-term inflation expectations, as measured by the spread between nominal and indexed bonds, converged to the new 2.5% target. This outcome underscores the importance of instrument independence, clearly defined goals, and an institutional framework that aligns incentives and reinforces confidence in monetary policy.

Finally, the history of the Bank of Israel provides a nice example of the impact of credibility on macroeconomic outcomes. Between 2001 and 2007, the central bank faced two major economic shocks under distinct credibility regimes—first with low credibility and later with high credibility. In late 2001, the dot-com bubble burst and in the face of a weakening economy, the Bank of Israel cut the policy rate by 200 basis points. This led to a depreciation of the shekel, which generated an upward pressure on prices with headline inflation rising to 7% by July 2002. Only 5 months later, the Bank of Israel would begin raising rates by 450 basis points, which raised questions about the policy intentions and exacerbated the exchange depreciation via the risk premium when a weaker shekel was already reflecting an economic recession. Inflation continued to rise, and long-run inflation expectations ratcheted upwards to levels above the 3% upper level of the target band. The central bank maintained a tight stance at around 9% until mid-2003, although the economy was struggling to get out of a protracted recession.

In hindsight, it may seem that the central bank kept the policy rate too high for too long and the accompanying exchange rate appreciation pushed inflation into negative territory for an extended period. However, as Fig. 1 shows, this was understandable since the Bank of Israel was fighting a high inflation regime with long-run inflation expectations stubbornly above the 1−3% band and arguably needed a period of below target inflation to anchor inflation expectations. The episode illustrates how low monetary policy credibility can complicate the management of the economy and result in abrupt changes in the policy rate and contribute to volatile economic activity.

The Bank of Israel eventually succeeded in bringing long-run inflation expectations back inside the target band restoring credibility despite its high costs. Furthermore, the Bank of Israel would later adopt a more forward-looking approach to inflation targeting. This combination would quickly prove to be invaluable for efficiently managing the output–inflation trade-off. In 2006, headline inflation overshot the upper band from a one-time pass-through effect of exchange rate depreciation and a steep increase in oil prices along with a fall in spare capacity. In this case, only a modest response from monetary policy was required unlike in 2002–3 and it did not result in an upward ratcheting in long-term inflation expectations. Instead, real interest rates remained broadly stable throughout 2006, while long-run inflation expectations continued their descent toward the midpoint of the target range (Fig. 2).

Once a central bank is successful in establishing credibility as the Bank of Israel did, the benefits from an improvement in the output–inflation trade-off under anchored inflation expectations is clear. Therefore, central banks may want to take pre-emptive action against threats to their credibility to maintain such benefits. After several years of above target inflation from the pandemic era, models with endogenous policy credibility can provide the intuition behind a campaign for

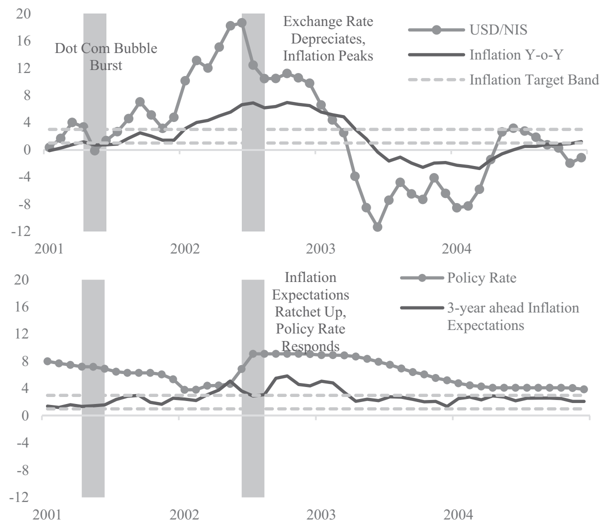

Figure 1: Israel interest rates, inflation and exchange rates, 2001–4 (%)
Note: NIS = new shekel.
Source: Bank of Israel, Central Bureau of Statistics.

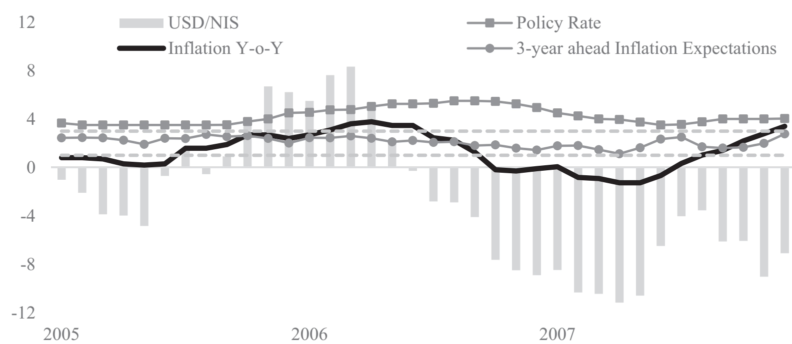

Figure 2: Israel interest rates, inflation, and exchange rates, 2005–7 (%)
Note: NIS = new shekel
Source: Argov *et al*. (2007); Bank of Israel, Central Bureau of Statistics; IMF staff estimates

a monetary policy strategy that is more explicitly focused on anchoring inflation and inflation expectations.

III. The canonical linear multi-country gap model

This section describes the main behavioural equations of a simple canonical semi-structural multi-country gap model that largely follows Berg *et al*. (2006). The role of this model is to serve as a core production model at a central bank. In the next section we transform the canonical model to ENDOCRED to explore more interesting policy perspectives that complement the canonical model.

The canonical model includes equations for output, inflation, a short-term interest rate, and the exchange rate for two economies that are jointly determined. The gaps of variables from their equilibrium values play a crucial role in the functioning of the system. Gaps are denoted with a hat while equilibrium values are denoted with a bar on top. We present the model for a country labelled i, where the specifications for other countries should be similar, although the coefficient estimates, and the standard deviations of the structural shocks will differ based on expert knowledge of those economies.

(i) Monetary policy

Monetary policy is a function of its lag and movements of the output gap, $\hat{y}_t$, and the deviation of the expected year-on-year inflation rate, $\pi 4_{t+3}$, from its target, π^{tar}. The inclusion of expected inflation implies that the central bank may want to discount shocks that are expected to reverse within a three-quarter horizon. Incorporating this type of inflation forecast-based rule has been part of the early semi-structural models developed by the Bank of Canada (Coletti *et al.* 1996). They invested heavily into developing methods for solving forward-looking models which allowed them to do interesting policy scenario analysis and are once again investing in the next generation of analytical models (Coletti 2023). At around the same time John Taylor had popularized a variant of the same equation where, $\pi 4_{t+3}$, is replaced with, $\pi 4_t$, making it backward-looking. The equation includes a disturbance term, ε_t^i.

$$i_{i,t} = \delta_{i,1} i_{i,t-1} + \left(1 - \delta_{i,1}\right) \left[\bar{r}_{i,t} + \pi 4_{i,t+3} + \delta_{i,2} \left(\pi 4_{i,t+3} - \pi^{tar}\right) + \delta_{i,3} \hat{y}_{i,t}\right] + \varepsilon_{i,t}^i \tag{1}$$

Where the three-quarter-ahead year-on-year inflation rate forecast represents the average of the expected inflation rates for the upcoming three quarters:

$$\pi 4_{i,t+3} = \frac{1}{4} \sum_{j=0}^{3} \pi_{i,t+j} \tag{2}$$

In the canonical linear model presented in this paper, inflation forecast-based reaction functions (IFBRFs) feature prominently. These rules rely on the year-on-year inflation rate forecast three quarters ahead, calculated as the average of quarterly inflation rates for $t+1, t+2,$ and $t+3$. The IFBRFs were first developed at the Bank of Canada in the late 1980s as part of a broader effort to address model uncertainty (Isard *et al.* 1999). The fundamental innovation was to use forward-looking inflation forecasts as inputs to monetary policy decisions, which proved robust across a range of model specifications, including those with nonlinearities such as convex Phillips curves or endogenous policy credibility.

The three-quarter horizon was chosen for its effectiveness in balancing short-term responsiveness with the need to avoid overreacting to temporary inflation deviations. The analogy is often made to steering a car: policy-makers use incoming data to make course corrections gradually, allowing the economy to adjust dynamically. This approach ensures that errors in understanding the economy—such as underestimating inflation pressures—are incorporated into future forecasts, avoiding excessive responses to observed inflation alone. This distinguishes IFBRFs from simpler, backward-looking Taylor-type rules, which use contemporaneous inflation and are less effective in dealing with nonlinear dynamics.

While these reaction functions performed well during periods of relative stability, such as the Great Moderation, their limitations became evident during the Global Financial Crisis (GFC) and other episodes involving large shocks or significant nonlinearities. These challenges highlighted the need to move beyond IFBRFs towards frameworks that minimize explicit loss functions, allowing central banks to design more robust policy paths under conditions of heightened uncertainty. This shift, explored in the next section, is central to developing prudent risk management approaches that can address scenarios where inflation and output deviate significantly from expected paths.

The policy feedback, through an endogenous interest rate, is represented by Fig. 3. In the general situation, where the inflation rate differs from the long-term target, policy-makers have a choice how to respond. The approach may be different depending on the preferences regarding the short-term output–inflation trade-off. It might involve a smooth approach or a planned over- or undershoot. Out of the available options, the central bank will implement the one that 'looks best', that is, the one that reflects its judgment as to the best outcome relative to the trade-offs. This type of judgment-based policy-making will feature again later where the policy in the model is understood to support not replace judgment when applied in a real-world setting.

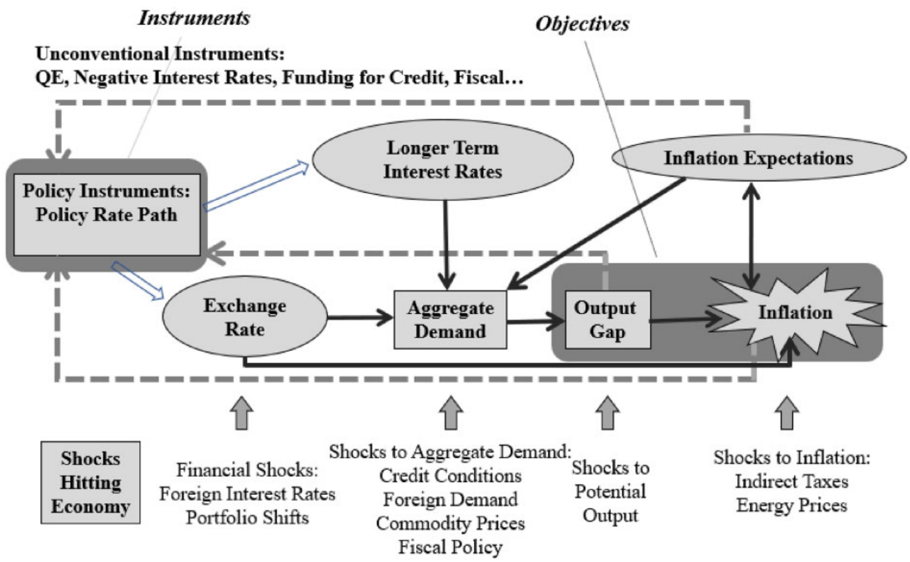

Figure 3: Monetary policy transmission mechanism
Source: Authors' construction.

Perhaps more importantly, the endogenous interest rate signifies that a central bank's policy goes well beyond the current setting of the policy rate on the decision day. The most direct channel of monetary policy is not only the decision of that very short-term repo rate but the expectations of future policy rate movements over the short to medium term, as depicted by the arrows pointing to 'Longer-term interest rates'. Indeed, the cost of borrowing for businesses and households over longer terms isn't directly set by the central bank. Instead, it is influenced by expectations of future policy rates, which shape the entire yield curve, as well as the current policy rate, which is reflected in the rectangle for the 'Policy Rate Path'. Thus, the transparency regarding how the path of the policy rate might evolve in the future plays a crucial role in shaping expectations and influencing the transmission mechanism. A central bank that uses an exogenous interest rate path (including a path derived from current market forward rates) in a forecast is inconsistent with this depiction of the transmission mechanism. If Figure 3 were modified to represent an exogenous interest rate path, arrows representing feedback to the policy rate would be removed.

In the real world, financial conditions that matter for households and firms in their consumption, investment, and borrowing decisions are interest rates at different maturities. Typically, government bond yields serve as a pricing benchmark with virtually no default risk due to their access to the economy's tax base. Banks, in turn, apply additional risk premiums when offering loans—such as mortgages, consumer credit, corporate bonds, or other forms of lending—to account for the potential that borrowers may default. In bond markets, short-term rates are considered risk-free due to their limited exposure to fluctuations, but longer-term bonds inherently carry greater risks. These risks should be reflected in a 'term premium', compensating investors for holding longer maturities. The long-term interest rates reflect market expectations of future short-term rates, adjusted by term premiums to account for risk and uncertainty.

The model incorporates this feature of long-term effective interest rate, $r^{w}_{i,t}$, as a weighted combination of market interest rates across different maturities, including 3-month (1-quarter), as well as 1-year (4-quarters), 3-year (12-quarters), and 5-year (20-quarters) real interest rates:

$$\hat{r}^{w}_{i,t} = \omega_{i,1}\hat{r}_{i,t} + \omega_{i,4}\hat{r}^{(4)}_{i,t} + \omega_{i,12}\hat{r}^{(12)}_{i,t} + \omega_{i,20}\hat{r}^{(20)}_{i,t} \tag{3}$$

The market real rates themselves are derived from the sum of expected real short-term interest rates for different maturities and corresponding term premiums across various horizons. The expected real interest rates for a specific maturity are the average short-term real interest rates over the respective horizon. The market real interest rate for a 4-quarter horizon is defined as:

$$\hat{r}_{i,t}^{(4)} = \frac{1}{4}\sum_{j=0}^{3}\left(\hat{r}_{i,t+j}\right) + \hat{\phi}_{i,t}^{(4)} \tag{4}$$

We define 3-year and 5-year expected interest rates in the same way.

(ii) Risk-adjusted UIP condition

The uncovered interest parity (UIP) is a key concept in international finance. It posits that the difference in nominal interest rates between two countries should equal the expected change in their exchange rates. According to UIP, investing in a foreign asset should not yield higher returns than investing in a domestic asset once exchange rate movements are accounted for. For instance, if the domestic interest rate is higher than the foreign interest rate, the UIP suggests that the domestic currency is expected to depreciate in the future, offsetting the higher returns from domestic assets and ensuring no arbitrage opportunity. However, in practice, the UIP does not always hold, especially in the short run. Exchange rate movements are influenced by a multitude of factors beyond interest rate differentials. Additionally, investor behaviour often introduces complexities that deviate from the theoretical model.

This is where the risk-adjusted UIP comes into play. It builds on the standard UIP model by incorporating a risk premium (u_{t+j}) into the equation. Investors typically demand additional compensation for holding assets in a country perceived as riskier. This compensation, reflected as a risk premium, accounts for factors like market volatility, liquidity preferences, economic stability, geopolitical risks, etc. Furthermore, the presence of a disturbance term (ε_t^z) allows the exchange rate to deviate from the fundamentals.

$$r_{i,t} = \left[z_{i,t+1}^e - z_{i,t}\right] + \left[r_t^f + u_{i,t}\right] + \varepsilon_{i,t}^z \tag{5}$$

In standard frameworks, the exchange rate is assumed to be determined by fundamentals, aligning with the expected real exchange rate in each period. This implies a forward-looking market where participants use rational expectations to align the exchange rate with economic conditions. However, empirical evidence strongly suggests that exchange rate markets are not fully forward-looking or purely based on fundamentals.

Instead, they exhibit *partly backward-looking behaviour*, where past exchange rate trends influence current dynamics. Notably, Meese and Rogoff (1982) tried to evaluate whether traditional macroeconomic exchange rate models from the 1970s based on macroeconomic fundamentals like interest rate differentials, purchasing power parity, and monetary dynamics could predict exchange rates out-of-sample more accurately than a random walk model. They found that these models generally failed to outperform the random walk, highlighting the limited predictive power of traditional fundamentals-based models for short-term exchange rate forecasting. This reflects the market's reliance on historical data, herd behaviour, and delayed adjustments to new information. By allowing for hybrid expectations, your framework acknowledges this critical balance between fundamentals and backward-looking tendencies. Thus one-period-ahead exchange rate expectations can be modelled in the following way:

$$z_{i,t+1}^e = \tau_{i,1} z_{i,t+1} + \left(1 - \tau_{i,1}\right) z_{i,t-1} \tag{6}$$

In this canonical model we assume $\tau_{i,1} = 1$, a special that would be consistent with the famous Dornbusch overshooting model (Dornbusch, 1976).

(iii) Output gap

Output gap is a function of its past and expected value, lagged real exchange rate gap, $\hat{z}_{t-1}$, foreign output gap, $\hat{y}_t^w$, and it incorporates the lag of the effective long-term real interest rate gap, $\hat{r}_{i,t-1}^w$, to indicate the importance of maturity structure of real interest rates in the transmission channel. Aggregate demand shocks are represented by $\varepsilon_t^{\hat{y}}$.

$$\hat{y}_{i,t} = \beta_{i,1}\hat{y}_{i,t-1} + \beta_{i,2}\hat{y}_{i,t+1} - \beta_{i,3}\hat{r}_{i,t-1}^w + \beta_{i,4}\hat{z}_{i,t-1} + \beta_{i,5}\hat{y}_{i,t}^w + \varepsilon_{i,t}^{\hat{y}} \tag{7}$$

The parameters are based on the work of Alichi *et al*. (2009), which provides a monetary policy framework for the US economy. $\beta_{i,3} = 0.2$, $\beta_{i,4} = 0.02$. Setting $\beta_{i,2} = 0$ and you recover a backward-looking specification. It is important to note that semi-structural models offer greater flexibility than DSGE models by incorporating empirically observed lag structures without being constrained by rigid theoretical assumptions. This allows them to capture delays in the transmission of economic shocks, such as the effects of monetary policy on output or inflation, more accurately. By including backward-looking behaviour and hybrid expectations, semi-structural models strike a balance between theoretical rigor and empirical realism, making them particularly useful for policy analysis and forecasting where DSGE models' rigidities can limit practical applicability.

(iv) Inflation

A linear Phillips curve, which is a function of expected and past inflation, the lagged output gap ($\hat{y}_{t-1}$) and the change in the real exchange rate gap ($\hat{z}_t$). Cost-push shocks are represented by ε_t^{π}.

$$\pi_{i,t} = \lambda_{i,1}\pi 4_{i,t+4} + (1 - \lambda_{i,1})\pi 4_{i,t-1} + \lambda_{i,2}\hat{y}_{i,t-1} + \lambda_{i,3}\left(\hat{z}_{i,t} - \hat{z}_{i,t-1}\right) + \varepsilon_{i,t}^{\pi} \tag{8}$$

$\pi 4_{i,t}$ represents the average inflation rate over the past four quarters, or 1 year. This calculation takes the inflation rates for the current quarter and the three preceding quarters, and then averages them to obtain the 1-year moving average inflation rate. Essentially, we're smoothing out short-term fluctuations in inflation to focus on the broader trend. Why does this matter? Financial and economic systems often experience noise or volatility in quarterly inflation data. A single spike in inflation might not indicate a trend, just as a temporary dip doesn't always signal a slowdown. By using a moving average, we filter out these temporary disturbances, creating a more stable measure of inflation. This approach is particularly useful in models that require a clear, consistent view of inflation dynamics. It helps policy-makers, economists, and analysts better understand how inflation is evolving over time, guiding more informed decisions.

Setting $\lambda_{i,1} = 1$ and you recover a purely forward-looking Phillips curve resembling the system presented by Calvo (1983), otherwise inflation becomes a combination of backward and forward-looking components as introduced by Fuhrer and Moore (1995).

The equations described thus far can be solved together and form the dynamic behaviour of the economy in response to shocks. Subject to certain restrictions on parameters, the real interest rate will adjust sufficiently to find a path for the real economy that will bring inflation back to its target and a path in which the real exchange rate will adjust to assist in the task of bringing inflation back to its target. The endogenous interest rate and exchange rate paths are what gives internal consistency to the model's macroeconomic projections.

IV. ENDOCRED: a model with a non-linear Phillips curve, an exchange rate as a shock absorber or shock amplifier, a monetary policy loss function, and monetary policy credibility

The endogenous policy credibility model (ENDOCRED) is not a core production model but a thinking device, enabling policy-makers to explore alternative scenarios and refine judgments in production processes. For instance, it helps central bankers understand how inflation premiums in sticky prices and wages persist even when financial market expectations remain anchored, ensuring that policies are calibrated to address these dynamics effectively. Models like ENDOCRED complement the linear canonical production model by addressing the persistence of inflation premiums and the dynamic nature of credibility. The prudent risk management approach, rooted in the lessons of 2021 and the insights of critics like Summers, offers a robust framework for managing uncertainty and enhancing policy effectiveness.

(i) The convex Phillips curve

The first modification to the canonical model is introducing a convex Phillips curve, reflecting the non-linear relationship between inflation and unemployment that was an important feature of Phillips' original model (1958). Macklem (1997) provides an in-depth review of the origins of

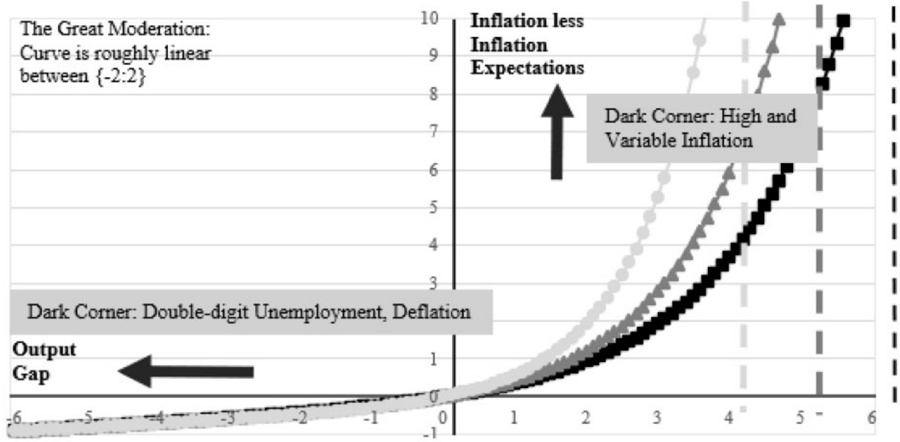

Figure 4: Convex Phillips curve according to different values of y_{max} between 4 and 6
Source: Authors' illustrative Phillips Curve; Kostanyan *et al.* (2022a).

this convexity, highlighting the non-linear relationship between economic activity and inflation and emphasizing that capacity constraints make inflation more sensitive to positive output gaps than negative ones. This convexity in the Phillips curve suggests that proactive and measured monetary policy is crucial to prevent significant economic imbalances and control inflation effectively. Recent work by Forbes *et al.* (2021) establishes that the Phillips curve exhibits significant nonlinearity, where inflation is largely unresponsive to economic slack in low-inflation environments due to downward wage and price rigidity but becomes markedly steeper in high-inflation regimes or when output surpasses potential, reflecting stronger inflationary pressures. Benigno and Eggertson (2023) show that inflation in the 2020s was driven by tight labour markets, with steep inflation responses to low unemployment and minimal effects from wage rigidity at high unemployment levels. Their findings emphasize that anchored inflation expectations and appropriate monetary policy can lower inflation without triggering a severe recession, contrasting with past periods like the 1970s.

The model employs a convex inflation expectations-augmented Phillips curve, illustrated in Fig. 4, where its convex shape comes from the non-linear output gap term, $\left(\frac{\hat{y}_{i,t-1}}{\hat{y}_{max}-\hat{y}_{i,t-1}}\hat{y}_{max}\right)$.

$$\pi_{i,t} = \lambda_{i,1}\pi 4_{i,t+1} + (1-\lambda_{i,1})\pi 4_{i,t-1} + \lambda_{i,2}\left(\frac{\hat{y}_{i,t-1}}{\hat{y}_{max}-\hat{y}_{i,t-1}}\hat{y}_{max}\right) + \lambda_{I,3}\left(\hat{z}_{i,t} - \hat{z}_{i,t-1}\right) + \varepsilon^{\pi}_{i,t} \qquad (9)$$

As the output gap gets closer and closer to its maximum value, the slope of the Phillips curve gets steeper. The y_{max} parameter follows the logic of the relationship between the output and unemployment gap set forth by Okun's Law, in that a high output gap results in an unsustainably low unemployment gap. This is represented by the right part of the curve where the dark corner and high and variable inflation prevail, as famously highlighted by Blanchard (2014).

To describe the asymptotic region of the curve, we like the disaggregated approach taken by Evans (1985), which describes how bottlenecks—sectors where firms operate at full capacity—cause aggregate supply to become progressively less elastic as demand increases. As more sectors reach capacity limits with labour becoming fully employed, wages adjust flexibly to clear the market. The aggregate supply curve steepens, eventually leading to inflation without further output gains. This conceptual approach is useful to connect the anecdotal information about labour shortages during the pandemic with the steepening of the Phillips curve which some economists used to explain part of the recent surge in inflation. Summers (2021) and Blanchard (2021) argued against the notion that pandemic-era inflation would be transitory, emphasizing that unprecedented fiscal and monetary stimulus could push the economy into the steeper region of the Phillips curve. In this scenario, tight labour markets would amplify wage and price pressures, potentially leading to persistent inflation. They warned of risks like de-anchored inflation expectations and a wage-price spiral. Blanchard and Bernanke (2023) revisit this debate, acknowledging that while labour market overheating eventually contributed to persistent inflation, the initial surge was primarily driven by product market shocks, such as commodity price increases and supply chain disruptions. They highlight that these factors were underestimated in early inflation forecasts. The 1970s US economy is an example of a dark corner with high and variable inflation coupled with high unemployment, a phenomenon known as stagflation. Driven by oil shocks, monetary policy missteps, and the collapse of the Bretton Woods system, inflation reached double digits, later requiring sharp and painful disinflationary measures.

The middle region of the curve, where the output gap is close to zero, represents the linear space and is best characterized by the Great Moderation era (from the mid-1980s until the GFC) where the output–inflation trade-off was modest and well-behaved. The left side of Fig. 4 represents the dark corner where high unemployment and deflationary forces dominate. In this region, the Phillips curve is relatively flat based on the effects of downward wage and price rigidities (Forbes *et al*. 2021), as well as the hysteresis effects described by Blanchard and Summers (1986). A notable example of when this environment prevailed was the post-GFC period, where it took policy-makers several years to escape a low inflation trap. In some cases, such as in the euro area, these deflationary pressures persisted into the pandemic.

Hysteresis, as described by Blanchard and Summers (1986), highlights how temporary shocks to unemployment can have lasting impacts on the economy, eroding the economy's productive potential through mechanisms like skill loss, capital deterioration, and labour market dynamics favouring insiders over outsiders. These persistent effects make it imperative to adopt models that go beyond linear approximations. Debelle and Laxton (1997) emphasize the role of monetary policy to provide a buffer zone to guard against excessive economic variability, especially in a world where hysteresis effects may arise. Building on Laxton *et al*. (1994a), Clark *et al*. (1996), and Turner (1995), they support the existence of asymmetries in the Phillips curve, advocating for models that incorporate inherent nonlinearities, such as a convex Phillips curve, to better represent the real-world dynamics of inflation and output.

Additionally, Laxton *et al*. (1999) argue that the costs will be higher if policy-makers assume linearity when in fact it is convex. If the Phillips curve is linear, positive and negative demand shocks will have equal effects on inflation. Additionally, the timing of monetary policy responses becomes less important, giving central banks little motivation to act early against inflationary pressures and more reason to delay. In contrast, in the case of a convex Phillips curve, inflation rises disproportionately faster from positive demand shocks than it declines in response to equivalent negative demand shocks. This makes early action against rising inflation critical to avoid larger problems later. By acting promptly, central banks can reduce the need for more extreme measures in the future and stabilize employment levels, thereby lowering the average unemployment rate over time. Therefore, in a convex world, a prudent risk management approach to monetary policy aims to prevent significant cyclical imbalances. Small steps to test the limits of an economy's capacity—such as allowing moderate inflationary pressure—are relatively low-risk. However, large mistakes, like letting the economy overheat significantly, can lead to steep costs in terms of higher inflation, economic instability, and the need for severe corrective measures.

(ii) Uncovered interest rate parity: shock absorbers and amplifiers

To explore the dynamics of exchange rates and interest rates in different monetary policy regimes, we derive a multi-period uncovered interest rate parity (UIP) condition. This derivation provides a framework for analysing how exchange rate and interest rate movements interact with the monetary transmission mechanism. Depending on the credibility of the central bank and the prevailing economic conditions, these variables can act as either shock absorbers or shock amplifiers (Fig. 5). During normal times, when economic stability prevails, exchange rates and interest rates generally function as stabilizing forces, absorbing shocks and mitigating their impact. However, the role of credibility becomes especially crucial during periods of economic turbulence, filled with

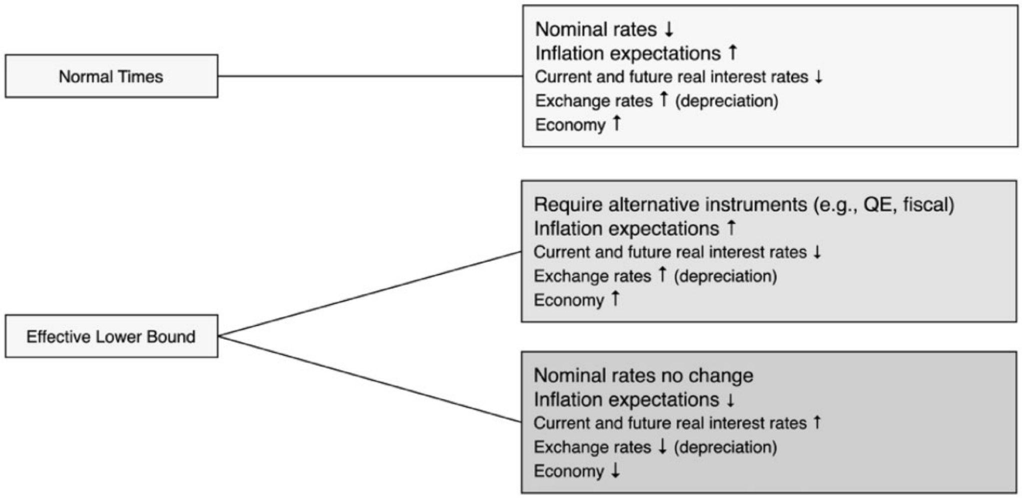

Figure 5: Exchange rates and interest rates as shock absorbers or amplifiers
Source: Adapted from Clinton *et al.* (2015).

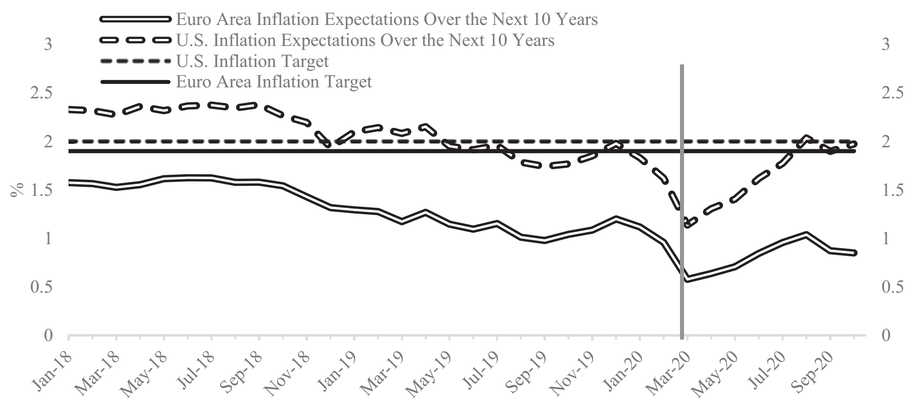

Figure 6: Inflation expectations over the next 10 years in the US and euro area
Source: Bloomberg.

heightened economic uncertainty. When the economy enters the 'dark corners' of either high and variable inflation or a low inflation trap, the central bank's credibility is tested to its full extent. In such turbulent times, credibility determines whether exchange rates and interest rates continue to act as stabilizing shock absorbers or instead amplify shocks, exacerbating economic volatility and deepening instability.

Recognizing the importance of these dynamics, we begin by introducing the standard one-period risk-adjusted UIP condition.

$$r_t = [z_{t+1} - z_t] + \left[r_t^f + u_t\right] + \varepsilon_t^z \tag{10}$$

Extending it to the next period, we get:

$$r_{t+1} = [z_{t+2} - z_{t+1}] + \left[r_{t+1}^f + u_{t+1}\right] + \varepsilon_{t+1}^z \tag{11}$$

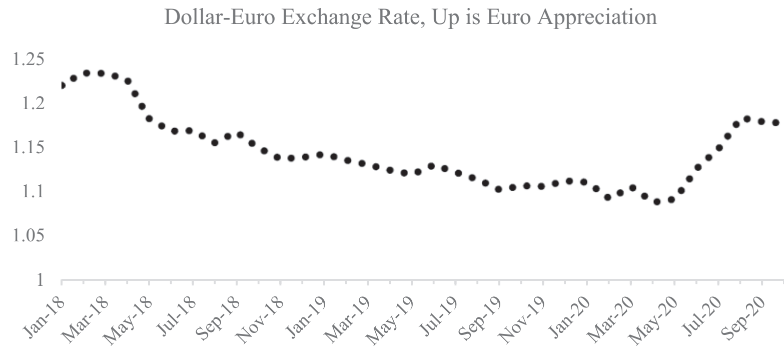

Figure 7: A breakdown in the ECB transmission mechanism due to the effective lower bound
Source: Bloomberg

If this holds for any time t:

$$r_{t+k} = \left[z_{t+k+1} - z_{t+k}\right] + \left[r^f_{t+k} + u_{t+k}\right] + \varepsilon^z_{t+k} \tag{12}$$

Summing up all the equations, from time t to $t + k$ yields:

$$\sum_{j=0}^{k} r_{t+j} = \left[z_{t+k+1} - z_t\right] + \sum_{j=0}^{k}\left[r^f_{t+j} + u_{t+j}\right] + \sum_{j=0}^{k}\varepsilon^z_t \tag{13}$$

Real exchange rate as a shock absorber

Under normal circumstances, with an active monetary policy, a negative demand shock leads to a reduction in inflation in the short run, while the long-run real exchange rate (z_{t+k+1}) remains unaffected. In response, an inflation targeting central bank typically lowers the policy rate to stimulate the economy and to bring inflation back to target. According to the UIP condition, this rate cut leads to an immediate depreciation of the currency: the spot exchange rate must rise to offset the anticipated decline in future interest rates.

Or in other words, in a credible policy regime, medium-term inflation expectations would rise and real interest rates would decline more than nominal rates. At the effective lower bound (ELB), while the nominal rate cannot fall further, expectations of prolonged ELB conditions and higher inflation would lead to a reduction in real interest rates. Thus, in case of normal times, as well as during ELB with an active credible policy, we have ($\downarrow \sum_{j=0}^{k} r_{t+j}$). As a result, the real exchange rate will depreciate ($Z_t \uparrow$), given that long-run real exchange rate (z_{t+k+1}), expected trajectory for real foreign interest rate along with risk premium ($r^f_{t+j} + u_{t+j}$), as well as disturbance term (ε^z_t) remain unaffected.

$$\downarrow \sum_{j=0}^{k} r_{t+j} = \left[z_{t+k+1} - \uparrow z_t\right] + \sum_{j=0}^{k}\left[r^f_{t+j} + u_{t+j}\right] + \sum_{j=0}^{k}\varepsilon^z_t \tag{13.1}$$

This depreciation boosts demand by stimulating exports and encouraging a shift in expenditure from foreign goods to domestic goods.

Real exchange rate as a shock amplifier

At the ELB, the exchange rate can exacerbate the effects of a shock. If the policy response is passive and lacks credibility, a negative demand shock would lead expectations of lower inflation in the future. This could cause both current and anticipated short-term real interest rates to rise

Figure 8: Inflation expectations and the measure of credibility 2018–24
Note: The target in the US is assumed to be 2.3% as inflation expectations are tied to the Consumer Price Index while the Fed targets the Personal Consumption Expenditure price index. Vertical lines signify pandemic lockdowns and re-opening.
Source: Author's calculations; Bloomberg.

($\uparrow \sum_{j=0}^{k} r_{t+j}$), resulting in a real appreciation of the currency ($Z_t \downarrow$).

$$\uparrow \sum_{j=0}^{k} r_{t+j} = \left[z_{t+k+1} - \downarrow z_t\right] + \sum_{j=0}^{k} \left[r^f_{t+j} + u_{t+j}\right] + \sum_{j=0}^{k} \varepsilon^z_t \tag{13.2}$$

The appreciation exacerbates the recession.

To analyse the real-world implications of the ENDOCRED model, we apply it to a two-country framework, focusing on the United States and the eurozone during the early stages of the Covid-19 pandemic. Using the multi-period risk-adjusted UIP condition, we examine how credibility—or the lack of it—shaped the monetary transmission mechanism, particularly through the behaviour of exchange rates and interest rates. The model highlights how these variables acted as shock absorbers for the US economy, supported by a credible central bank, while they functioned as shock amplifiers in the eurozone, where credibility was weaker during this period. This dynamic underscores the importance of monetary policy credibility in ensuring the smooth functioning of the transmission mechanism and avoiding macroeconomic instability, particularly in times of heightened economic uncertainty.

The two-country set-up distinguishes between US monetary policy, modelled with a loss function, and euro area monetary policy, represented by a canonical inflation-forecast-based reaction function. While these approaches are not exact replicas, they reflect the historical behavioural differences between the Fed and the ECB. During the pandemic, these differences were evident as the eurozone struggled with a low inflation trap, with inflation expectations significantly below its target, while, in contrast, inflation expectations in the US remained relatively well-anchored (Fig. 8). This two-country analysis highlights the importance of credibility in maintaining effective monetary policy and exchange rate stability.

As the pandemic progressed, inflation expectations ratcheted downwards in both countries from the uncertainty presented by the lockdown policies which not only hit the supply side of the economy but also demand, lowering inflation in the short run. Normally under these circumstances, an inflation forecast targeting central bank would be expected to reduce the policy rate and the exchange rate would depreciate and act as a shock absorber to help eliminate the output gap and steer inflation back to the target as depicted in a standard nominal UIP equation where s_t is the nominal exchange rate.

$$\Downarrow \sum_{j=0}^{k} i_{t+j} = \left[s_{t+k+1} - \Uparrow s_t\right] + \sum_{j=0}^{k}\left[i^f_{t+j} + u_{t+j}\right] \tag{14}$$

However, since it was a globally synchronized shock, central banks around the world were cutting interest rates to stimulate their economies. Yet, the ECB was handicapped with rates at the effective lower bound. As inflation expectations ratcheted down and nominal rates not being able to decline further naturally means that real interest rates would naturally rise and apply appreciation pressure on the exchange rate (equations 14.1, 15, Fig. 9).

$$\sum_{j=0}^{k} i_{t+j} = \left[s_{t+k+1} - \Downarrow s_t\right] + \sum_{j=0}^{k}\left[i^f_{t+j} + u_{t+j}\right] \tag{14.1}$$

$$\Uparrow r_t = i_t - E_t\pi_{t+1} \Downarrow \tag{15}$$

(iii) Adding a loss function for monetary policy with asymmetric preferences to overheating

In the model we have an option for monetary policy that is represented by a loss function that penalizes squared deviations of negative output gap only, $\widehat{yneg}^2_{i,t+j}$, inflation from the target, $(\pi 4_{t+j} - \pi^*)^2$, changes in the policy rate, $(i_{i,t+j} - i_{i,t+j-1})^2$, and the price level gap, $(P_{i,t+j} - P^*)^2$.

$$Loss_{i,t} = \sum_{j=0}^{\infty} \rho^j[\omega_{i,1}(\pi 4_{i,t+j} - \pi^*)^2 + \omega_{i,2}\widehat{yneg}^2_{i,t+j} + \omega_{i,3}(i_{i,t+j} - i_{i,t+j-1})^2 + \omega_{i,4}(P_{i,t+j} - P^*)^2 \tag{16}$$

The term ρ represents the discount rate. The weights (ω_i) embody the costs that policy-makers attach to each of these items. Monetary policy minimizes this loss function, subject to the constraints imposed by the structure of the model. Monetary policy has choices with respect to the speed at which inflation returns to the target.

This may be faster if the cost of missing the inflation target is high relative to the costs of output gaps and interest rate volatility. Or, it may be slower if the cost of inflation-targeting errors is relatively low, such as when long-term inflation expectations are well-anchored and there is a high degree of confidence in the inflation-targeting regime. The quadratic loss function implies symmetric aversion to overshoots and undershoots with respect to the inflation target and potential output. However, one might argue that policy-makers' preferences would not be symmetrical. In this case, it is possible to restrict the loss function to only recognize undershoots and not overshoots and vice versa. In fact, our calibration of the loss function for the US only responds to negative output gaps and not positive gaps, reflecting a view that the Fed is more tolerant of overheating than cooling in the real economy.

(iv) Constructing monetary policy credibility from the bond market

Standard linear models typically assume that central banks have perfect credibility, but periods of high or persistent inflation reveal that this assumption is often unrealistic. Understanding this discrepancy is essential because monetary policy credibility hinges on the extent to which medium- and long-term inflation expectations remain anchored. When medium-term expectations deviate persistently from the inflation target, credibility erodes, leading to higher long-term inflation expectations and shifts in wage- and price-setting behaviours that align with those expectations. In extreme cases, such as when inflation uncertainty becomes particularly severe, agents may opt to price major goods and services, including housing, in foreign currency, a phenomenon known as dollarization.

Credibility influences inflation expectations by determining the weight placed on past versus forward-looking information. In scenarios of lower credibility, greater weight is placed on past inflation data, with the forward-looking component receiving less emphasis. This contrasts with models that assume perfect credibility, where expectations are largely forward-looking and reflect the central bank's policy goals. The inclusion of credibility in the ENDOCRED model allows for a time-varying process in the evolution of inflation expectations, unlike the canonical model where these parameters are fixed.

Under ideal conditions of perfect credibility, expectations should be fully forward-looking and model-consistent, aligning with the central bank's policy assumptions. In an imperfect credibility scenario, however, agents tend to extrapolate from past outcomes, leading to a greater reliance on backward-looking expectations. Even in highly credible environments, backward-looking elements may persist, making inflation expectations empirically challenging to model.

Blanchard and Bernanke (2023) provide an important case study of inflation dynamics using a backward-looking specification for inflation expectations. Their model, however, does not incorporate monetary policy nor consider the role of expectations in guiding policy decisions, which limits its direct applicability to policy analysis. In contrast, the ENDOCRED model integrates both retrospective (*ex post*) and prospective (*ex ante*) expectations, making it more suitable for understanding the interplay between inflation expectations and policy actions. This approach mirrors firms' pricing strategies, which combine past trends with future projections over an annual horizon. While measuring inflation expectations remains a complex task, the ENDOCRED framework offers a basis for understanding the formation of both backward- and forward-looking expectations and provides a foundation for addressing issues of risk management in policy contexts.

The first two terms in the inflation expectations equation comprise a weighted average of a model-consistent forecast of the 4-quarter ahead year-on-year inflation rate and the year-on-year inflation rate observed last quarter. Additionally, the employment of credibility removes the fixed parameters in the canonical model and replaces it with our measure of the stock of credibility, $Cred_{i,t}^{Stock}$, which ranges between 0 (no credibility) and 1 (full credibility) and can change over time. When credibility is imperfect (falls below one), two key processes come into play. First, existing inflation becomes more persistent, as reflected in the coefficient of the backward-looking component in expectations. Second, inflation expectations can adjust upward or downward depending on whether the economy is in a high- or low-inflation regime, driven by the inflation bias that emerges within these regimes.

$$\pi 4_{i,t}^{e} = \left(Cred_{i,t}^{Stock}\right)\pi 4_{i,t+4} + \left(1 - Cred_{i,t}^{Stock}\right)\pi 4_{i,t-1} + \kappa_i^{High}\left(prob_{i,t}^{High}\right) + \kappa_i^{Low}\left(prob_{i,t}^{Low}\right) + \varepsilon_t^{\pi^e} \tag{17}$$

We define two distinct inflationary regimes to illustrate public expectations and their implications, using subjective probability distributions. The first is a high inflationary regime, characterized by public scepticism that inflation will converge to the central bank's target, instead anticipating a significantly higher level. For illustrative purposes, we assume an inflation level of 5%, not as an empirical estimate but as a benchmark to capture the dynamics and risks of such a scenario, akin to the concerns of the 1970s. If inflation expectations were to rise to 5%, then the probability of being in a high inflation regime would be 100%, and monetary policy credibility would be zero as a result. The second regime is a low inflationary scenario, reflecting public belief that inflation will fall well below the target, potentially resulting in a low-inflation trap. Here, we adopt a level of –1% to account for the 'dark corner' of low inflation described by Blanchard, which highlights the risks of deflationary pressures. This means that if inflation expectations were to fall to –1%, we would interpret this as a 100% probability of being in a low inflation regime, with monetary policy credibility reduced to zero. These illustrative benchmarks help conceptualize the formation of inflation expectations and the divergence of public sentiment in high- and low-inflation environments. This framework allows economists to define the relevant regimes based on their subjective assessments or values, while the methodology provides a versatile tool to explore inflation dynamics across different countries and alternative regimes.

We take a simple probabilistic approach where the probability of being in a high or low inflation regime is denoted by $prob_{i,t}^{High}$, $prob_{i,t}^{Low}$, respectively. Only one can exist at a time and the higher the probability the more it will bias inflation expectations away from the central bank target. We demonstrate the bias effect in inflation expectations when credibility declines by including a coefficient for the bias term, κ, to capture this bias in the transition from perfect to imperfect credibility. Credibility is built gradually by consistently achieving stated goals. Conversely, it can be eroded quickly by actions that contradict announced objectives.

There are three processes for shaping expectations. The first is optimistic but cautious, assigning weight to both the central bank's inflation target (π^*) and past inflation, with a greater emphasis on the target as long as credibility remains high. The second is sceptical, reflecting historical experience and assuming inflation will revert to a high level (π_t^{High}), while largely disregarding the central bank's target. Similarly, a third sceptical process exists, also rooted in historical patterns, but assumes inflation will revert to a low level (π_t^{Low}) and similarly gives little importance to the central bank's inflation target. When the actual inflation is less than the target, the probability of a high inflation regime is zero. Otherwise, we calculate the probability of being in a high inflation regime by dividing the squared deviation of expectations from the target by itself plus the squared deviation of expectations from the high inflation regime.

The forecast errors expected by optimists and sceptics will be the difference in actual observed inflation and their expectations. The forecast errors in this framework represent the deviations between actual inflation and the inflation levels people expect under their optimistic or sceptical scenarios. These errors adjust dynamically based on how closely actual inflation aligns with either the target or the extremes of the high or low inflation regimes. When actual inflation moves closer to the target and further away from the dark corners of high or low inflation regimes, the forecast error associated with optimistic expectations decreases. When actual inflation fully aligns with expectations under the optimistic scenario (target-level inflation), the forecast error for optimistic expectations becomes zero. Mathematically, this implies that the numerator in the probability formula for either high or low inflation regimes becomes zero, leading to a probability of zero for being in those regimes. This reflects a situation where inflation expectations are perfectly anchored to the target. On the other hand, as actual inflation drifts away from the target and approaches the high or low inflation regimes (the dark corners), the forecast errors for sceptical expectations diminish. In the extreme case, where actual inflation fully aligns with expectations under the high or low inflation regimes, the forecast errors in those regimes become zero. Mathematically, this eliminates the second term in the sum of the denominator, making it equal to the numerator of the fraction and resulting in a probability of 100% for being in either the high or low inflation regime.

$$prob_{i,t}^{\pi^*=High} = \begin{cases} 0, & if\ \pi 4_{i,t} < \left[\gamma_{i,1}\pi 4_{i,t-1} + (1-\gamma_{i,1})\pi_t^T\right] \\ \frac{100\left(\varepsilon_{i,t}^T\right)^2}{\left(\varepsilon_{i,t}^T\right)^2+\left(\varepsilon_{i,t}^H\right)^2}, & otherwise \end{cases} \tag{18}$$

Where forecast error under optimistic expectations is:

$$\varepsilon_{i,t}^T = \pi 4_{i,t} - \left[\delta_{i,1}\pi 4_{i,t-1} + (1-\delta_{i,1})\pi_t^T\right]$$

Forecast error under sceptical expectations for high inflation is:

$$\varepsilon_{i,t}^H = \pi 4_{i,t} - [\delta_{i,2}\pi 4_{i,t-1} + (1-\delta_{i,2})\pi_t^{High}]$$

We do the same for the low inflation trap where:

$$prob_{i,t}^{\pi^*=Low} = \begin{cases} 0, & if\ \pi 4_{i,t} > \left[\gamma_{i,1}\pi 4_{\ i,t-1} + (1-\gamma_{i,1})\pi_t^{Low}\right] \\ \frac{100\left(\varepsilon_{i,t}^T\right)^2}{\left(\varepsilon_{i,t}^T\right)^2+\left(\varepsilon_{i,t}^L\right)^2}, & otherwise \end{cases} \tag{19}$$

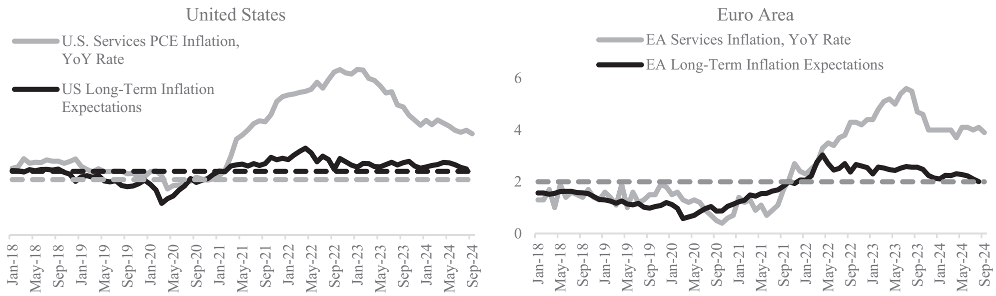

Figure 9: Inflation expectations and services inflation 2018–24.
Source: Author's calculations; Bloomberg.

Where forecast error under sceptical expectations for low inflation is:

$$\varepsilon^{L}_{i,t} = \pi 4_{i,t} - \left[\gamma_{i,1}\pi 4_{i,t-1} + (1-\gamma_{i,1})\pi^{Low}_{t}\right]$$

We then subtract the combined probabilities from 100 and divide by 100 to get a credibility index between 0 and 1:

$$Cred^{Flow}_{i,t} = \frac{100 - prob^{High}_{i,t} - prob^{Low}_{i,t}}{100} \tag{20}$$

Figure 8 plots the results of our credibility index, $Cred^{Flow}_{i,t}$, using the 10-year inflation expectations from the bond market for the US and the euro area from 2018. The main takeaway is that inflation was better anchored in the US heading into the pandemic where Fed credibility was near perfect. Meanwhile, the euro area was still mired in a low inflation regime with inflation expectations persistently below the ECB target and therefore entered the pandemic with worse credibility. This difference in credibility will become an important feature when we conduct a projection exercise in the following section for June 2020 where lower levels of credibility amplified the impact of the pandemic shock.

Ten-year inflation expectations have since recovered, but a premature conclusion here would be that monetary policy credibility in the US and the euro area has been re-established by just looking at inflation expectations as derived from the bond market. While it is remarkable how little the bond market has priced higher long-term inflation during the pandemic era, the situation in the US and the euro area is hardly on solid ground. There are measures of underlying inflation that remain inconsistent with the 2% objective in both countries. Our preferred conceptual measure for underlying inflation is the Atlanta Fed's measure of sticky price inflation. Its methodology to separate frequently adjusted prices, known as flexible prices, from infrequently set prices, known as sticky prices, offers superior insight. In this paradigm, sticky prices may tell us something about how price-setters view the future when setting their prices. However, the euro area does not have flexible-sticky price indices, so we just plot services inflation for both countries to maintain consistency (Fig. 9).

That said, we can sympathize with the Fed and the ECB's attempt to take advantage of these conditions in the bond market. It certainly looks like a case of the Fed using its perceived high credibility to optimize policy and achieve a soft landing. However, it is playing a dangerous game when sticky service inflation has remained as persistent as it has where both economies are vulnerable to inflationary shocks while this status quo remains. This issue is the subject of the scenarios we have prepared for the monetary policy outlook in the US and euro area using the latest data in Section VII.

Finally, we introduce the monetary policy credibility stock index, $Cred^{Stock}_{i,t}$, that evolves according to a standard stock accumulation process, where the stock of credibility depends partly on its lag and partly on the signal from the bond market as well as a disturbance term, ε^{γ}_{t} representing a shock to monetary policy credibility, which may be positive or negative:

$$Cred^{Stock}_{i,t} = \rho{*}Cred^{Stock}_{i,t-1} + (1-\rho){*}Cred^{Flow}_{i,t-1} + \varepsilon^{Cred}_{i,t} \tag{21}$$

$Cred^{Stock}_{i,t}$, then determines the weights on the backward and forward-looking components in the formation of inflation expectations equation where higher levels of credibility lead to more forward-lookingness.

$$\pi 4^{e}_{i,t} = \left(Cred^{Stock}_{i,t}\right)\pi 4_{i,t+4} + \left(1 - Cred^{Stock}_{i,t}\right)\pi 4_{i,t-1} + \kappa^{High}_{i}\left(prob^{High}_{i,t}\right) + \kappa^{Low}_{i}\left(prob^{Low}_{i,t}\right) + \varepsilon^{\pi^{e}}_{t} \tag{17}$$

Where $\kappa^{High}_{i} > 0$ biases inflation expectations higher while $\kappa^{Low}_{i} < 0$ biases inflation expectations lower.

When $Cred^{Stock}_{i,t} = 1$, credibility is perfect, and inflation expectations become fully forward-looking and the inflation regime bias disappears. This reduces inflation persistence and ties inflation more tightly to the target, such that the central bank must do less in response to shocks, and convergence to the target rate is faster. The other extreme case when $Cred^{Stock}_{i,t}, \kappa^{High}_{i}, \kappa^{Low}_{i} = 0$ then we get the original backward-looking specification for inflation expectations as in the canonical model.

(v) Applying the two-country ENDOCRED model to the US and euro area at the early onset of the pandemic

To illustrate the mechanics of ENDOCRED, we use the backdrop from the pandemic to calibrate the initial conditions for a simulation exercise in June 2020 (Fig. 10). Importantly, long-term inflation expectations had drifted down to 1.5% in the US and 0.8% in the euro area reflecting the view at the time that the Fed and the ECB would have difficulty managing such a large negative demand shock. For the purposes of the scenario, we set the respective inflation targets to these long-term inflation expectations values while also setting initial credibility in the US at 0.9 and in the euro area at 0.7, reflecting the calculations presented earlier in Fig. 5.

To generate the scenario, we used a combination of demand and supply shocks. The dominant shock is a common negative aggregate demand shock that opens an output gap of about 3% in both countries. The magnitude mirrors the effect of the pandemic lockdowns where both aggregate demand and supply would have fallen but demand by more than supply. We add some small deflationary shocks at the beginning to reflect these negative demand conditions as well.

In the simulation, the Fed still spends a long time at the ELB but not as long as the ECB. The reason for this is that the ECB enters the pandemic with lower levels of credibility since it allowed inflation expectations to ratchet downwards beforehand. The damage of this policy becomes evident when both the US and the euro area are hit by the same negative demand shock presented by the lockdown policies. In the case of the US with higher levels of credibility, the decline in the policy rate and extended period along the ELB is compelling enough for financial markets to expect inflation to return to levels that are more consistent with the Fed's 2% target. However, in the case of the euro area, no one believes the ECB is potent enough to respond to the shock and so inflation and inflation expectations drift even lower from a lack of credibility. This divergence in inflation outlook widens the expected price level between the US and the euro area and the EURUSD exchange rate appreciates, reinforcing the deflationary forces and amplifies the negative demand shock and needlessly prolongs the recovery in the euro area. This self-fulfilling outlook is re-iterated by the ECB's own forecasts at the time presented in Fig. 11 where inflation was expected to remain very low (1.3%) for a few years.

The results of the simulation show that a breakdown in the ECB's transmission mechanism in response to a globally synchronized demand shock could have been anticipated, as illustrated by the simulated exchange rate and its actual values. The simulation does not offer a solution to the ECB's problem. That question is the subject of the next section and requires a deeper discussion about the broader analytical framework of central banks that goes beyond any one model. However, having this understanding in hand could have triggered a need from the central

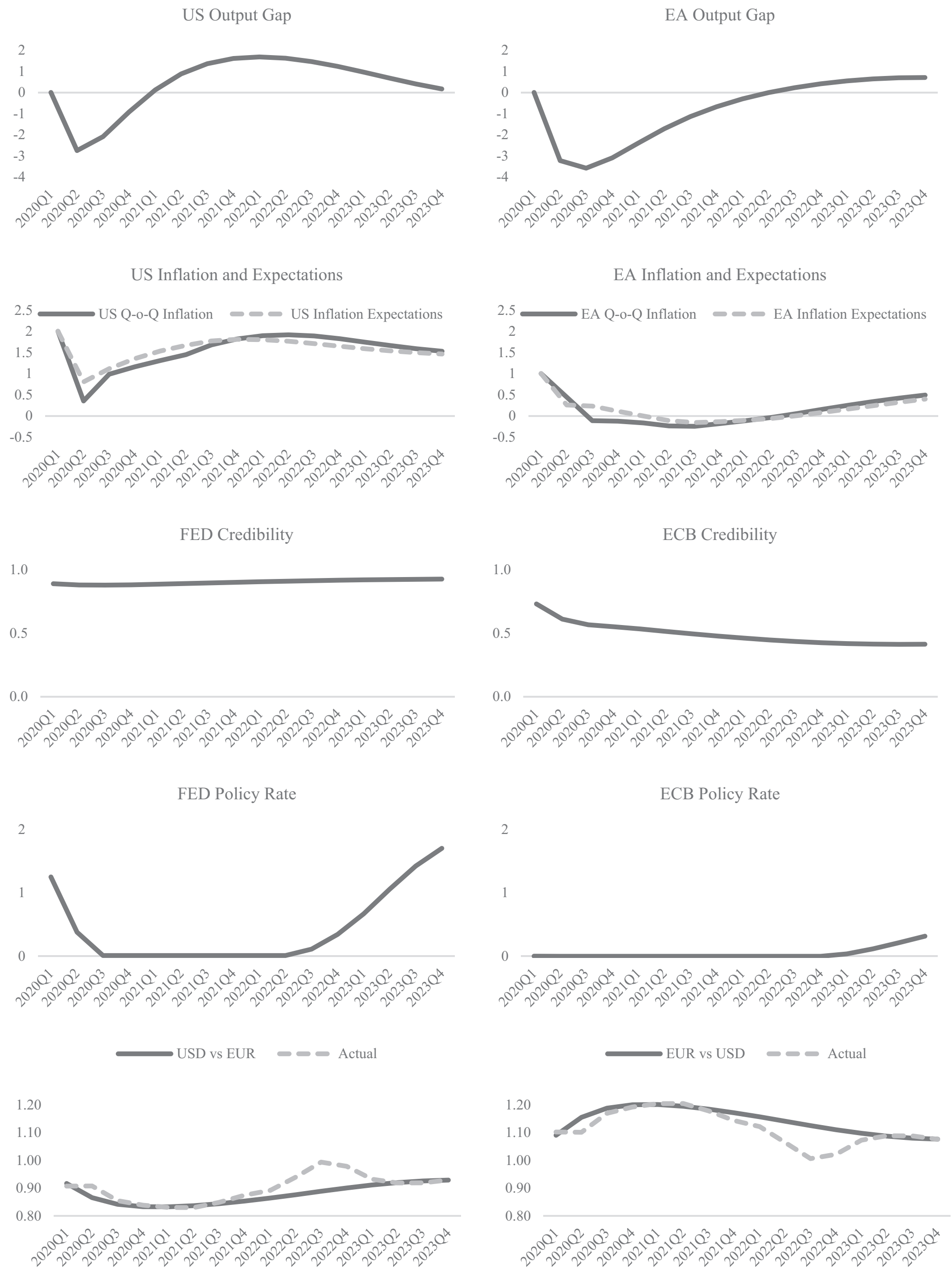

Figure 10: June 2020 mock simulation using ENDOCRED
Source: Authors' calculations.

bank to coordinate with fiscal authorities and work towards replacing the policy space missing from monetary policy with fiscal. In essence, if the ECB wanted to communicate a credible path for the recovery and avoid counterproductive movements in the exchange rate then it would have needed to show how a more forceful fiscal response was required.

Figure 11: ECB scenarios, June 2020
Source: ECB June 2020 macroeconomic projections.

V. The future of monetary policy frameworks: continuing the discussion of Ben Bernanke's recommendations to the Bank of England to adopt a scenarios-based approach to monetary policy and more

The previous section illustrates the macroeconomic implications of a lack of credibility as defined in the model, however the reason why the ECB lacked credibility requires a broader discussion about analytical frameworks. In this section we discuss some of the pitfalls made by the ECB while also outlining a series of basic steps we recommend for structuring the adoption of a risk management approach to monetary policy:

Step 1: Establish a clear inflation target.

Step 2: Publish the path of the policy and exchange rate that is considered consistent with achieving the inflation target.

Step 3: Adopt a plausible scenarios-based approach to monetary policy.

Step 4: Adopt a fully fledged risk management approach to monetary policy that emphasizes avoiding dark corners.

(i) Step 1

Establish a well-defined target. The announcement of inflation targeting in 1997 by the Bank of England (BoE) offers perhaps the most compelling evidence of the power of a credible inflation targeting announcement. The announcement almost immediately eliminated the credibility gap in the bond market, even before the BoE had demonstrated it would deliver on its commitment. Prior to the Covid pandemic, the ECB's inflation objective was unclear and communicated as 'an inflation rate below, but close to, 2%'. However, that issue has been addressed in the ECB's recent strategy review by stating unambiguously that the inflation target is 2% and symmetric (ECB, 2021). Removing the ambiguity has removed a lot of the perceived tolerance of the ECB to inflation expectations ratcheting downwards as happened during the early onset of the pandemic.

(ii) Step 2

Publish the path of the policy rate and exchange rate that can be considered consistent with achieving the inflation target. Bernanke recommended publishing the policy rate in his BoE review but only for alternative scenarios and did not include publishing an endogenous exchange rate. As previously described, we view the exchange rate as a fundamental piece of macroeconomic storytelling, especially for small open economies such as the UK. Furthermore, in our view there is no productive purpose served for a central bank to present an incomplete projection and presenting one can actually be counterproductive as we demonstrate with ECB forecasts in June 2020. Either you choose to present a fully consistent macroeconomic forecast which includes interest rate and exchange rate dynamics, or not. Taking half measures by publishing the interest rate but not the exchange rate or only publishing an endogenous interest rate for some scenarios but not all suggests the central bank is still struggling to establish a common set of principles for building a credible monetary policy framework.

Also, it is worth noting that the Bernanke BoE review limited its peer sample group to other advanced countries with similar resources per capita. There is a growing contingent of smaller central banks that publish an endogenous interest rate path which includes the CBA, NBG, Czech National Bank, RBNZ, Riksbank, Norges Bank, National Bank of Ukraine, Bank of Russia, Central Bank of Chile, Bank of Israel, South African Reserve Bank, National Bank of Poland, National Bank of Tajikistan, and Bank of Botswana, to name several. The level of economic development or financial resources is not exactly relevant when it comes to establishing best practices. Best practices can be achieved with relatively few resources, especially with the potential that AI can have to massively raise productivity among central bank economists.

The central banks that publish an endogenous interest rate and in some cases an exchange rate have learned that it serves as a useful quantitative vehicle to describe a credible monetary policy strategy. Without it, central banks leave themselves vulnerable to speculative attacks on their credibility as there is nothing obvious that tethers the central banks' commitment to anchor the economy to the target other than qualitative statements. The endogenous interest rate path that is published among these central banks is typically produced by the staff where the ownership ultimately rests with the Chief Economist and therefore some would say loses meaning since these are not the people in charge of setting the policy rate. However, the purpose of the projected path as produced by the staff serves as a vital benchmark for policy-makers to ground their own qualitative views without the discussion turning into a cacophony. For instance, the CBA staff produce a series of quantitative case scenarios in the Monetary Policy Report on the same day the Board decides on the policy rate. In a corresponding Transparency Report that is published on the same day, all Board members have an opportunity to briefly describe the rationale for their decision and express their views about the outlook in relation to the case scenarios provided by the staff (CBA, 2024).

While the ECB surely has models that produce an endogenous interest rate and exchange rate path, it does not publish this path in its macroeconomic forecasts. Instead, the ECB presents an output and inflation forecast using exogenous interest rate and exchange rate assumptions, and therefore omits the story of monetary policy and the transmission mechanism from its presentation of its forecast. This can become problematic as we have documented throughout the paper.

Publishing the path has the added benefit as a teaching device for central banks to educate financial markets on the general behaviour and preferences of policy-makers in response to different types of shocks. Improving financial markets' understanding of central bank behaviour is something central bankers began to realize in the 1990s was critical for improving efficiency. A prominent example of improved efficiency which comes from higher levels of transparency along this dimension is described by Engen *et al*. (2015 (ELR 2015)). They assessed the Fed's implementation of quantitative easing and qualitative forward guidance in the aftermath of the GFC. They found that these policies had a positive effect on the recovery, but the stimulus was gradual. For instance, it took a very long time for the public to believe the Fed's qualitative forward guidance stance. By March 2009, the Fed was communicating to markets that economic conditions likely warranted 'exceptionally low' levels of the fed funds rate for an 'extended period'. However, it would take several years for this qualitative forward guidance to get priced in financial markets.

Like ELR 2015, we believe that had the Fed been more transparent, such as publishing an interest rate forecast where interest rates were expected to remain at the ELB for the projected horizon, that financial markets would have been quicker to price an easier monetary policy stance. At the time, looking at the Fed's Greenbook/Tealbook where the Fed staff produce multiple scenarios using its semi-structural workhorse model FRB/US, it would have been clear that the Federal Open Market Committee was never really considering a recovery in the real economy that would have warranted a normalization of the policy rate. However, a higher expected path of the fed funds rate was a persistently held belief in financial markets, keeping the monetary policy stance tighter than it should have been and as ELR 2015 suggests contributed to the protracted recovery.

There remain concerns with publishing the path of the policy interest rate in some policy circles. Some view it as a commitment that impedes flexibility, and others view it as a sequence of policy decisions that could never be agreed upon by a committee. The commitment argument is dealt with once one recognizes that the projection of the policy rate will be endogenous, depending on the scenario that is being considered. As for the latter concern, a common practice among central banks that publish an interest rate forecast is to make it very clear that the forecast is the product of the staff and not owned by the policy-makers. Instead, the forecast is viewed as a key input into the decision of the policy-makers, but only one input among others—policy-makers need not agree with the forecast and can incorporate other information into their decision-making.

This clear distinction takes care of a lot of the governance issues related to how the forecast should be produced and interpreted. If this distinction is observed, then policy-makers will not be handicapped by the staff projection and will remain free to express their own views in relation to the staff projection, which will become a benchmark that can structure a discussion about uncertainty and can prevent such a discussion from being counterproductive. However, to further the cause of constructive discussions in uncertain times the next step should be pursued.

(iii) Step 3

Adopt a plausible scenarios-based approach to monetary policy as recommended by Ben Bernanke in his BoE review. A prominent reason for adopting a scenarios-based approach not mentioned by Bernanke is that it will enable a more transparent exercise than the baseline forecast approach which, in our experience, can lead to a manipulation of the forecast to incorporate the different voices within the policy-making board, which can become a source of inconsistency. Such 'fudging' of the forecast is a perfectly natural consequence of having only a single outlet like a central projection. Instead, to ensure integrity in the production of scenarios, we believe that the Chief Economist must ultimately be responsible for this part of the analytical framework. Of course, the Chief Economist must engage policy-makers and receive feedback early in the process to ensure any scenarios the staff produce are relevant to the current policy-making discussion. However, we recognize that this presents a major potential weak point in this set-up as the role and responsibility of the Chief Economist becomes paramount. A process of this kind will require strong rapport between the Chief Economist and the policy-making board. There will need to be a high standard of accountability for the Chief Economist. In our view, if at any point the policy-makers lose confidence in the ability of the Chief Economist to carry out this task, then the Chief Economist will need to resign.

That said, before describing the FPAS Mark II approach, we find it important to express the pitfalls of moving to this step without first having established Steps 1 and 2. Returning to the pandemic period, the ECB produced multiple scenarios in June 2020 based on different assumptions related to the severity of the Covid-19 pandemic (Fig. 11). At the time, the ECB did not have a clearly defined target and its projections for inflation and unemployment were accompanied by an exogenous interest rate and exchange rate assumption. Therefore, the projections lack purpose when the objective is unclear and lack consistency when the monetary policy transmission mechanism is absent. Furthermore, a serious problem presented in these scenarios is that inflation never returns to a target. The ECB presents four scenarios, where inflation settles at 1.7%, 1.6%, 1.3%, and 0.9% after 2–3 years in each of them. This type of scenarios-based approach, while it addresses uncertainty, would still invite attacks on its credibility. By publishing these scenarios, the ECB essentially gave its stamp of approval for inflation expectations to wander downward as evident in the June 2020 experience and illustrated in the simulation exercise in Section IV.

As for how to implement a scenarios-based approach, the CBA has chosen a structure where the analytical process begins by defining a market reference scenario. After all, it should be the central bank's main communication objective to nudge financial markets in a particular direction, when necessary. Therefore, it seems logical that a communication strategy to achieve this begins by recognizing what is currently priced in financial markets, which we refer to as a market reference scenario. It is more difficult to derive a market reference scenario in emerging markets like Armenia where they currently conduct a survey of commercial bank expectations of the policy path. Since the US and euro area have deep financial markets and professional forecasters, the Fed and the ECB can derive a much richer market-based outlook with all the relevant variables (interest rates, GDP, inflation, unemployment, etc.).

Then with the market reference scenario and narrative in hand, the CBA conducts an adversarial collaborative case study approach where it derives two plausible scenarios that would require a policy rate path that is above (Case A) or below (Case B) the market reference scenario. The scenarios are chosen by the Chief Economist but are meant to incorporate the most pertinent issues that the policy-makers are concerned about at the time. Of course, this requires some collaboration between the staff and the policy-makers during the projection process but ultimately the scenarios would be owned by the staff, and policy-makers should not feel tied to these projections when they express their personal views. The scenarios simply serve as an illustration that makes a strong case for why the 'most likely' scenario is a Case A vs Case B path. And perhaps more importantly it acts as a frame of reference for policy-makers to describe their own views. Are they more aligned with Case A-type scenarios or Case B-type scenarios? This is one way the framework attempts to address communication issues related to the cacophony of voices commenting on monetary policy. The scenarios provide structure for discussing the range of views that will always exist rather than pursuing futile attempts to achieve consensus. This set-up mirrors how Alan Greenspan described his approach in his 2003 Jackson Hole speech on 'Monetary Policy under Uncertainty':

> A policy action calculated to be optimal based on a simulation of one particular model may not, in fact, be optimal once the full extent of uncertainty is taken into account. It is entirely possible that different policies will exhibit different degrees of robustness with respect to the true underlying structure of the economy. For example, policy A might be judged as best, conditional on a particular model of the economy, but might also be seen as having relatively severe adverse consequences if the true structure of the economy turns out to be other than the one assumed. On the other hand, policy B might be somewhat less effective in advancing the policy objectives under the assumed baseline model but might be relatively benign in the event that the structure of the economy turns out to differ from the baseline. (Greenspan, 2003)

Obviously, the staff cannot incorporate all risks into two scenarios and should augment the analysis with an exhaustive list of risks with a qualitative assessment of their policy implications. So far, these two scenarios can be generally regarded as scenarios that work within a linear framework where macroeconomic forces are not getting too out of hand—i.e. we are in the linear part of the Phillips curve and the linear part of the monetary policy loss function where deviations of inflation from target and output from potential are between –1 and 1. However, as the Covid-19 pandemic showed, when uncertainty is heightened and there are reasonable fears of entering a dark corner of monetary policy. then it has become apparent that central banks must:

(iv) Step 4

Adopt a risk management approach to monetary policy that emphasizes avoiding dark corners or policies of least regret.

The priority for the next generation of monetary policy frameworks should be to formalize the risk management approach to monetary policy that brings non-linear implications embedded in models such as ENDOCRED to the forefront of regular policy analysis. This takes the plausible scenarios-based approach one step further:

> given our inevitably incomplete knowledge about key structural aspects of our ever-changing economy and the sometimes asymmetric costs or benefits of particular outcomes, a central bank seeking to maximize its probability of achieving its goals is driven... to a risk-management approach to policy. By this I mean that policy-makers need to consider not only the most likely future path for the economy but also the distribution of possible outcomes about that path. They then need to reach a judgment about the probabilities, costs, and benefits of the various possible outcomes under alternative choices for policy. (Greenspan, 2003)

Here ENDOCRED provides important insights for conducting this type of analysis. A central banker's worst fear will likely always be unanchored inflation and inflation expectations and ENDOCRED brings that issue to the foreground. Furthermore, experimenting with the convex Phillips curve and uncertainty around the non-accelerating rate of unemployment (NAIRU) can illustrate the costs and benefits of alternative policy choices as described in Debelle and Laxton (1997). Finally, a nice feature of the model is the quadratic loss function that imbues monetary policy with a natural switch from a linear to a non-linear response. When the deviation of inflation from the target or output from potential is between –1 and 1, the response is roughly linear. The moment these gaps exceed –1 or 1 then it is a signal for policy-makers to get more aggressive with their policy strategy to lower the risk of entering a dark corner or a policy of least regrets.

Coined by the Reserve Bank of New Zealand, a 'policy of least regrets' described their policy strategy during the initial phases of the pandemic to explain the mix of ultra-easy monetary and expansionary fiscal policies (Hawkesby 2021). Such policies, if successful, were communicated at the time to have inflationary consequences but the *ex ante* risk was considered acceptable given the uncertainty around the collapse in demand caused by the lockdowns. These types of scenarios within the FPAS Mark II framework are referred to as Case X scenarios and again follow Greenspan's risk management vision: 'At times, policy practitioners operating under a risk-management paradigm may be led to undertake actions intended to provide some insurance against the emergence of especially adverse outcomes' (Greenspan 2003).

To summarize, a fully fledged risk management approach to monetary policy begins with a well-defined inflation objective accompanied by macroeconomic projections with an endogenous interest rate and exchange rate that steer inflation back to the target. This experience and structure allow central banks the freedom to investigate uncertainty without thinking it will threaten its credibility since the endogenous policy in the model ensures all scenarios credibly return inflation back to the target. There are two layers of uncertainty analysis, linear or highly plausible scenarios represented by Case A and B scenarios and non-linear or dark corner scenarios represented by Case X scenarios. In the next section we conduct a projection exercise to illustrate this type of framework in practice and how a central bank would potentially use a Case X scenario to lay the foundation of a policy of least regrets today.

All these components capture the key insights from Alan Greenspan's view of what a risk management approach to monetary policy means in practice. However, while Greenspan was purposefully opaque in his communication strategy, we have left that paradigm behind and have moved towards greater levels of transparency. And based on the structure we have laid out, there is no reason that a central bank cannot do this type of uncertainty analysis and communication in a transparent way. It simply requires experience, discipline, and trust that being honest with the public and financial markets is the best path forward to build credibility and produce better policy and macroeconomic outcomes in the process.

VI. Applying FPAS Mark II with ENDOCRED simulations: US economy outlook and strategic policy communication

This section presents an abridged forecast exercise using ENDOCRED to produce FPAS Mark II scenarios for the US economy that illustrate the current shift within the monetary policy world towards scenarios-based forward guidance (Fig. 13). There is no shortage of issues in the US these days that could push the future path of the Fed funds rate in different directions. These include uncertainty around the stars and bars (underlying inflation, the NAIRU, and the neutral

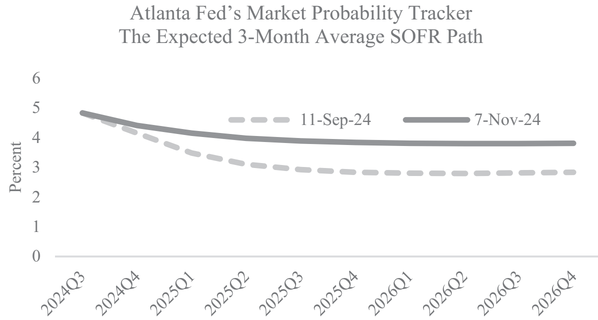

Figure 12: What is priced in financial markets? The market reference scenario
Source: Atlanta Fed.

interest rate), fiscal policy and debt sustainability, a possible bubble in asset prices, as well as new policies connected to the incoming Trump administration, namely tariffs. For the purposes of this exercise, we choose to focus on the topic of higher underlying inflation and the NAIRU which are most related to the analysis around the non-linear Phillips curve and endogenous policy credibility.

The analytical process begins by trying to understand what is priced in financial markets and then using this to serve as a central projection or reference point, around which one can prepare alternative macroeconomically consistent scenarios. To do this one would look at the totality of the information available in financial markets and, if available, use consensus forecasts for key variables such as GDP, inflation, exchange rate, and the policy rate as the reference point. In the exercise that we report in this paper, we construct a model-based market reference scenario that follows closely the expected path of the Fed funds rate that was priced in financial markets as of 7 November 2024, which has experienced substantial volatility in 2024. In the summer of 2024, a rise in the unemployment rate triggered fears that labour market weakness was accelerating and would soon be consistent with a recession thus requiring deep cuts in the Fed funds rate. However, in the intervening months, recessionary fears abated as the labour market stopped weakening and the expected Fund funds rate shifted substantially higher once again (Fig. 12). The narrative of the market reference scenario could be summarized as a return to the prevailing soft-landing view where the unemployment rate stabilizes around the Fed's current view of the NAIRU, disinflation continues in sticky prices, and the real economy can absorb a higher neutral interest rate without causing a recession. We generate a market reference scenario that follows this narrative which essentially entails setting the initial conditions of the economy and then simply letting the model to run without any shocks. The initial conditions are defined by real GDP being a bit above potential output, underlying inflation pressures are modest, the unemployment rate is near NAIRU, and credibility is perfect, hence monetary policy is restrictive and therefore it is high time to bring the policy rate to its neutral position or risk a recession. However, a key insight here is that based on the latest Fed dot plots in December 2024, the median long-run neutral rate is set at 3% or 80 bps below what is priced in financial markets creating potential risks of the Fed falling behind the market.

(i) Case A

Case A is a higher underlying inflation scenario. We apply an inflation shock to the market reference scenario at the beginning of the forecast to reflect higher underlying inflation as seen in categories such as sticky prices where inflation has been steadily between 3 and 4%. With the labour market continuing to outperform the Fed's estimate of the NAIRU, monetary policy would need to be re-evaluated in terms of how restrictive it has been thus far. In the scenario, the Fed responds quickly by talking up an extended pause to further rate cuts to maintain a more restrictive policy stance into 2025 to counteract the inflationary forces and bring the labour market into better balance with its objectives.

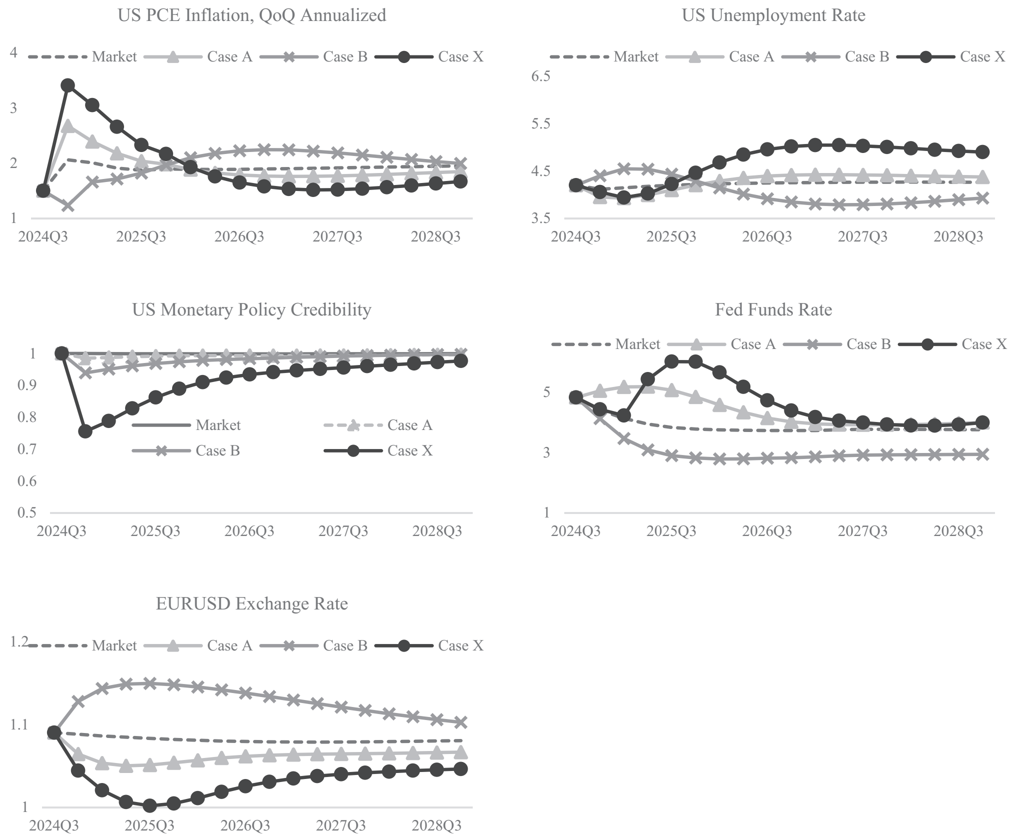

Figure 13: Illustrative Case A, Case B, Case X, and market reference scenarios, November 2024
Source: Authors' calculations.

(ii) Case B

Case B is a hard landing scenario reminiscent of the views that percolated in September 2024 and got priced in the expected path of the Fed funds rate. To generate the scenario we apply a negative demand shock to the market reference scenario. The rationale for the scenario reflects the view that inflation remains anchored and monetary policy has been highly restrictive for some time. The long and variable lags of monetary policy are still filtering their way through the economy resulting in substantial labour market slack forming and inflation briefly undershooting the target requiring deeper interest rate cuts to prevent a more serious recession. The size of the negative demand shock was chosen to mimic the market view in September 2024, illustrating how quickly the market can shift between a Case A and Case B scenario over the span of a couple months and again illustrating the importance of a scenarios-based approach that prevents market fears that the central bank might be falling behind the curve, so to speak.

(iii) Case X

Case X describes a dark-corner-type of scenario that only differs from the Case A scenario in a subtle way but can have serious consequences. In this scenario the Fed delays its response to the higher underlying inflation scenario which we tune to the market reference scenario. Why would it delay its response? The most obvious candidate is a NAIRU shock mirroring the type of conditions confronted by the Fed in the 1970s. In the scenario, the near-term unemployment rate is similar to the Case A scenario, but we assume that the NAIRU is higher than what the

Fed currently communicates. The higher NAIRU masks the true nature of excess demand in the economy as it did in the 1970s. Hence, it takes time for the Fed to recognize it, while sticky price and wage inflation remain more persistent than expected. We get the classic insight from ENDO-CRED where a delay in tightening of monetary policy in the short run leads to a deterioration in credibility and a more aggressive higher-for-longer tightening cycle than had it pursued a Case A policy stance to begin with.

The presentation of scenarios should stimulate a constructive discussion among policy-makers and the public on the monetary policy outlook. Are policy-makers happy with the market reference scenario? Do they want to nudge the market in a Case A or B direction? Or in a more extreme case, do they want to pursue a policy of least regrets to prevent the risk of a Case X scenario from materializing?

Suppose the Fed wants to take advantage of the relative calm in commodity prices such as food and oil and pursue a policy that is focused on ensuring credibility is achieved not only in bond markets but also among wage- and price-setters where there are still concerns. The Fed communicates its preferences for a higher path of the policy rate until there is clearer evidence that an inflation premium has not become embedded in the economy. This modest insurance policy would also avoid the potential deleterious effects of underestimating the NAIRU which would push us closer to the non-linear Phillips curve world. The Fed communicates that it must ensure a higher degree of confidence that the economy is anchored to its 2% target with the additional objective of making the economy more resistant to inflationary shocks in the future.

VII. Challenges ahead and comprehensive strategies for small open economies: United Kingdom and Israel

Given this is an Oxford journal, it would be apropos to conclude the discussion by commenting on the BoE and whether there are lessons to learn for its current predicament. The challenges facing the BoE today are somewhat analogous to those faced by the Bank of Israel between 2001 and 2003. Long-term inflation expectations in the UK as derived by the bond market have been above target for years, as evident in Fig. 14 where we present the monetary policy credibility flow variable, $Cred_{i,t}^{Flow}$, for the UK, which has suffered as a consequence. The situation is compounded by the challenge of elevated sticky services inflation where the lack of credibility could significantly impact on the BoE's ability to restore macroeconomic stability. In our view, a root cause stems from the fact that the BoE does not have a history of presenting a consistent macroeconomic projection, which contributes to attacks on its credibility.

As in the Bank of Israel's experience, diminished credibility could make it harder for monetary policy to meet its inflation and output objectives. The BoE must be mindful of repeating this history, especially if the economy faces another shock while in this vulnerable state. It too could benefit from an anti-Case X strategy as described in the previous section. However, since the UK is a small open economy, the BoE has the potential to pursue a more comprehensive strategy that is not afforded to larger countries where the exchange rate is more politically sensitive.

Small open economies have since refined their policy frameworks, providing greater flexibility in addressing high inflation expectations and avoiding excessive volatility. With the right tools, such as instrument independence and an FX intervention strategy—like that used by the Czech National Bank in 2015 (Clinton *et al.* 2017)—central banks can better navigate dark corner scenarios. In this context, the concern that if the BoE were to overdo it with restrictive monetary policy that it would risk a major recession and return to a persistent low-inflation trap with interest rates at the ELB. This is a fear that should be non-existent for small open economy central banks as long as they have the legal authority to purchase an unlimited number of foreign assets to establish a credible policy that would prevent the exchange rate from appreciating beyond a level which they specify. Here a comprehensive strategy would involve providing clear forward guidance to realign inflation expectations with the target, which may necessitate a more restrictive policy stance for an extended period. However, if this stance leads to excessive slack in the economy and inflation were to quickly fall, then the central bank has the option to respond quickly with conventional tools and if necessary to implement an exchange rate intervention strategy in order to smooth the transition from unanchored to anchored inflation expectations and limit volatility.

To end, the BoE would be wise to move quickly on the Bernanke recommendations but be judicious in its steps by first presenting a consistent macro projection, then moving towards scenarios-based approach and eventually towards an emphasis on avoiding dark corners, or perhaps what some like Mervyn King would refer to as radical uncertainty.

VIII. Conclusion

In this paper we have discussed the importance of credibility for monetary policy-making. We have described models which treat policy credibility as something which is endogenous and in which the level of that credibility affects the transmission mechanism of monetary policy. We have described the history of such models, have explained the intuition underlying them, and have set out the main behavioural equations which such models contain. We have then gone on to provide examples of the application of such models to different countries.

The ENDOCRED modelling framework consists of a class of semi-structural macroeconomic models of this kind. In particular, these models explore scenarios with important non-linearities which we believe that policy-makers should be concerned about, especially those scenarios where a policy response is delayed. Central banks need to be vigilant to ensure the monetary policy regime is credible since when that is the case, the policy response—even in bad circumstances—will not need to be as extreme as if credibility was not guaranteed. A strategy centred around credibility is not only focused on anchoring long-term inflation expectations in bond markets but also medium-term expectations within wage- and price-setters and perhaps—most importantly—will be a strategy which ensures a properly functioning monetary policy trans-

United States high credibility inflation targeter	United Kingdom low credibility inflation targeter	Israel high credibility inflation range targeter

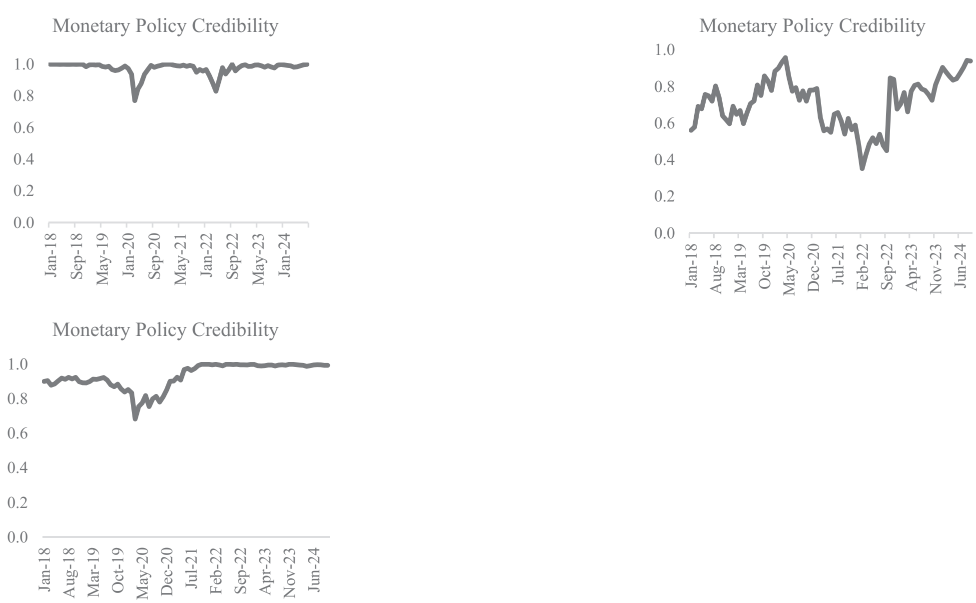

Figure 14: The fight for credibility across countries
Note: The target in the UK is assumed to be 2.8% as inflation expectations are tied to the Retail Price Index, not the CPI which historically has a wedge between the two series.
Source: Authors' calculations, Bloomberg, FRED.

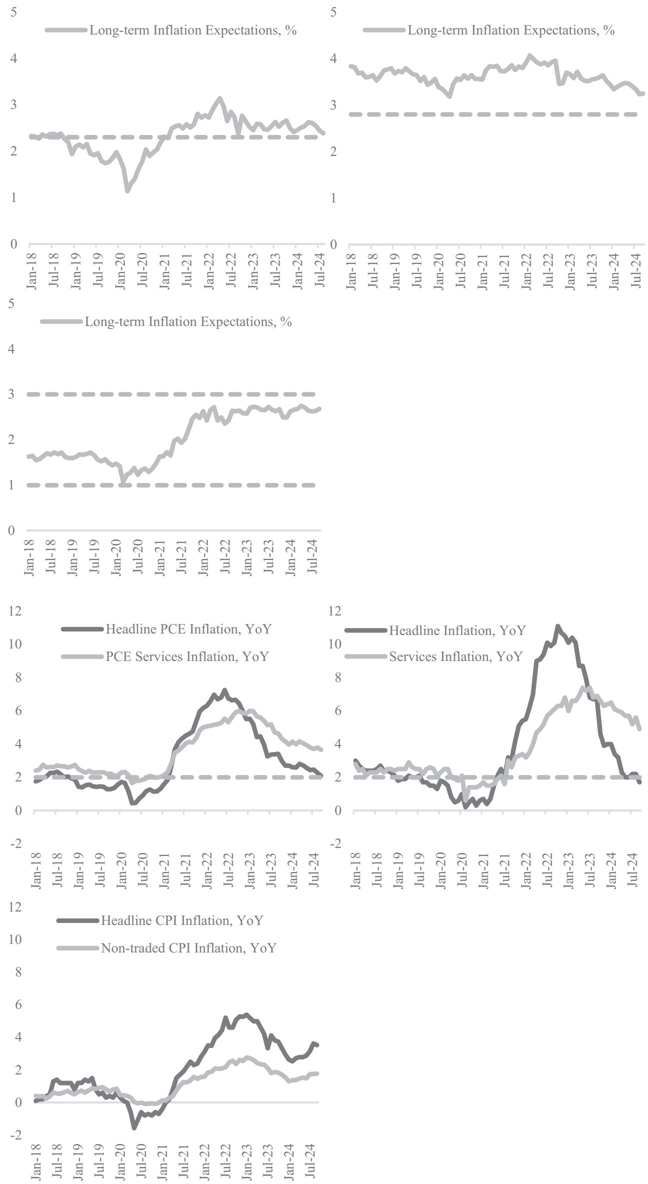

Figure 14: – *continued*

mission mechanism. Such a properly working transmission mechanism is one where long-term real interest rates and the exchange rate adjust quickly as a self-correcting measure in response to a shock based on the policy response that the central bank has trained financial markets to expect.

Essential to making sure that this does, in fact, happen, a broader notion of monetary policy credibility is ensuring that whenever a central bank produces a macroeconomic scenario, it must also publish an endogenous interest rate and exchange rate forecast, to ensure that it is providing a complete macroeconomic narrative that is consistent with achieving the central bank's objectives. Omitting these variables from the communication through which monetary policy is transmitted naturally gives financial markets more opportunity to question the credibility of monetary policy.

We have discussed practical questions relating to the publication of forecasts of this kind for the interest rate and the exchange rate. We recommend in order to maintain macroeconomic integrity in any scenario produced by the central bank, that they are model-based scenarios that include an endogenous interest and exchange rate response generated by the staff and the Chief Economist. In the framework which we are recommending it will be the function of the policy-making board to provide a decision as to what the interest rate should be on decision day as well as to express their quite possibly diverse viewpoints in a broader discussion of the uncertainty relating to the monetary policy decisions that have been made and will be made in the future. We believe this clear separation of roles and responsibilities strikes the right balance between communicating monetary policy via a formal structure provided by a model and providing the flexibility that will be necessary to enable members of a policy-making board to freely express their views.

Monetary policy frameworks only truly get tested when faced with large shocks, especially nasty stagflationary shocks exemplified by the pandemic and post-pandemic era inflation surge. Monetary policy frameworks must evolve to meet these challenges which can colloquially be referred to as the dark corners of monetary policy. The FPAS Mark II framework which we have described seeks to achieve this outcome by building on the successes of an FPAS Mark I framework but also incorporating more avenues for uncertainty analysing the uncertainty attached to monetary policy-making. To illustrate the workings of this FPAS Mark II framework, we have described a simple forecast exercise using the ENDOCRED model to prepare scenarios for the US economy. We believe that the scenarios which we have presented also illustrate the kind of risks which are faced by small open economies as well as by the US.

As the global economic environment continues to evolve, the insights provided by the ENDOCRED model are increasingly relevant. Policy-makers must remain vigilant against the risks of delayed responses, complacency in addressing credibility, and inadequate preparation for non-linear economic shocks. The integration of credibility into monetary policy frameworks is not merely an academic exercise but a practical necessity.

Funding

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