26. Inflation targeting and monetary policy in practice: the experience of the Bank of England

Simon Lloyd, Huw Pill, and Galina Potjagailo

26.1 INTRODUCTION

Inflation targeting was first introduced in the United Kingdom in 1992, following Sterling's ejection from the Exchange Rate Mechanism (ERM) of the European Monetary System. It was given more concrete institutional form following the Bank of England's independence in 1997, as formalized in the Bank of England Act (1998).

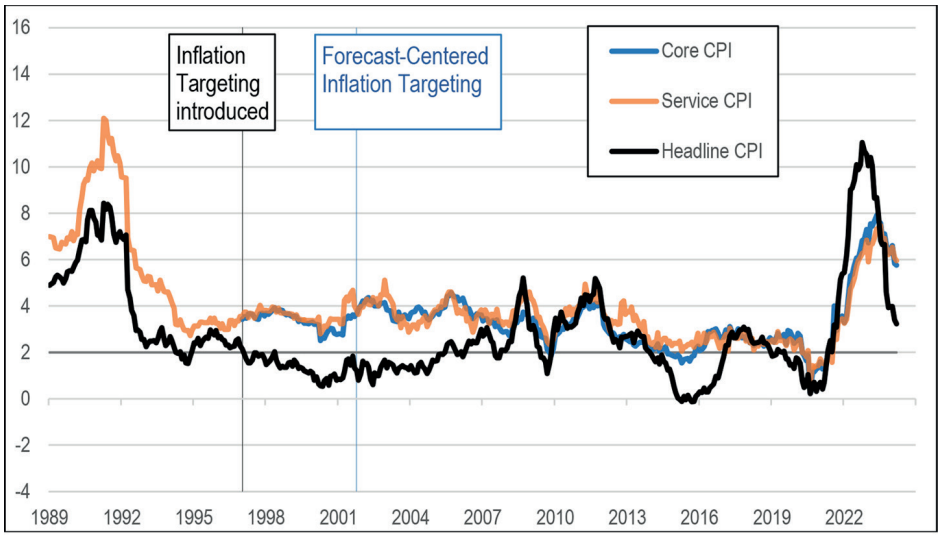
That legislation created a Monetary Policy Committee (MPC), which was assigned operational responsibility to achieve an explicit inflation target. At the outset, this involved the MPC setting Bank Rate – the rate paid on reserve balances at the Bank of England – with the aim of steering a wider set of short-term money-market interest rates and ultimately influencing broader financial conditions and the macroeconomy, including consumer price developments.

The inflation target was determined by the government and communicated to the Governor of the Bank by the Chancellor of the Exchequer in an annual remit letter. Initially, the inflation target was set at 2.5 per cent for the Retail Price Index (RPI), but this was changed to a 2 per cent target for the Consumer Price Index (CPI) in December 2003.

Many aspects of the UK's monetary policy framework have evolved since then. Perhaps most notably (and as in other jurisdictions), "unconventional" monetary policy tools, such as quantitative easing, were adopted in the aftermath of the Global Financial Crisis once Bank Rate had been lowered to what was seen as its effective lower bound. But the essence of the institutional arrangements and, most importantly, the 2 per cent target for CPI inflation have remained in place throughout.

For most of the past quarter century, this framework has proved successful – certainly relative to the UK's inflation experience in the 1970s and 1980s when a variety of intermediate-monetary and exchange-rate targets were employed to guide monetary policy. As Figure 26.1 illustrates, CPI inflation has remained close to 2 per cent since the adoption of inflation targeting in the mid-1990s. While headline CPI inflation (the black line) has at times deviated from target, such deviations were relatively small and only very slightly skewed.

Recent years have proved more challenging for the UK's inflation targeting regime. The repercussions of the COVID-19 pandemic and Russia's invasion of Ukraine led to large increases in inflation rates globally, from which the UK was not immune. Indeed, the surge of consumer-price inflation in the UK proved both relatively strong and persistent compared with those seen in other areas. Annual UK CPI inflation peaked at over 11 per cent in October 2022, initially mainly due to goods-price inflation on the back of post-pandemic supply-chain bottlenecks as well as global energy- and food-price spikes caused by the war in Ukraine. As these external shocks propagated through the UK economy, core-CPI and services-price



Note: Monthly year-on-year percentage changes, in per cent, period 1989M1 until 2024M3. Core CPI inflation excludes food and energy items. Horizontal grey line shows the 2% CPI inflation target, vertical lines show dates when inflation targeting and FCIT were introduced.
Source: ONS, own calculations.

Figure 26.1 UK headline, core, services, and goods inflation rates over time

inflation rates increased to levels above 7 per cent in 2023, in part reflecting second-round effects in domestic price, wage and margin dynamics. Even as headline CPI inflation declined towards the end of 2023, owing to lower goods-, energy- and food-price inflation, the persistence of services-price inflation at high levels remained a concern for the MPC.

In the remainder of this chapter, we explain the distinctive institutional, operational, and structural features of the UK economy and its inflation targeting regime. We emphasize the "Forecast-Centred Inflation Targeting" (FCIT) character of the UK monetary policy framework, which places a published inflation forecast that is collectively "owned" by the MPC at the heart of the internal formulation of policy decisions and their communication to external audiences. By nature, an approach centred on a baseline forecast offers less scope for communicating alternative paths of policy rates around that baseline, which has constrained the presentation of the rationale for monetary policy decisions in recent years at the Bank of England.

More specifically, we argue that the unique constellation of shocks seen since the COVID-19 pandemic in 2020 have highlighted limitations to the FCIT setup. Alongside institutional features of the FCIT framework, we suggest that three features of the UK economy have amplified UK inflationary pressures and thus magnified the challenges to the UK's inflation targeting framework: the UK's exposure to global factors, owing to its status as a small-open economy and international financial centre; the role of energy prices, owing to the UK's heavy reliance on imported intermediate goods, including commodities (and especially natural gas); and the UK's comparative advantage in services trade, which leaves it a net importer of goods, implying that aggregate inflation can temporarily deviate from target if there are asymmetric inflationary shocks in goods and services.

These developments have created opportunities for researchers, opening avenues for future research. New methods are required to make the Bank's understanding of inflation dynamics more robust. We end the chapter by summarizing new work by Bank of England authors that has helped policymakers navigate the challenges of recent years.

26.2 WHAT IS DISTINCTIVE ABOUT THE BANK OF ENGLAND?

Relative to other inflation targeting regimes, the UK's FCIT framework had several distinctive features – both in its institutional setup and with respect to features of the UK economy.

26.2.1 Institutional Features

The UK's experience with inflation targeting began in September 1992 with a discomforting rise in UK inflation expectations, following the UK's exit from the ERM on "Black Wednesday". At the beginning of September 1992, annual inflation expectations 10-years-out stood at around 4.5 per cent. By the end of that month, they had risen to 6 per cent 10-years ahead and 7 per cent 20-years ahead.

Against this backdrop, the UK government turned to inflation targeting in October 1992 seeking to restore policy credibility and stabilize longer-term inflation expectations. At that time, only New Zealand and Canada had previously adopted similar regimes (in 1990 and 1991, respectively).

Initially, the UK regime was controlled by the government, with the Bank of England simply enacting policy decisions taken at HM Treasury. Significant institutional changes were introduced in May 1997: monetary-policy decisions were taken out of the political arena and placed in the hands of the new MPC of the Bank of England. The nine-member MPC was granted operational responsibility to set monetary policy to achieve an inflation target – initially the 2.5 per cent target for RPI inflation, changed to a 2 per cent target for CPI inflation in December 2003.

The institutional underpinnings of the UK setup therefore differ from those in other jurisdictions. Although the MPC has independence to set its monetary policy instruments, it receives its mandate and target from the government. While other central banks, like the US Federal Reserve, have the freedom to set their own target, the Bank of England's inflation target is formally renewed each year by the Chancellor. Therefore, the MPC is "operationally independent", but not "target independent".

26.2.2 The Role of Inflation Forecasts

Among the choices made by the MPC itself, the more central role accorded to its inflation forecast in the formulation and communication of monetary policy decisions stands out. The centrality assigned to the inflation forecast distinguishes the MPC from peers at other central banks, where a wider set of analyses and simulations enter the policy discussion and external communication.

Other central banks produce and (often) publish "staff-owned" forecasts,[1] which are inputs to the policy discussion and around which monetary policymakers can communicate a "preferred path" for the interest-rate outlook.

By contrast, in the Bank of England's FCIT regime, Bank staff produce an inflation forecast, but the MPC collectively "own" that forecast. That forecast is presented as the "best collective judgement" of the Committee as a whole, rather than the view of staff. In that context, the policy decision and the published inflation forecast are characterized as two sides of the same coin: at least in principle, the same forecast that is used to formulate the policy decision internally within the MPC is also used externally to present the decision and its rationale to the public, media and market participants. The MPC's inflation forecast is conditioned on the market path for interest rates, and so the required stance for monetary policy derives from how the conditional forecast for future inflation made at time t, $E_t\left[\pi_{t+j}\right]$, compares to the inflation target, π^*.

The MPC forecast has therefore been characterized as a single funnel into which internal analysis based on a rich set of indicators, models and judgements is poured. Analysis and data are therefore weighted by the MPC collectively in coming to a policy decision based on how much different factors are judged to affect the inflation forecast (including the risks around the central case) at the policy-relevant 12- to 24-month horizon. While this characterization was always something of a pretence, it nonetheless captured the essence of the policy framework.

For the external presentation of monetary policy decisions, the MPC's inflation-forecast fan charts remain one of the key tools. Over a lengthy period following the establishment of the inflation targeting regime, the media, market participants and the public have been encouraged to look to the inflation fan chart both to provide a justification of the most recent policy decision and as an implicit guide to future policy choices. The MPC's assessment of the economic situation, the rationale for its Bank Rate decision and any guidance about future rate moves were characterized as being discernible from the fan chart, which acted as a "summary statistic" of the MPC's assessment.

This setup maintained an elegant symmetry between the characterization of the internal decision-making process and the presentation of decisions to the public. In turn, this bolstered the MPC's reputation for transparency, and served the MPC well in a more benign inflation environment than we have faced in recent years.

26.2.3 The UK Economy's Exposure to Inflationary Shocks

Specific features of the UK economy have, however, challenged the implementation of its FCIT framework at times. In theory, the FCIT setup is well-suited to addressing demand-side disturbances that do not pose trade-offs for policy. However, challenges can arise within that framework when there are trade-off inducing shocks coming from the supply side. And for a small-open economy with an international financial centre, like the UK, external developments are especially relevant.

Recent experience poses questions about whether factors specific to the FCIT framework might have made the UK economy more susceptible to current inflationary shocks. To get some insight into the possible challenges for the MPC in meeting their inflation target, we examine the texts from the open letters sent by the Governor of the Bank of England to the Chancellor of the Exchequer. The institutional framework dictates that such a letter needs to be sent each time UK headline inflation deviates by more than 1pp above or below the 2 per cent target. During the first 10 years of the Bank of England's independence, UK inflation remained at or close to its target. The first open letter to the Chancellor was sent by the

Governor in April 2007. Since then (to December 2023), over 30 letters have been exchanged, reflecting both above and below target periods of inflation.

Each of these letters have a similar structure, including a section headed "Why has inflation moved away from the 2% target?" In the subsequent paragraphs, the Governor provides their explanation, underpinned by Bank of England staff analysis, as to why inflation has deviated from the target and how the MPC plan to return inflation to target within a reasonable time. Figure 26.2 presents a cloud of words found in the "Why has inflation moved away from the 2% target?" section in the 30 letters sent between May 2010 and September 2023. Words are sized by the frequency with which they are used in these letters.

Note: Cloud constructed from 30 Governor letters from May 2010 and September 2023. Size of words represents frequency of use. Words pertaining to inflation and prices, as well as definitions (e.g. rate, per cent), have been omitted from the cloud.

Figure 26.2 *Cloud of words used in "Why has inflation moved away from the 2% target?" section of Bank of England Governor's letters to the Chancellor of the Exchequer*

While this text-based evidence is only illustrative, three key themes are evident in the word cloud. These reflect the economic mechanisms that – at least in the eyes of the MPC – have driven UK inflation away from its target. The first is the **UK's exposure to "global" factors**, which follows from its position as a small-open economy with an international financial centre. Because of this, the "appreciation" (or depreciation) of Sterling can influence inflation, in large part through the impact of currency moves on "import" prices. More generally, since the UK will be a price-taker in international markets, global developments can influence UK inflation. The second theme is the **role of "energy"**. A particular dimension of UK openness comes through its reliance on imported intermediate goods, including commodities. Among the most important of late has been natural gas. Changes in energy prices, often due to external events, can generate large swings in UK inflation. Finally, the UK's comparative advantage in **"services" trade** leaves it as a net importer of goods, opening a third key mechanism through which inflation can deviate from its target if inflationary shocks in goods and services do not offset each other.

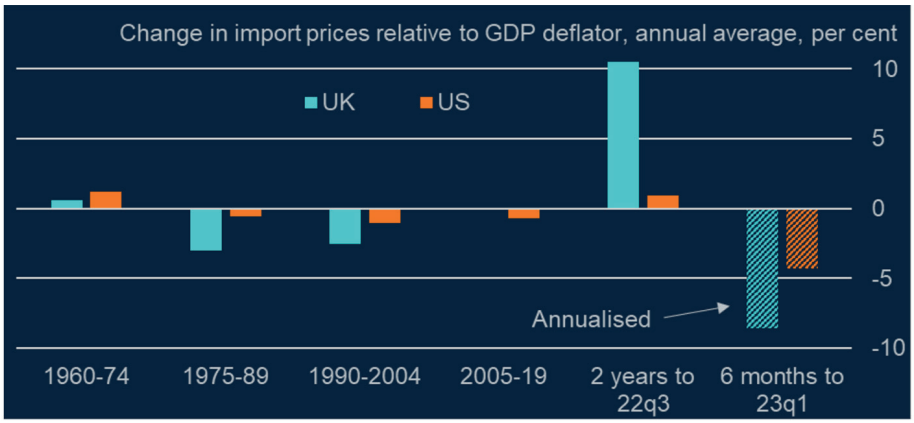
In the following, we first look at the role of each of these features, and then discuss how all three have combined to challenge the FCIT setup to near-breaking point during the post-COVID period.

The UK as a small-open economy. Total UK trade – measured as the sum of imports and exports – is equivalent to over 60 per cent of UK GDP, well above the average for major advanced economies. This openness brings many economic benefits to the UK, but it also implies that the UK inflation can be affected by foreign developments (Cesa-Bianchi et al., 2021). While inflationary pressures in a closed economy depend on developments in domestic costs, which in turn depend on domestic spare capacity, inflationary pressures from abroad can also be important for an open economy like the UK.

External demand can exert pressure on domestic resource utilization, and therefore domestic inflation. With UK exports' share of GDP growing over most of the past half century, the importance of this channel has steadily increased over time (Carney, 2017). Import prices can affect domestic inflation *directly* given that spending on the final goods and services bought by UK households from abroad will be part of the consumption basket used to construct inflation measures. Import prices can also affect UK inflation *indirectly*, through the impact of the prices of foreign-produced intermediate inputs used to produce those final goods and services, thus weighing on domestic costs. And given that the UK is a price taker in global markets, the prices of domestically produced tradable goods made in the UK are also likely to be strongly influenced by international developments, even when those goods are sold at home.

In the years prior to the COVID-19 pandemic, these channels had, for the most part, imparted steady disinflationary pressure on the UK economy. Globalization fostered integration of lower-cost producers into the global trade network, acting like an increase in potential supply for advanced economies. Consistent with this, average import-price growth, relative to the GDP deflation, was declining in the UK in the decades prior to 2019 (Figure 26.3). Given the scale of trade globalization, and in particular the growth of global value chains in production networks (World Bank, 2020), the importance of foreign developments for domestic inflation grew over time. For example, Auer et al. (2017) found that a doubling in the share of imported intermediates in GDP is associated with a doubling in the importance of global factors for domestic inflation.

While these developments can support a FCIT regime in containing inflation when external shocks are disinflationary – as they were prior to the onset of COVID – such developments can



Source: Broadbent (2023).

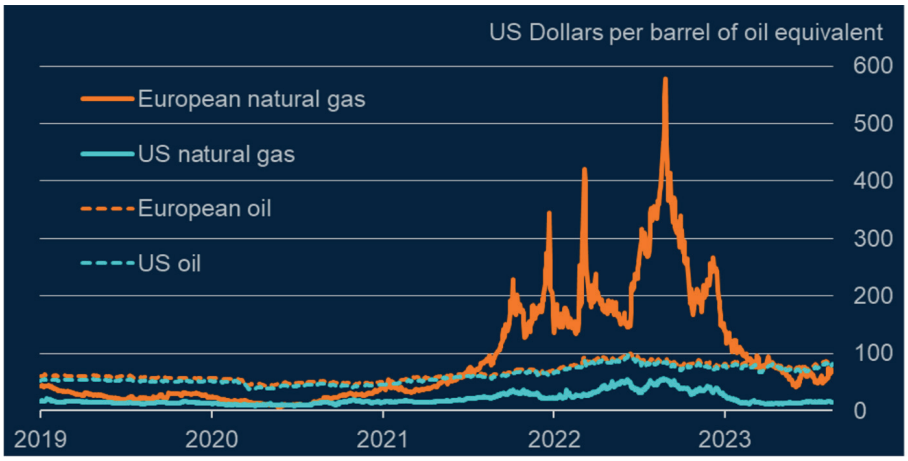
Figure 26.3 UK import price growth relative to GDP deflator over time

challenge the regime's ability to contain CPI inflation when inflationary shocks occur. The increasing role of such cross-border links can make inflationary shocks particularly acute for small-open economies like the UK, not just because the impact of those global developments on domestic inflation will be large but also because their external nature means that their effects can be difficult to offset with domestic policy instruments – like Bank Rate.

The UK as an energy importer. Amongst the intermediate inputs used to produce final goods and services, energy is one of the most important. Some energy sources, like oil, are relatively easy to trade or may even be available domestically – so that, in response to price increases abroad, trade flows can be redirected, or domestic supply raised. However, natural gas is an energy good that is not flexibly tradable between continents, since flows largely depend on existing infrastructure of pipelines from a few source countries. So, supply disruptions and swings in gas prices can have strong effects on domestic prices and thus pose notable challenges for the FCIT regime.

Russia's invasion of Ukraine, which started in 2022, brought this into sharp relief. Aside its human toll, the war was accompanied by a steep reduction in the supplies of energy, in particular natural gas, from that region. Owing to their reliance on Russian gas prior to the invasion, the UK and Europe saw energy costs rise to a much greater extent than elsewhere. At its August 2022 peak, the wholesale price of gas was over ten times higher in Europe than in North America, and the equivalent of nearly $600 for a barrel of oil (Figure 26.4).

Due to the distinct way in which retail energy bills are calculated in the UK, the direct impact of gas price increases on the CPI was even larger than in the rest of Europe (Broadbent, 2023). Domestic gas and electricity prices in the UK are set by the regulator using a formula that depends on the lagged, forward price of gas in wholesale markets, so that prices faced by consumers respond directly to global developments. Price caps supported by government subsidies in 2022–23 were no more generous than in other European countries, so that much of the gas-price spike passed through to CPI inflation. Moreover, because of the lags involved in the regulatory formula, the response of retail to wholesale prices was also more drawn out



Source: Broadbent (2023).

Figure 26.4 European gas prices rose very steeply in 2022

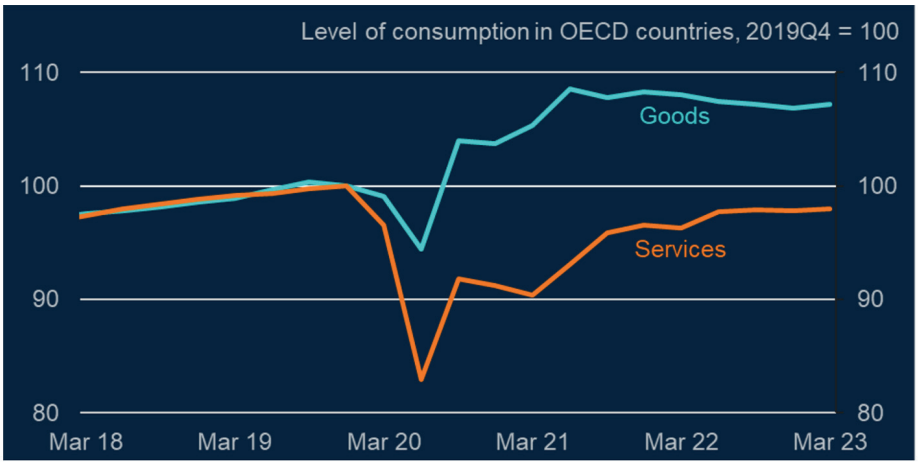
in the UK. As a result, domestic energy utility prices in the UK grew more strongly compared to the euro area and the US.

The UK as an international financial centre and services exporter. As well as being highly open in international trade, the make-up of the UK's imports and exports is also highly asymmetric. As a major international financial centre, the UK's foreign assets and liabilities sum to over five times its GDP – a substantially higher share than in other major advanced economies (Beck et al., 2023). These financial linkages play an important role in supporting the UK's comparative advantage as an exporter of services.

The UK's reliance on imported goods, while exporting services, means that changes in the relative price of goods and services can, at least temporarily, influence headline UK inflation. In the years prior to the COVID-19 pandemic, the disinflationary effects of globalization had mostly affected the prices of goods (Abdih et al., 2016), in part because trade in goods had been liberalized to a much greater extent than trade in services (Joy et al., 2018). This had disinflationary effects for the UK via weak import-price growth and thus weak, or even negative, goods-price inflation prior to the GFC. In turn, a relatively higher rate of services-price inflation could be accommodated, while still meeting the aggregate inflation objective. For example, UK core goods prices fell an average of 0.3 per cent in the two decades to 2017, while services prices rose by an average of 3.4 per cent (see Figure 26.1).

This dynamic reversed with the COVID-19 pandemic, as consumers in many countries, including the UK, shifted spending away from services disrupted by economic lockdowns and towards a material rise in the global demand for goods (Figure 26.5). Together, these shifts in demand and supply, had inflationary consequences for core goods prices. Combined with supply-chain disruptions and the inflationary consequences of war, the acceleration of goods prices contributed substantially to the peak in UK inflation in 2022.

The initial pandemic-induced rotation of inflation towards goods and away from services was followed by a more broad-based inflation rise and translated into a substantial rise of UK underlying inflation (Potjagailo et al., 2022). This occurred as services inflation caught up



Source: Broadbent (2023).

Figure 26.5 *The asymmetric effects of COVID-19 on the demand for goods and services*

once the economy reopened and demand increased. Services- and goods-price inflation rates are not independent since goods and energy constitute inputs for the service sector, and spillovers from goods- into services-prices can be relatively stronger in presence of large shocks and when inflation is high (Borio et al., 2023). While goods-price inflation came down quickly once the external shocks unwound, services-price inflation remained elevated, reflecting a higher degree of inertia in these price changes and a propagation toward domestically generated inflation via wage-price dynamics.

26.3 CHALLENGES TO IMPLEMENTING THE UK'S FCIT REGIME

The experience from the first 25 years of FCIT has taught us that the regime can work well when shocks emanate from the demand-side of the economy, are comparatively small, or when sectoral asymmetries offset each other in a way favourable for the headline inflation target. But recent shocks have been both distinctive in character and large in magnitude, creating stresses in the MPC's existing forecasting and policy framework.

Post-COVID events have demonstrated how the UK's openness, reliance on energy imports and comparative advantage in services exports can combine into a "perfect storm" of concurrent shocks to amplify inflationary pressures and magnify the challenges for FCIT. A reliance on imports reduced the efficacy of policy instruments in the face of external shocks. A heavy dependence on energy imports left domestic prices particularly susceptible to the large volatility in oil and gas markets. And imbalances in the domestic provision of goods relative to services increased spillovers from external shocks into domestically generated inflation, making it more challenging to use traditional policy tools that are set around an aggregate inflation target in response to sectoral shocks.

In forming their forecast and policy decisions against this backdrop, the MPC – acting within the UK's FCIT institutional framework – have had to form "best collective judgements" over how the various shocks could propagate through the economy. They have done so noting that the different shocks may interact with one another in novel and potentially complicated ways to alter economic behaviour. These changes have rendered forecasting models, estimated in more benign circumstances, less reliable guides to the economic outlook.

All this has made the MPC's traditional macroeconomic forecasts less useful – and thus less central – to the development and communication of monetary policy decisions than was the case in the past – especially relative to the "halcyon days" of inflation targeting in the late 1990s and early-to-mid 2000s. To put it bluntly: as forecasting inflation has become more difficult, the FCIT monetary-policy framework that places an inflation forecast at its heart has inevitably been subject to strain. The FCIT policy framework is therefore subject to challenge.

It was recognized from the outset that the FCIT strategy adopted by the Bank of England in the mid-1990s embodied vulnerabilities. For example, the framework could be disrupted by large terms-of-trade shocks (comparable to the infamous 1970s "oil shocks"); it was exposed to difficulties in forecasting inflation, should the structure of the economy, inflation process and/or monetary-policy transmission mechanism change rendering forecast models unstable; it risked a potential neglect of monetary and financial developments; and it was to a large extent dependent on the anchor or the inflation target remaining credible, with the magnitude and character of disturbances to the economy not being too large. To a greater or lesser extent, all these vulnerabilities have been exposed by recent experience.

One way of thinking about these challenges is to view them as an inevitable consequence of responding to large shocks, which move inflation well away from its 2 per cent target. Via their impact on tradable goods, food and energy prices, the COVID-19 pandemic and invasion of Ukraine certainly qualify as large shocks in this context.

Standard inflation forecasting models of the type underlying the MPC's FCIT strategy in the past are typically linearized, and therefore represent approximations that hold only in the region around the target-consistent steady state where linear approximations apply. These models should not be expected to work well when the economy moves beyond that region.

In particular, the assumption that the impact of economic disturbances on inflation and monetary policy can be analysed on a "holding-all-else-equal" basis is seriously challenged. Rather than seeing the impact of shocks in an additive manner, one needs to consider how those shocks interact with one another in a multiplicative manner. One notable example of this is the important interaction we have seen in recent years between the tightness of the UK labour market (with vacancy rates elevated in the aftermath of the COVID-19 pandemic, and the unemployment rate at 40-year lows) and the impact of the very large energy, food and tradable goods prices shocks after the pandemic and invasion. The risk of second-round effects in domestic price, wage and margin setting behaviour stemming from the latter is likely to be exacerbated by the extent of the former: this is the type of multiplicative effect that linear models may struggle to deal with.

If a robust monetary policy is to be formulated in this difficult context, then non-linearities and amplification mechanisms in the price-setting process need to be entertained and analysed, requiring models that go beyond linear approximations. This is what the final section of this chapter considers.

26.4 NEW EMPIRICAL APPROACHES AS CROSS-CHECKS TO THE FORECAST

Considering the challenges associated with FCIT, staff at the Bank of England have been building a suite of new approaches to provide a more broad-based and nuanced understanding of inflation dynamics and risks to inflation. The aim is building towards a broad portfolio of tools available to policymakers when forming their view on the state of the economy – away from solely relying on the central forecast.

While any empirical model faces challenges during low-probability tail events – for which we simply do not have many past observations to learn from – a wider suite of models can reflect the uncertainty around model choices and around the nature and size of shocks. And a balance must be found between enhancing models with flexible features that could help deal with non-linearities and asymmetries during specific periods and keeping models in our toolkits that are generally applicable over longer periods and in accordance with the distinct features of the UK economy.

Recent Bank staff analyses look, among other things, at non-linearities in the slope of the Phillips curve related to global supply constraints (Cesa-Bianchi et al., 2023), micro-level estimates of the pass-through of cost-push shocks via supply chains (Dhingra, 2023) and potential asymmetries in that pass-through (Mrabet and Page, 2023), the determinants of firm inflation expectations and perceptions (Yotzov et al., 2023), and the effects of energy price shocks on profit margins (Piton et al., 2023).

In the following, we illustrate two pieces of analysis in greater detail: a neural-network model to dissect UK service inflation into (non-linear) contributions from many indicators (Buckmann et al., 2023), and an inflation-at-risk model to assess the effects of shocks on tail outcomes (Anesti et al., 2023; Garofalo et al., 2023).

26.4.1 Dissecting UK Service-Price Inflation via a Neural-Network Model

Buckmann et al. (2023) present a machine-learning model to account for non-linearities in the links between an array of economic indicators and UK services-price inflation. Machine-learning methods exploit granular data and flexibly "learn" non-linear relationships to optimize predictive performance, which makes them increasingly appealing to central banks, including for monitoring inflation (Araujo et al., 2024). But their results can be difficult to interpret in relation to standard economic models and are thus subject to "black-box-type" critique.

To address this challenge, Buckmann et al. (2023) rely on a version of a neural-network model proposed by Goulet Coulombe (2022) which adds a degree of economic structure. A range of indicators are fed into sub-networks that reflect the building blocks of the Phillips curve (Figure 26.6): an output-gap-type block, lagged inflation, and inflation expectations. The lagged-inflation block is further split into: (a) input costs and goods prices to reflect *indirect spillover effects* into services via for instance input-output linkages, and (b) service prices, output costs and pay that reflect nominal inertia and domestically generated inflation. The "output gap" component reflects a range of indicators on activity, investment, consumption, labour market dynamics, a Bank of England output gap measure, as well as sectoral activity measures to account for sectoral dispersion.[2]

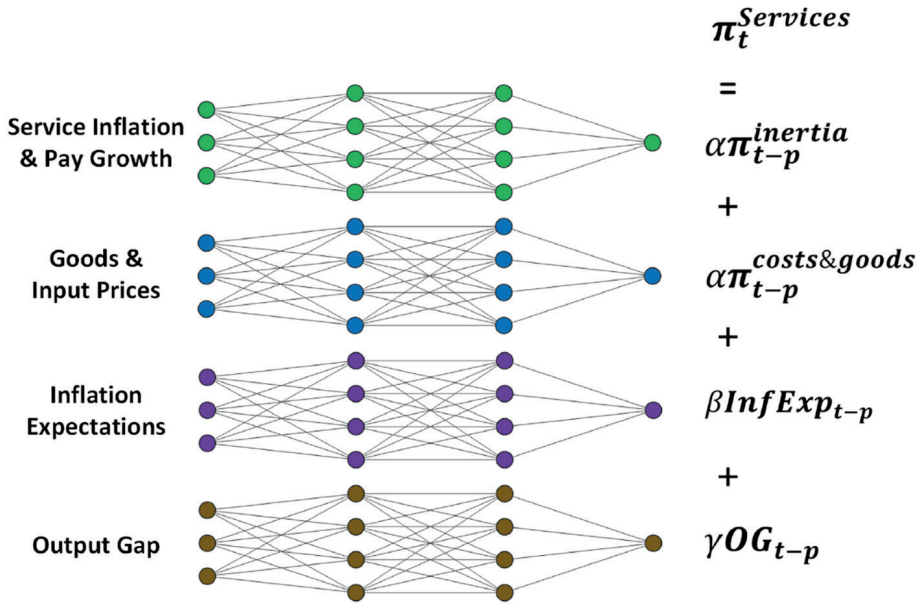


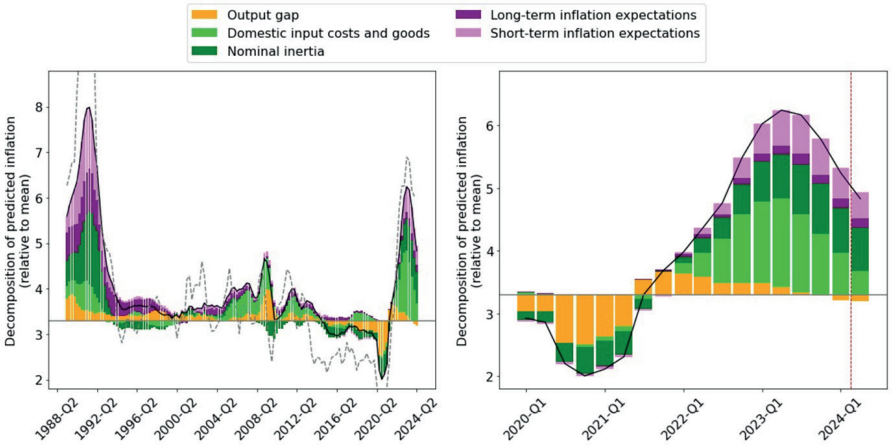
Table 26.6 A neural network with Phillips curve structure

The networks learn to distil this information in a non-linear way into latent components that jointly form the one-quarter-ahead optimized services-price inflation forecasts. The model is trained using out-of-bag cross validation, to avoid overfitting, over the period 1988Q1–1999Q4. It is then retrained repeatedly over an expanding sample, producing out-of-sample forecasts from 2000Q1 up to 2024Q2.

Figure 26.7 decomposes successive services-price inflations forecast into contributions from model components. The model reproduces the major fluctuations in services-price inflation such as the surge during the late 1980s, the decline during the COVID-19 pandemic and the recent rise. The rise of UK services-price inflation during the end 1980s is mainly assigned to the role of elevated inflation expectations. Around the time of the establishment of the FCIT framework, all contributions come down and the role of inflation expectations diminishes.

Throughout the sample period, there were spillovers from tradable goods into services-price inflation via input-output linkages and cost-push effects, but those were not accompanied by changes in nominal inertia. The latter fluctuated little in the past and represented a drag on services-price inflation during the decade following the GFC, likely due to timid wage growth. In the recent period, however, there were large and synchronized contributions from both components. Inflation expectations contributions picked up as well, albeit to a lesser extent than in the early 1990s.

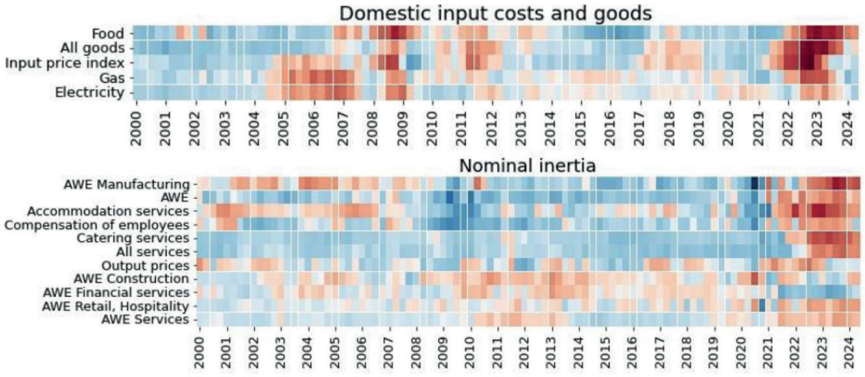
To add intuition, Buckmann et al. (2023) dissect signals that the model exploits from individual variables within the input costs and goods and nominal-inertia components, based on Shapley values (Lundberg and Lee, 2017), shown in Figure 26.8. Signals from variables related to goods prices and input costs have rarely been as strong and synchronized, and only in the recent episode have they also translated into positive signals from nominal inertia indicators.



Notes: Decompositions from out-of-sample 1-quarter ahead forecasts for 2000 to 2024Q2, out-of-bag cross validation up to 1999. Bars show contributions to forecast (solid line), relative to the mean service inflation of 3.3% during 1997–2019. Outturn (dashed grey). Right panel zooms into forecasts since 2020.

Figure 26.7 Decomposition of service inflation via the neural Phillips curve

Since 2023Q3, the model indicates a turning point in services-price inflation, albeit remaining at high levels. The marked drop in signals from gas prices, electricity and input prices accounts for most of the slowdown. However, the nominal-inertia and inflation-expectations components remain large and can reflect risks to persistence in aggregate inflation. Specifically, continuing strong signals come from lagged services-price inflation dynamics and from wage



Notes: Darker colours indicate stronger positive (negative) signal, derived as Shapley values for each quarter and price sub-category or wage series. AWE = average weekly earnings.

Figure 26.8 Signals from input costs and goods and from nominal inertia over time

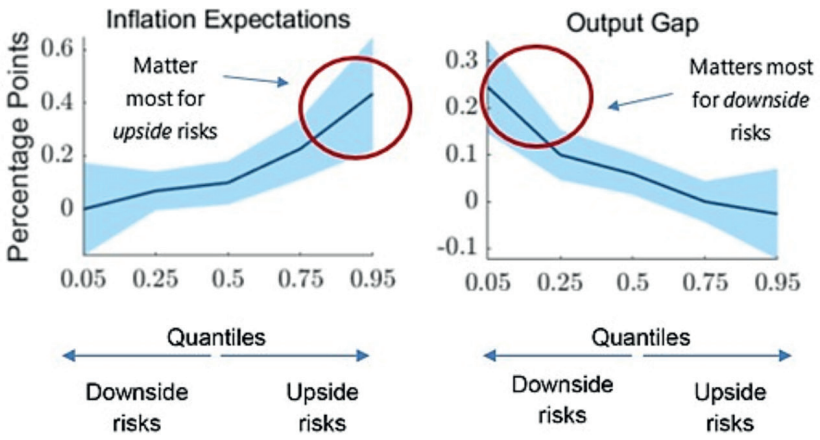
pressures, potentially reflecting ongoing second-round effects on domestic inflation beyond the direct effects of external shocks.

26.4.2 Modelling Inflation Risks with an Inflation-at-Risk Model

As well as predicting and decomposing the "modal" outlook for inflation, it is also important for policymakers to understand "risks" around the inflation outlook within an FCIT framework. Anesti et al. (2023) outline an "Inflation-at-Risk" model, which is designed to assess the uncertainty and balance of risks around the outlook for UK inflation, and to understand how this uncertainty relates to underlying economic conditions. This data-driven approach relies on quantile regression, a statistical tool, to estimate the relationship between a range of indicators and the entire distribution of possible inflation outcomes. Through this, the model determines which variables are important, not just for explaining changes in the expected path for inflation, but also in shaping the overall level of risk around that path.

To set up their model, the authors include various macroeconomic indicators that are typically considered important for driving inflation dynamics, specifically: lagged inflation, inflation expectations (for a combination of households and corporates), the estimated output gap, and world export prices. The quantile-regression model is estimated using data from several advanced economies (US, UK, euro area and Japan) with a variety of historical inflation experiences and is used to investigate how changes in each of the variables affect the whole distribution of possible inflation outcomes across a range of forecast horizons.

Among their main results, Anesti et al. (2023) find that inflation expectations and the output gap are particularly important for shaping risks around the central projection in the near term. Figure 26.9 shows the estimated coefficients from those two variables across five different



Notes: Coefficient estimates across quantiles at the one quarter ahead horizon. Thick line shows point estimates and shaded area is 68% confidence interval. Model is estimated using data from UK, US, euro area and Japan from 1995–2022.

Figure 26.9 Inflation expectations, the output gap and the balance of risk

quantiles (i.e., different parts of the inflation distribution) reported on the horizontal axis. They show how the outlook for future inflation one-quarter ahead – and the risks around it – respond to changes in each of the variables. If the line for a coefficient is broadly flat and non-zero, it means that changes in the corresponding variable are associated with a shift in the whole distribution. In contrast, if the line is not flat, then changes in the variable contribute to a change in the balance of risks. For example, the variable may have a larger effect on the left or right tail of the distribution than at the mean. These results refer to the predicted conditional inflation distribution one-quarter ahead, but the picture over other short-run horizons is very similar.

Higher inflation expectations today contribute to an increase in the central forecast for inflation next quarter, but they also shift the balance of risks to the upside, increasing the likelihood of inflation coming out above the central projection. On the other hand, a more negative output gap (i.e., a greater degree of economic slack) contributes to a reduction in the central projection for inflation while simultaneously shifting the balance of risks to the downside.

In contrast to these two variables, lagged inflation and world export prices have significant effects over the entire the predicted inflation distribution. Higher past inflation or inflationary pressures from the rest of the world contribute to an increase in the central projection for inflation without affecting the overall balance of risks the forecast.

Anesti et al. (2023) also use the model to produce forecasts for possible UK inflation outcomes. Figure 26.10 shows the estimated distribution of possible inflation outcomes one quarter ahead for each period over 2019–22 from our model. Notably the model estimates a rise in upside inflation risk over the later period of 2020 – the model thus detects upside risks early on that then materialized over 2021.

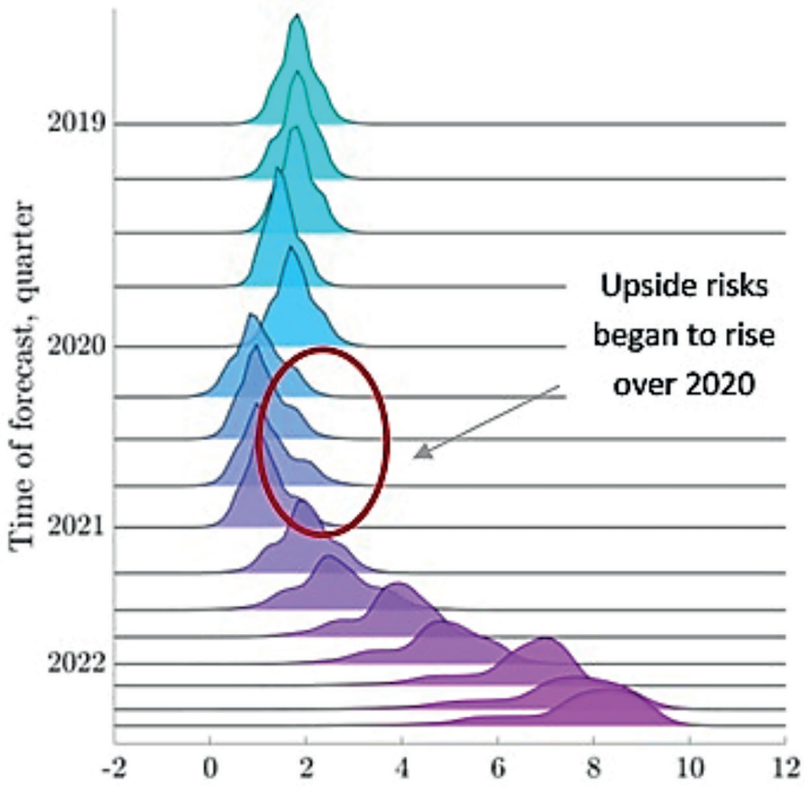
Garofalo et al. (2023) further extend the inflation-at-risk model to analyse the impact of oil-supply shocks on the inflation forecast distribution. Through the lens of their model, they show that such shocks have more pronounced effects on the upper tail of the inflation distribution that at the centre, consistent with the findings in Figure 26.10.

Overall, the findings from both the neural-network and inflation-at-risk models highlight how comparatively new data-driven approaches can be used to assess the level and drivers of risks around the inflation outlook, improving the analytical underpinnings inflation analysis and building a larger set of tools available for policymakers in addition to the central forecast within the UK's FCIT framework.

26.5 CONCLUDING REMARKS

The onset of the COVID-19 pandemic and the Russian invasion of Ukraine represented large shocks to the global economy, and – given that the UK is a small-open economy susceptible to international influences – significant external shocks to the UK economy. The magnitude and character of these shocks exposed some of the underlying vulnerabilities in the UK's FCIT strategy.

The Bank of England's MPC has taken measures to contain the inflationary pressures created by those shocks and return headline consumer-price inflation in the UK to its 2 per cent target. Considerable progress has already been made in that direction. But the extent to which the FCIT framework supported the formulation and presentation of those MPC measures is naturally a subject for discussion. The Bank of England itself invited former Federal Reserve



Notes: One quarter ahead probability distributions for year-on-year inflation (%); distributions fitted from quantile-regression output using non-parametric approach.

Figure 26.10 Model forecasts for UK inflation over COVID

Chair Ben Bernanke to conduct a review of the role of its inflation forecasts in the formulation of monetary policy (Bernanke, 2024).

In this chapter, we have reviewed why the UK economy and the MPC's FCIT framework faced a "perfect storm" given the character of the economic disturbances faced in recent years. While existing modelling frameworks have fallen short in some respects, the chapter demonstrates how prompt action by Bank of England staff has developed novel frameworks, invoking new non-linear techniques and methods, which have provided a basis for analysing inflation developments and their monetary policy implications during this challenging period.

Much work remains to be done to address the recommendations made in the Bernanke report and ensure that the MPC's framework is robust to the challenges posed by a potentially more uncertain and volatile world. But we are headed in the right direction.

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NOTES

1. For example, US Federal Reserve staff forecasts are reported, with delay, in the Tealbook.
2. The role of this component for inflation can be interpreted as "inflation-relevant output gap contribution", i.e., any (non-linear) relationship between inflation and output gap fluctuations. However, a Phillips curve slope is not explicitly identified, and the output gap contribution might be confounded by supply-side drivers. Indeed, the model struggles to identify negative effects from the output gap component during the GFC, for instance, which can relate to standard identification issues in Phillips curve estimations (Del Negro et al., 2020; McLeay and Tenreyro, 2020). In follow-up research, Buckmann et al. (2023) are incorporating sign restrictions and identified shocks into a machine-learning model based on boosted trees, in order to separate demand and supply drivers of CPI inflation.

REFERENCES

Abdih, Y., Balakrishnan, R., and Shang, B. (2016). What is keeping US core inflation low? IMF Working Paper No. 16/124.

Anesti, N., Garofalo, M., Lloyd, S., Manuel, E., and Reynolds, J. (2023). Unknown measures: Assessing uncertainty around UK inflation using a new inflation-at-risk model. *Bank Underground Blog*, 13 July.

Araujo, D., Doerr, S., Gambacorta, L., and B. Tissot (2024). Artificial intelligence in central banking. BIS Economic Bulletin No. 84.

Auer, R., Borio, C., and Filardo, A. (2017). The globalisation of inflation: The growing importance of global value chains. BIS Working Paper No. 602.

Beck, T., Lloyd, S., Reinhardt, D., and Sowerbutts, R. (2023). Macro-financial policy in an international financial centre: The United Kingdom experience since the global financial crisis. In C. Borio, E. Robinson, and H. Shin (eds.), *Macro-financial Stability Policy in a Globalised World: Lessons from International Experience*. London: World Scientific, pp. 183–223.

Bernanke, B. (2024). Forecasting for monetary policy making and communication at the Bank of England: A review. Bank of England. https://www.bankofengland.co.uk/independent-evaluation-office/forecasting-for-monetary-policy-making-and-communication-at-the-bank-of-england-a-review.

Borio, C. E., Lombardi, M., Yetman, J., and Zakrajšek, E. (2023). The two-regime view of inflation. BIS, Bank for International Settlements Papers No. 133.

Broadbent, B. (2023). The economic costs of restricting trade: The experience of the UK. Speech given at the Federal Reserve Bank of Kansas City 46th Economic Symposium, Jackson Hole, Wyoming, 26 August.

Buckmann, M., Potjagailo, G., and P. Schnattinger (2023). Dissecting UK service inflation via a neural network Phillips curve. *Bank Underground Blog*, 10 July.

Carney, M. (2017). [De]globalisation and inflation. 2017 IMF Michel Camdessus Lecture, 18 September.

Cesa-Bianchi, A., Dickinson, R., Kösem, S., Lloyd, S., and Manuel, E. (2021). No economy is an island: How foreign shocks affect UK macrofinancial stability. *Bank of England Quarterly Bulletin*, 2021 Q3.

Cesa-Bianchi, A., Hall, E., Pinchetti, M., and Reynolds, J. (2023). Did supply constraints tilt the Phillips curve? *Bank Underground Blog*, 5 July.
Del Negro, M., Lenza, M., Primiceri, G. E., and Tambalotti, A. (2020). What's up with the Phillips curve? NBER Working Paper No 27003.
Dhingra, S. (2023). A cost-of-living crisis: Inflation during an unprecedented terms of trade shock. Speech given at the Resolution Foundation, 8 March.
Garofalo, M., Lloyd, S. and Manuel, E. (2023). Fuelling the tail: Inflation- and GDP-at-risk with oil-supply shocks. *Bank Underground Blog*, 10 August.
Goulet Coulombe, P. (2022). A neural Phillips curve and a deep output gap. *arXiv preprint arXiv:2202.04146*.
Joy, M., Lisack, N., Lloyd, S., Reinhardt, D., Sajedi, R., and Whitaker, S. (2018). Mind the (current account) gap. Bank of England Financial Stability Paper No. 43.
Lundberg, S. M., and Lee, S. I. (2017). A unified approach to interpreting model predictions. NIPS'17: Proceedings of the 31st International Conference on Neural Information Processing Systems.
McLeay, M., and Tenreyro, S. (2020). Optimal inflation and the identification of the Phillips curve. *NBER Macroeconomics Annual*, 34(1), 199–255.
Mrabet, H., and Page, J. (2023). How do firms pass energy and food costs through the supply chain? *Bank Underground Blog*, 24 August.
Piton, S., Yotzov, I., and Manuel, E. (2023). Profits in a time of inflation: Some insights from recent and past energy shocks in the UK. *Bank Underground Blog*, 30 August.
Potjagailo, G., Wanengkirtyo, B., and Lam, J. (2022). How broad-based is the increase in UK inflation? *Bank Underground Blog*, 27 October.
World Bank (2020). *Trading for Development in the Age of Global Value Chains.* World Development Report 2020. Washington, DC: World Bank.
Yotzov, I., Bloom, N., Bunn, P., Mizen, P., Ozturk, O., and Thwaites, G. (2023). Firm inflation perceptions and expectations: Evidence from the Decision Maker Panel. *Bank Underground Blog*, 7 July.