CHAPTER 11. AN OVEVIEW OF THE BANK OF ENGLAND QUARTERLY MODEL OF THE (BEQM)

This model is the main tool in the suite of models employed by the staff and the Monetary Policy Committee (MPC) in the construction of the projections contained in the quarterly *Inflation Report*. You can download the model from http://www.bankofengland.co.uk/publications/other/beqm/index.htm

1. The role of models and forecasts at the Bank of England

The Bank of England is mandated by the Chancellor of the Exchequer to aim at an inflation target—at the time of writing, a 2% annual inflation rate of the Consumer Prices Index (CPI)—and uses a very short-term nominal interest rate as its instrument to pursue this target. Because of the lags between changes to interest rates and the associated effects on inflation, setting monetary policy is inherently a forward-looking exercise. Hence the quarterly *Inflation Report*, in addition to assessing the current state of the economy, contains projections for output growth and inflation up to two years out.

The Bank uses numerous economic models to help produce these projections. Each projection is produced by the MPC rather than as a mechanical output from any model. It is helpful to use a macroeconomic model as the primary organisational framework to process the various judgments and assumptions made by the Committee. In particular, a key element of the forecast process is for Committee members to assess the extent to which different economic judgments and assumptions concerning the big issues affecting the economy could influence their view of future prospects. In order to be able to carry out this sort of analysis, the main forecast model ideally needs a relatively explicit economic structure that identifies the key behavioural parameters and channels within the economy.

2. An overview of BEQM

BEQM describes the behaviour of the UK economy at a relatively aggregated level that is closely related to the incomes and expenditures recorded in the UK National Accounts. To do this, the model contains formal descriptions of the behaviour of private domestic agents,

policymakers and the rest of the world, and their interactions in markets for capital and financial assets, goods, and labour.

Firms seek to maximise profits by hiring labour and buying capital in order to produce output. Firms and workers bargain over wages and, given the outcome, firms are assumed to choose the labour they wish to employ so that the costs of any extra workers are compensated for by the higher revenues they generate.

Similarly, firms' desired level of capital is determined by the cost of capital and the return to extra investment.

The output that firms produce is sold in markets for domestic consumption, investment and government purchases, as well as in housing and export markets. Firms are assumed to face varying degrees of competition in these markets, which implies that firms may receive a different profit margin from the sale of their goods in each market. The composition of total sales will therefore affect revenue and profits, so that relative demand conditions will matter as well as overall demand conditions.

Firms face competition from importers for consumption and investment goods, and have to price their products in export markets so as to achieve maximum profits.

In addition, various short-run factors can influence firms' behaviour, such as the short-run prospects for demand affecting the speed with which they invest.

Households consume imported and domestically produced goods.

When deciding on their current level of consumption, and hence their level of saving or borrowing, households are assumed to want to keep their lifetime consumption as smooth as possible. To do this, households can borrow and save using a range of financial assets, including domestic equities, corporate debt, government debt, money, and foreign assets.

In addition, in the short run, households' levels of consumption can be influenced by a variety of other factors, such as short-term fluctuations in their income and their level of confidence about the future.

The government buys output from domestic firms and pays for it by raising taxes and selling debt, in addition to a small amount of revenue that accrues from seigniorage. Total revenue also has to be sufficient to pay the cost of servicing the existing level of government debt and any government transfers.

For long-run solvency, the fiscal authority may at some stage have to adjust a policy instrument—such as a tax rate—to ensure that the fiscal budget constraint is met. A variety of fiscal policy ‘rules’ can be considered. In general, these rules assume that any required fiscal adjustment occurs only gradually.

The monetary policy maker has the job of anchoring the nominal side of the economy. The nominal target is that the central bank targets an annual inflation rate of the CPI of 2%, using the short nominal interest rate as its instrument. An assumption about the policy rule used by the central bank—the monetary policy reaction function—is required for inflation to be anchored in the long run.

BEQM assumes that *UK capital markets* are ‘small’, in the sense that the demand for and supply of financial assets in the United Kingdom do not affect the level of interest rates prevailing in the rest of the world.
Since all claims on domestic firms’ assets and government debt must ultimately be held either by domestic households or the rest of the world, it follows that the United Kingdom’s net foreign asset position is determined jointly by the decisions of firms and the government about how many financial liabilities to issue and by domestic households about how many of these assets to hold.

These decisions also have implications for the *United Kingdom’s trade balance*.
Suppose, for example, UK households were assumed to want to hold only some of the domestic financial assets on offer, such that the United Kingdom maintained a net debt with the rest of the world. This would imply that, in the long run, the United Kingdom would need to have a trade surplus sufficient to meet the costs of servicing this debt. The equilibrium real exchange rate is assumed to move eventually so as to ensure that exports and imports achieve this long-run balance.

The *main channels* through which changes in monetary policy are transmitted to the rest of the economy have to be described now. The fact that prices and nominal wages move only slowly means that the central bank, by changing the nominal interest rate, has the ability to influence real interest rates.

Lower real rates tend to encourage consumers to spend more now. Lower real rates also encourage investment and spending on housing by lowering financing costs, and they make it less costly to hold inventories. The combined effect is to push up domestic demand.
To meet that demand, firms will demand more of the factors used in the production of goods and services, namely capital and labour. This in turn is likely to increase the costs of these factors of production.

The fact that the UK economy is a small open economy adds an important channel through which monetary policy operates. In particular, a lower domestic real interest rate may tend to encourage a depreciation in the real exchange rate. This will lead to both a direct price effect—the prices of imported goods will rise—and a number of possible indirect (or 'second-round') effects, reflecting both any pass-through from higher import prices onto domestic prices and costs, and the impact of any change in competitiveness associated with the change in the real exchange rate on the United Kingdom's trade balance.

Other things being equal, increased demand for workers leads to higher wage costs, which firms will typically attempt to pass on to some degree in the form of higher prices.
Similarly, increases in world prices or an exchange rate depreciation create pressure on import prices.
And increased demand for domestically produced goods will also create incentives for firms to raise prices.

Inflationary pressures reflect the degree of imbalance between the level of demand and the capacity of firms to meet that demand.
The level of demand and potential supply will depend on both the current stance of monetary policy and the stance expected in the future.
Firms' responses to these pressures on capacity will depend on the extent to which they are likely to persist, and hence on the expected stance of monetary policy in the future.
The importance of future expectations in determining current inflationary pressures underlines the central importance of monetary policy anchoring private sector expectations of the long-term inflation rate.

3. Some key technical features of BEQM

BEQM has *a well defined steady state*. This means that, in the long run, all variables in the model settle on paths that are growing consistently with each other in a sustainable equilibrium.

This aids analysis of economic issues, since an understanding of the medium term requires an understanding not just of short-run forces, but also of where the economy is heading to in the long run. For example, a stable steady-state solution would not be compatible with a situation in which household debt was increasing without bound.

Another important feature of the new model is that it contains more explicit *forward-looking representations of agents' expectations* about the future. These include expectations about future labour income, aggregate demand, the exchange rate, and so on. Models with fully forward-looking agents can sometimes exhibit unrealistic dynamic properties; in particular, if households and firms are assumed to have perfect foresight, they might adjust their behaviour immediately in response to future anticipated events. But in reality the economy does not 'jump' about in this fashion. That partly reflects the fact that it is often costly for households and firms to change their behaviour very rapidly.

In addition, firms and households do not have perfect foresight. Instead, they have to form expectations on the basis of limited information.

BEQM incorporates both of these features. In particular, it is structured in such a way that assumptions about the speed of adjustment and the amount of information available to agents can be altered and changed in order to help the Committee to assess how these assumptions could affect the future path of the economy.

4. Some illustrative simulation results

The simulations discussed below focus on the effects of *changes in the short-term nominal interest rate on output and inflation*, 'all other things are assumed to be equal'.

The precise effect of a change in the short-term nominal interest rate will depend on whether this change was anticipated by households and firms, on the credibility of the monetary policy regime and a host of other factors. So simulations can be used to provide only an illustration of the properties of a model. They cannot be used mechanically to predict how the economy—or even a model—will react to actual changes in economic variables.

Charts 1 and 2 illustrate the effect of a *temporary* change in the short-term nominal interest rate on output and inflation respectively. The simulation considers the effect of an *unanticipated* 1 percentage point rise in the short-term nominal interest rate for one year. Interest rates beyond the first year in this simulation are determined by a *monetary policy rule that assumes interest rates are set so as to return inflation to base.* Charts 1 and 2 show the effects of this simulation in BEQM, together with the most recently published simulations for the MTMM. To illustrate the sensitivity of the simulations to different assumptions, Charts 1 and 2 show three different simulations for BEQM, based on different assumptions about the form of the monetary policy rule, in which monetary policy is assumed to respond more or less strongly to deviations of inflation from target.

Chart 1
Response of GDP level to nominal interest rate increase

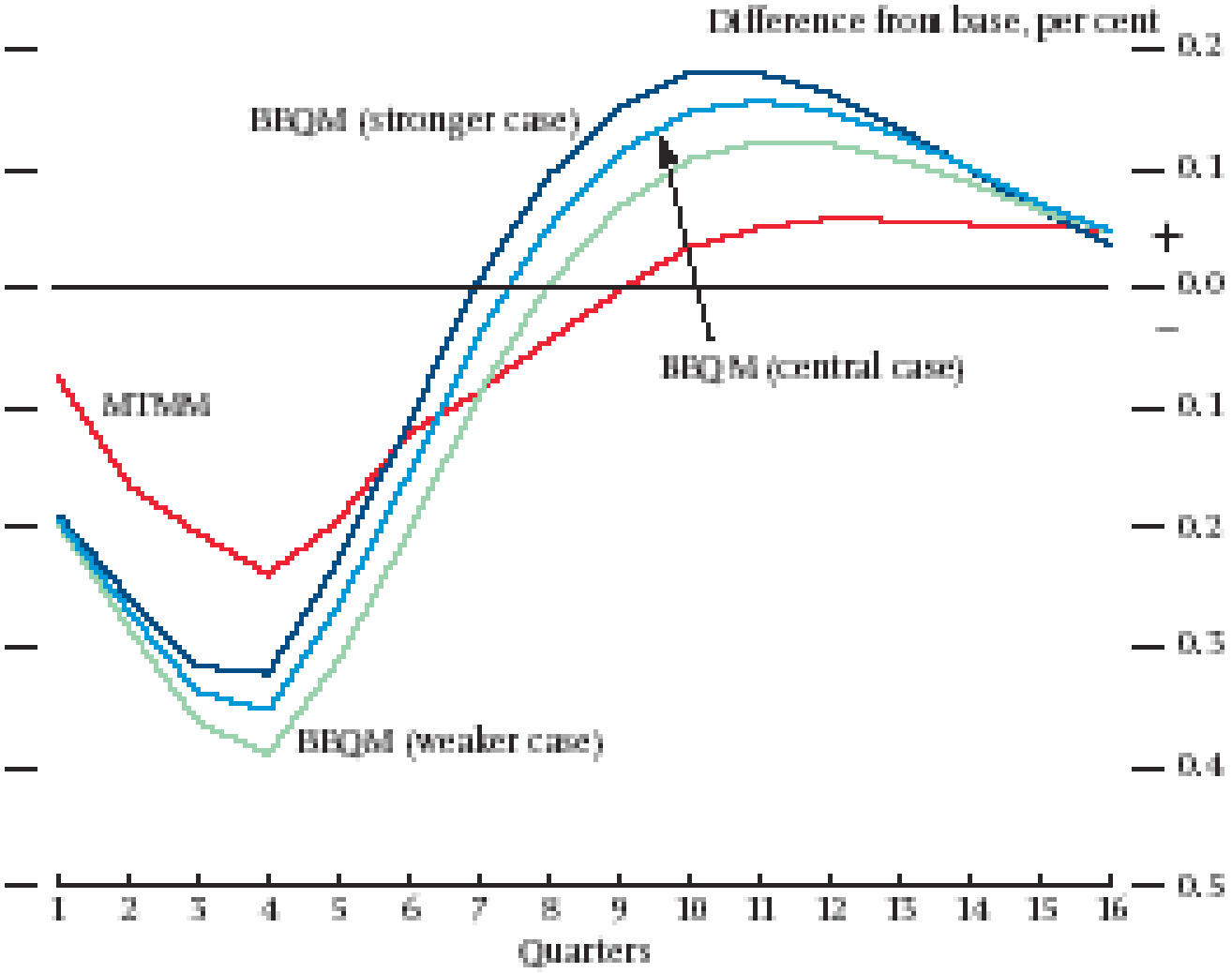
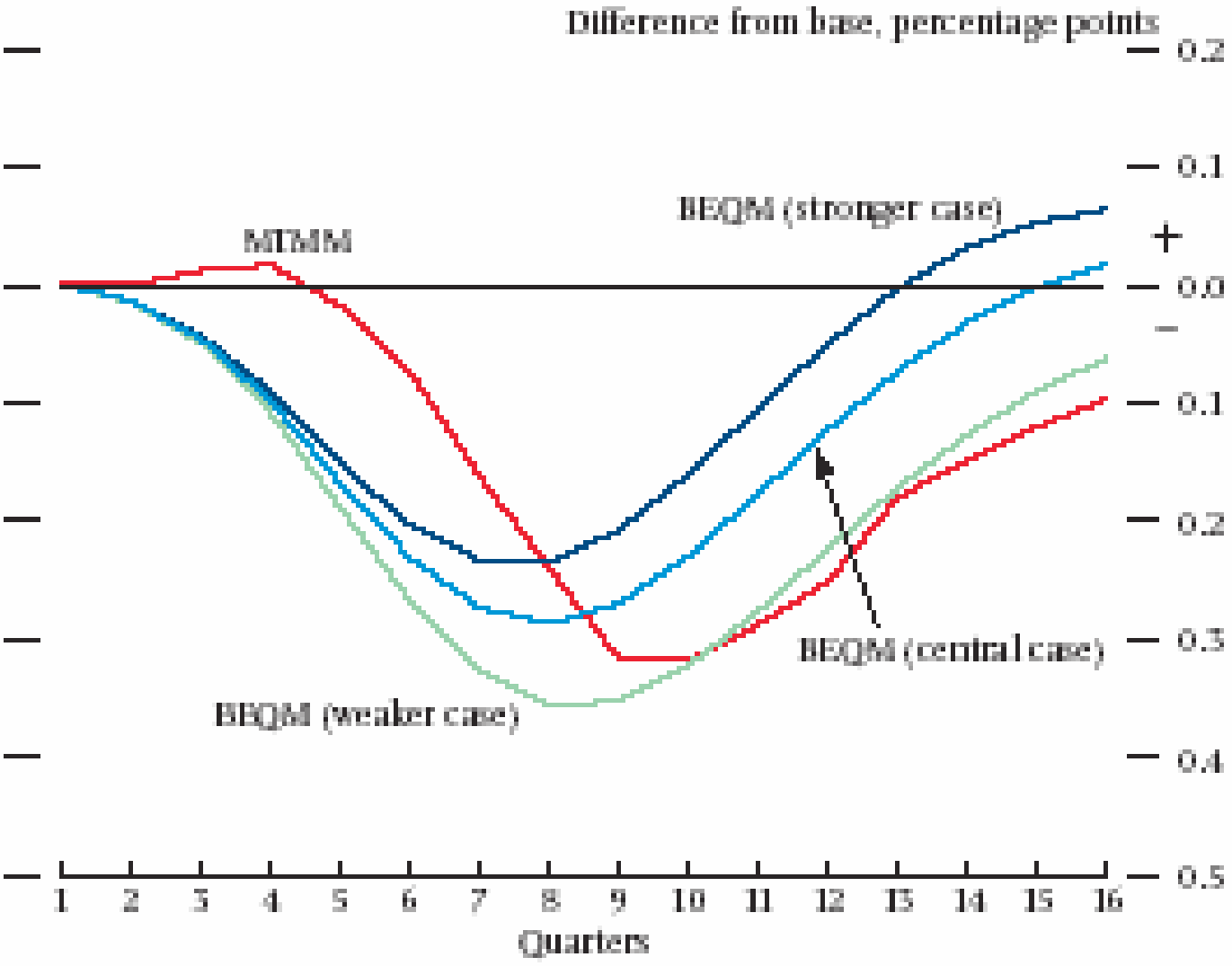


Chart 2
Response of annual inflation rate to nominal interest rate increase



The responses of output and inflation to the temporary change in interest rates are similar in the two models. The maximum effect on the level of real activity occurs after about one year and on inflation after about two years.

The demand effects come through a little more quickly in BEQM, reflecting in part the fact that consumption responds more strongly in the short run to interest rate changes in the new model. Further out, the effects of the temporary change in interest rates on inflation are somewhat less persistent in the new model, reflecting the fact that households and firms are

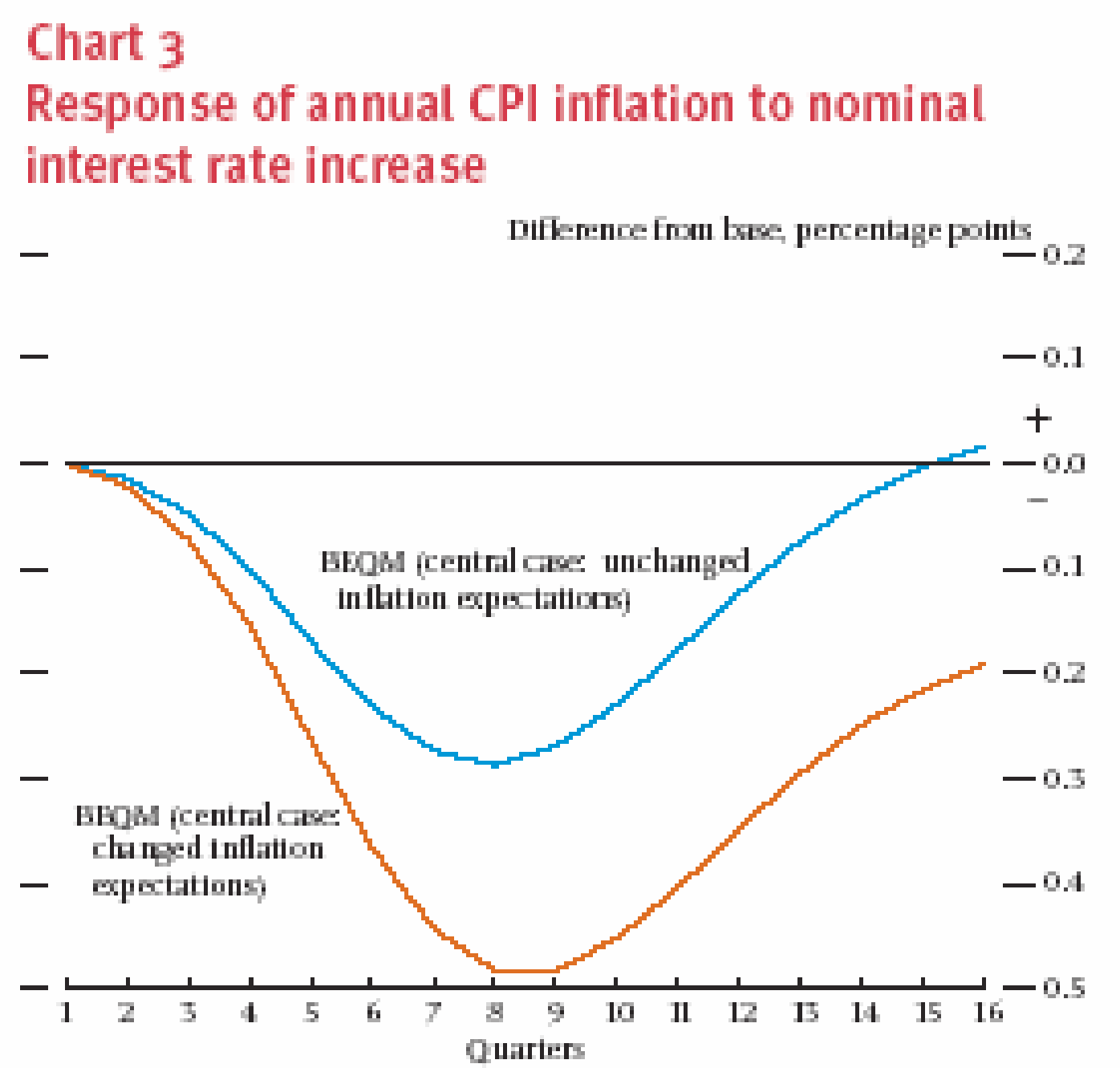
forward looking and that they expect monetary policy will be set so as to return inflation to base.

5. Response to nominal interest rate increase

The responses of output and inflation to a change in interest rates will also depend on the credibility of the inflation target. In particular, as inflation expectations become more firmly anchored around the inflation target—the inflation target becomes more credible—a change in the short-term interest rate is likely to have less impact on activity and inflation.

The simulations illustrated in Charts 1 and 2 are based on the assumption that the temporary change in interest rates does not affect households' and firms' long-run inflation expectations. To illustrate the sensitivity of these simulations to this assumption, Chart 3 compares the response of inflation in the central case with a situation in which households and firms perceive that the unexpected increase in interest rates may have been triggered by a reduction in the targeted rate of inflation.

The response of inflation to the change in interest rates in this case is significantly greater and, as such, underlines the importance of monetary policy credibility in determining the sensitivity of the economy to changes in interest rates.



6. Complements

We saw that the BEQM model is used to compute

1. a central forecast of the UK economy
2. to explore the sensitivity of this forecast to alternative hypothesis on the evaluation of the environment or economic policy

The results of the simulations of the model will have to be interpreted in economics terms and explained in plain English to economists who are not expert of macroeconometric modelling.

To reach these results the model the model must

1. be consistent with modern macroeconomic theory
2. have an accounting consistency, which means be built around the accounting framework of British National accounts
3. be able to reproduce the past path of the UK economy, which means be econometrically estimated

The model has a neo classical long run represented by a balanced growth path. It is Keynesian in the short run, which means that it includes plenty of real and nominal rigidities.

The BEQM has to provide a rich, explicit, theoretical structure, while matching the data. It also needs to be flexible and reliable under different forecasting assumptions and conventions. There is a contradiction between these two features of the model. For instance it must be able to generate a balanced growth path and be able to reproduce the past. The UK economy, like the French economy, does not grow along a balanced growth path. For instance the trends of the consumption price, the investment price and the imports price, are different. That means that there is a contradiction between theory and econometrics.

This has led to the concept of building the model with two parts – a layer that provides the theoretical core of the model, and a layer of extra dynamics designed, in part, to facilitate judgemental adjustments. The idea has been of adding *ad hoc* or 'data-driven' dynamics to theoretical structure. When used together, these two parts form the full model that is the actual platform used for producing forecast paths and allows the direct application of judgement.

The core model could be thought of as a dynamic general equilibrium model in which adjustment costs and other frictions are modelled explicitly. The individual building blocks of the theoretical core are largely conventional, and similar to those of the DGTPE model. The core model is calibrated and gives decent forecast for the medium run (two or three years)

The full forecast model supplements the paths from the theoretical core with a statistical model of the discrepancy between historical outturns and the paths generated by the core

model. The only restriction on the structure of *ad hoc* non-core equations is that the projected path for a given variable should always converge to the long-run equilibrium imposed by the core theory. This forecasting model is strictly autoregressive. That means that the equations of the *ad hoc* model take the paths from the core theory and combine them, if needed, with extra persistence and variables that proxy for effects missing in the core theory.

Actual forecast paths are thus combinations of three types of information:

- theoretical insight from the structural core model;
- data-driven evidence on historical correlations of endogenous variables with other factors, especially those that are not formally accounted for in the structural core
- a direct application of judgement, informed by other models and staff expertise

Figure 2.2: A stylised forecast sequence