Nowcasting UK GDP growth

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- Official estimates of UK GDP growth are published with a lag, but other data and statistical models provide an early indication of GDP growth.
- This article describes the approaches taken by Bank staff to produce early estimates ('nowcasts') of GDP growth, ahead of the publication of official estimates.
- Although the confidence bands around the Bank staff's nowcasts can be large, these estimates have tended to be more accurate than those from a simple statistical model.

Overview

An assessment of the current cyclical position of the UK economy is a key input into the Monetary Policy Committee's (MPC's) monthly policy decisions and its *Inflation Report* projections. Official GDP data are published with a lag, however, so 'nowcasts' — estimates of growth in the current quarter, or the most recent quarter for which no official estimate is available — help policymakers to form a view on the prevailing state of the economy. Bank staff use a variety of models and indicators to provide nowcasts for the MPC which, since May 2013, have been reported in the quarterly *Inflation Report* and in the MPC minutes (see **summary chart**).

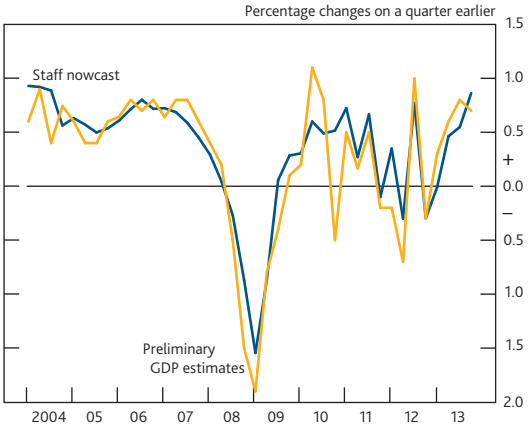
There are many different approaches to nowcasting, and a large body of literature on this topic. These differences stem from the range of data available that is considered useful, and the different ways of modelling the relationship between these data and GDP.

When growth is relatively stable, it is difficult to improve upon simple statistical models in which GDP growth depends linearly on its previous values. But the performance of such models is often poor during more volatile periods.

As this article discusses, Bank staff use two main models to nowcast GDP. One is based on modelling growth in different industries, while the other is based on mapping from survey indicators to GDP at an aggregate level.

A key aspect to nowcasting is also assessing when purely estimation-based nowcast models are likely to give a poor signal of GDP growth. The nowcasts produced by Bank staff take this into account, and so do not purely reflect the mechanical outputs of the models outlined in this article. In recent years, there have been a number of events that have led Bank staff to place less weight on the mechanical nowcasts implied by estimation-based models. For example, the financial crisis increased output volatility substantially, and special events — such as the Diamond Jubilee and London Olympics — had temporary effects on output that also increased quarterly volatility. This is likely to have been a key reason why the root mean squared error of the staff nowcast (0.3 percentage points) has been lower than that of a simple autoregressive model (0.6 percentage points) over the period 2004–13.

Summary chart Staff nowcast versus ONS preliminary estimate of GDP[(a)]



(a) The chart shows, for each quarter at the time of the *Inflation Report*, the staff nowcast alongside the preliminary estimate of GDP growth, which is published around 10–11 weeks after the *Inflation Report*. For example, the final observation is for 2013 Q4 — the nowcast was published in the November 2013 *Inflation Report* and the preliminary estimate was published in January 2014. Chained-volume measures. GDP is at market prices.

UK GDP nowcasts — estimates of growth in the current quarter, or the most recent quarter for which no official estimates are available — form part of a range of information on current economic conditions used by the Monetary Policy Committee (MPC) to inform policy.(1) Nowcasting is important because official data are published with a lag, and so the nowcast produced by Bank staff informs the starting point of the MPC's projections for GDP growth. This nowcast exploits information that is available earlier and at higher frequencies than official published figures for quarterly GDP growth. Since May 2013, staff nowcasts have been reported in the *Inflation Report* and in the MPC minutes.

After their initial publication, UK GDP data are often revised, reflecting the incorporation of new data sources, and, over time, any methodological changes. So in nowcasting UK GDP, it is important to decide whether to nowcast the first official estimate of GDP (called the 'preliminary' estimate), or what the official data will eventually show. Ultimately, it is the latter that is most important for policymakers. But, in practice, it is helpful to make an assessment of what the first official estimate is likely to be, and this is the focus of this article. One can subsequently model how that first estimate may be revised over time. Previous Bank work has assessed the relationship between early official estimates and mature estimates, and that approach is used to map from the nowcasts set out in this article to estimates of what the Office for National Statistics (ONS) will eventually publish.(2)

This article outlines the main approaches currently used by Bank staff to nowcast UK GDP and examines the performance of these approaches. But there are many different methods of nowcasting, so a broader overview of those adopted in the literature, and by other economic forecasters, is contained in the box on page 61.

Industry model

One approach to nowcasting GDP is to model the economy split into different industries. This approach makes use of official industry-level data and a range of indicators to build up an aggregate GDP nowcast. A key advantage of this approach is that monthly output measures and indicators of UK GDP, which are typically at an industry level, are generally more timely than expenditure and income measures.(3) Nowcasting using the expenditure measure of GDP is discussed in the box on page 64.

Monthly official UK output data are useful for nowcasting at an industry level. While monthly data are often more volatile than quarterly data, the monthly profile often has a sizable impact on the quarterly growth rate.(4) So nowcast models that use monthly data to estimate quarterly growth rates often outperform models that only use quarterly data.

In addition to official data, survey indicators have typically improved industry nowcasts for the United Kingdom. As a result, the coverage of a particular survey is a key factor in determining the optimal industry groups for nowcasting.

Taking into account the industry groups in both the official and survey data, there are some natural groupings for nowcasting output in the UK economy (**Table A**). For example, private non-distribution services (PNDS), currently the largest industry group used by staff to produce nowcasts, aligns well with the coverage of the Markit/CIPS UK services PMI survey.(5) Other surveys of the services industry are useful for nowcasting services output. But, historically, models that use data from the Markit/CIPS services PMI survey have, on average, slightly outperformed those that use other surveys. The output data and indicators currently used for the industry model are set out in the appendix.

Table A Industry groups for the UK economy

Share of UK gross value added, per cent(a)	
Private non-distribution services: private business and consumer services, excluding distribution	48
Government services: health, education and defence	19
Distribution services: retail, wholesale and motor trades	11
Manufacturing	10
Construction	6
Utilities: electricity, gas, steam, air, water supply and sewerage	3
Extraction: mining and quarrying, including oil and gas	2
Agriculture	1

(a) These shares are calculated using the 2010 weights currently used by the ONS to estimate the chained-volume measure of aggregate GDP. Consequently, these weights can be used to aggregate the nowcasts for the different industries. These weights change annually with the publication of the *Blue Book*.

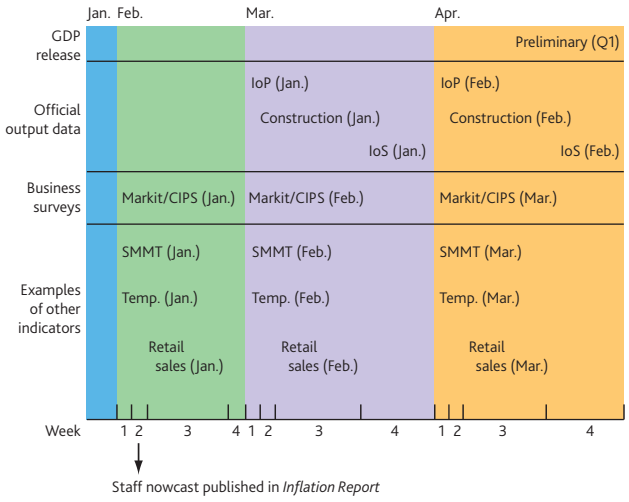
The contribution of monthly official data in nowcasting models relative to other data varies throughout the quarter, as more official data become available. The basic modelling relationship that Bank staff typically use in the industry model approach is, for a given month t:

$$Output_t = \alpha + \beta_1 output_{t-1} + \beta_2 \text{ indicator}_t + \text{error}_t \quad (1)$$

The inputs to this type of model change as new data are released. This is illustrated in **Figure 1**, using Q1 as an example. Q1 preliminary GDP data are released towards the end of April, so the figure shows indicators that are released up to that

(1) For a discussion of world GDP and trade nowcasts see Stratford (2013).
(2) For further details of the Bank's methods for dealing with data uncertainty since 2007, see Cunningham and Jeffery (2007). For details of the Bank's methods prior to this, see Ashley *et al* (2005).
(3) Indeed, preliminary GDP estimates constructed by the ONS rely most heavily on the output data, and data on expenditure and incomes in the UK economy tend to be incorporated into official data with a longer lag. For more details, see Lee (2013).
(4) One simple way to think about the importance of monthly dynamics within a quarter is to consider an example when the level of output increases only in the last month of the previous quarter. If output then remains flat in the nowcast quarter, quarter-on-quarter output growth would still be positive.
(5) CIPS stands for Chartered Institute of Purchasing and Supply, and PMI stands for Purchasing Managers' Index.

Figure 1 Illustrative release dates for a selection of indicators used for nowcasting Q1[a]



(a) Markit/CIPS refers to the PMI surveys, 'Temp' refers to UK mean temperature anomalies data published by the Met Office, 'SMMT' refers to Society of Motor Manufacturers and Traders car registrations, 'IoP' refers to the Index of Production release, 'IoS' refers to the Index of Services release, and 'Construction' refers to the Output in the Construction Industry release. Months in parentheses show the latest month covered in the release published at that time.

point. In the first month of the nowcast quarter, January in this case, nowcasts are generated for each month in the quarter by estimating equations that use the previous outturn(s) of the nowcast variable — autoregressive term(s) — and selected indicators.

At the time that Bank staff normally produce the nowcast for the *Inflation Report*, for example, no official data for industry output are available for the nowcast quarter. PNDS is the largest industry group used by staff to produce the nowcast, as discussed above. At the time of the February 2014 *Inflation Report*, PNDS output for January was estimated using ONS data for December and the Markit/CIPS services PMI survey indicator for January.(1) The forecast for PNDS output in February was generated using the industry model estimate for PNDS output in January, and a forecast for the Markit/CIPS services PMI survey indicator in February, and a forecast was generated similarly for PNDS output in March (the details are provided in the appendix).

Weighted survey model

An alternative approach to nowcasting GDP at an industry level is to focus on the relationships between survey indicators and GDP at an aggregate level. A disadvantage of this approach is that it excludes monthly official data. But the main advantage is that, for nowcasting early on in the data cycle, it does not require forecasts of monthly official data — it places full weight on the available survey data, which is more timely than the official data. And surveys of business expectations tend to be good indicators of output one quarter ahead, so in addition to a nowcast, this approach can be applied to produce a one quarter ahead forecast.

The weighted survey approach proceeds in three stages. First, the data from individual business surveys are aggregated to be as representative as possible of the whole UK economy. The surveys and data series that Bank staff currently use in this approach are outlined in **Table B**. Each survey yields an 'output' measure of recent activity, and an 'expectations' indicator of near-term growth. These output and expectations data from each business survey are then mapped to GDP growth. That involves transforming each series such that it has the same average and variance as GDP growth.(2) Each of the surveys may be used as an individual indicator of GDP growth, but, in the weighted survey model approach, the survey series are weighted together based on past performance, to produce a single nowcast. At the time of the *Inflation Report*, the weighted survey model uses a subset of the survey information to produce a nowcast because not all of the 'output' measures of activity for the nowcast quarter are available at this time (**Chart 1**).

Table B Business surveys used in the weighted survey model[a]

Survey: specific indicator	Industries included
BCC: domestic and export sales, past three months	Manufacturing,[b] services
BCC: confidence about future turnover	Manufacturing,[b] services
CBI: volume of output, past three months; volume of business, past three months; volume of sales this month compared with a year earlier[d]	Manufacturing,[c] business and professional services, consumer services, distributive trades[e]
CBI: volume of output, next three months; volume of business, next three months; volume of sales next month compared with a year earlier[d]	Manufacturing,[c] business and professional services, consumer services, distributive trades[e]
Markit/CIPS:[e] Output Index;[f] Business Activity Index;[f] Total Industry Activity Index[f]	Manufacturing, services, construction
Markit/CIPS:[e] New Orders Index;[f] Business Expectations Index; Future Business Activity Index	Manufacturing, services, construction

(a) BCC stands for British Chambers of Commerce and CBI stands for Confederation of British Industry.
(b) Construction firms are included in the manufacturing total.
(c) In the months in which the *CBI Industrial Trends Survey* is not released, updated indicators are obtained from the *CBI Monthly Trends Enquiry*.
(d) An indicator for the volume of sales compared with the previous quarter is only available from 2003 onwards.
(e) These monthly indicators are mapped into a quarterly growth rate before they are used in the model.
(f) Seasonally adjusted measure.

A further quantitative source of information on developments in output are the scores put together by the Bank's Agency network.(3) Each month, the Agents form an assessment of how manufacturing output levels and business and consumer services turnover compare in the most recent three months with that of the same period a year earlier. The resulting quantitative Agents' scores are therefore helpful in assessing

(1) Index of Services data for December 2013 were not yet published at the time, so the monthly growth rate was calculated using the monthly growth rates for October and November 2013 and the quarterly growth rate for 2013 Q4 from the preliminary GDP release.
(2) This is done by normalising each individual observation of the survey series (subtracting the mean of the survey series and then dividing by the standard deviation of the survey series), then multiplying it by the standard deviation of GDP growth and adding the mean of GDP growth. Following this adjustment, the new survey series have the same mean and variance as the GDP growth series.
(3) The Bank has twelve regional Agencies based around the United Kingdom. Each Agency provides a monthly assessment of economic conditions for its region, following discussions with individual businesses, organisations and groups. For more details, see www.bankofengland.co.uk/publications/Pages/agentssummary/default.aspx.

Different approaches to nowcasting

There is a wealth of literature on GDP nowcasting that covers a number of different approaches. The suitability of each approach depends on the information set available and the timeliness of official data and other indicators, which can differ significantly across countries. This box outlines a few of the main approaches, but more comprehensive reviews are available in recent literature, such as Bańbura *et al* (2013).

One approach to nowcasting is to use a basic statistical model, in which GDP growth depends linearly on its previous values. In periods of stable growth, it is difficult to improve upon this type of model, as discussed in Mitchell (2009). But during periods of more volatile growth, the performance of basic statistical models for nowcasting is often poor, as discussed in the final section of this article.

One common approach to nowcasting is to use 'bridge equations', which are regressions of quarterly GDP growth on selected monthly indicators. That is done in two steps. First, monthly indicators are forecast over the remainder of the nowcast quarter to obtain a quarterly nowcast for that indicator. Second, the resulting nowcasts are used as regressors in the 'bridge equation' to obtain the GDP nowcast. The industry model discussed in the first section of this article uses the first step of this approach (monthly series are forecast to obtain quarterly indicators), but because forecasts are obtained for each industry, the GDP nowcast is simply calculated using each industry's weight in GDP. The 'bridge equation' approach addresses one of the challenges of nowcasting: indicators are available for different frequencies (daily, weekly, monthly and quarterly), and are released at different times.(1) But using bridge equations limits the number of indicators, potentially discarding useful information, and also requires forecasts of some indicators, which could increase nowcast errors.

More recently, mixed-data sampling (MIDAS) has become a popular approach to nowcasting. The MIDAS approach is a simple way of handling data sampled at different frequencies that does not require indicators of a higher frequency, normally monthly, to be forecast over the quarter.(2) Instead, MIDAS equations directly relate quarterly GDP to the more frequent indicator and its lags. As discussed in Kuzin, Marcellino and Schumacher (2011), an alternative solution to this issue is a mixed-frequency vector autoregression (VAR), which can be put in a form that allows for missing values for data not yet available.

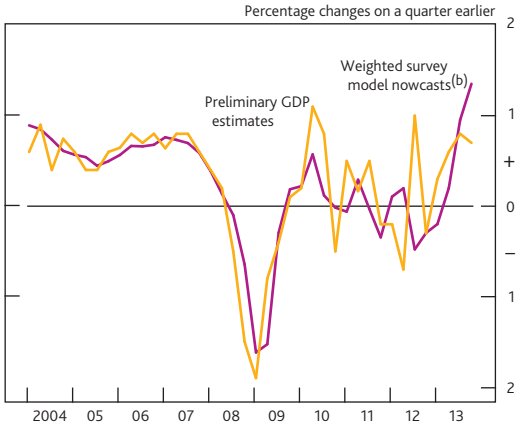
Another popular approach to nowcasting is to use factor models. In this approach, common statistical trends (referred to as 'factors'), which may reflect common economic influences, are estimated from a large set of data. This addresses the problem with some other approaches that potentially useful information is discarded. If there is a high degree of comovement among the series, then most of the movement in the series of interest can be captured by a few factors. Different types of factor methods are discussed in Eklund and Kapetanios (2008). The MPC's forecasting platform contains a range of different statistical models that can be used to nowcast GDP, including factor and VAR models.(3)

Several economic forecasters employ dynamic factor models, including the European Central Bank.(4) The performance of dynamic factor models varies from economy to economy. Barhoumi *et al* (2008), for example, evaluate the performance of a particular dynamic factor model for nowcasting GDP growth in selected European economies. Internal Bank of England analysis suggests that the performance of certain dynamic factor models for predicting UK GDP growth was poor during and following the recession, but Bank staff have not used this type of model systematically.

An area of development in the nowcasting literature has been estimating densities, rather than only producing a central estimate for GDP growth. A density nowcast provides the likelihoods that a model would attach to the different outturns of GDP growth occurring. This approach is a way of formalising the uncertainty around the outlook for the economy, and is used by the Norges Bank, for example.(5)

(1) This is sometimes called the 'jagged edge' problem — where some indicators have missing data points because they are less timely than other indicators.
(2) For further information, see Ghysels, Sinko and Valkanov (2007).
(3) For more details of the individual models, see Kapetanios, Labhard and Price (2007).
(4) For a summary of different types of dynamic factor models, see Stock and Watson (2011).
(5) See Aastveit *et al* (2011).

Chart 1 Weighted survey model nowcasts at the time of the *Inflation Report*[a]



(a) The chart shows, for each quarter at the time of the *Inflation Report*, the nowcast from the weighted survey model alongside the preliminary estimate of GDP growth, which is published around 10–11 weeks after the *Inflation Report*. Chained-volume measures. GDP is at market prices.
(b) The weighted survey model is explained in the text of this section, and estimated using equation **(2)**. The nowcasts shown in the chart are produced using the survey indicators available at the time of each *Inflation Report* — that is, the weighted survey model uses a subset of the survey information because not all of the 'output' measures of activity for the nowcast quarter are available at this time.

how output growth has evolved over the course of a year. But it is difficult to infer anything about the pattern of growth compared with the previous quarter from these data, and so they are not used in the weighted survey nowcast model. Instead, the information provided by the Agents is used to help interpret the results of the models.

A challenge with the weighted survey model is that the availability and performance of different surveys varies at the different stages of nowcasting and forecasting one quarter ahead. As a result, the weighted survey model is estimated at six different times in the data cycle, which correspond to when new survey observations become available. To illustrate this, **Figure 2** shows the stages for forecasting, and then nowcasting, Q1. On each occasion, the weight on each survey indicator is allowed to vary, according to its most recent performance.(1) In other words, the following equation is re-estimated each month, and the coefficients for each of the indicators change each month:

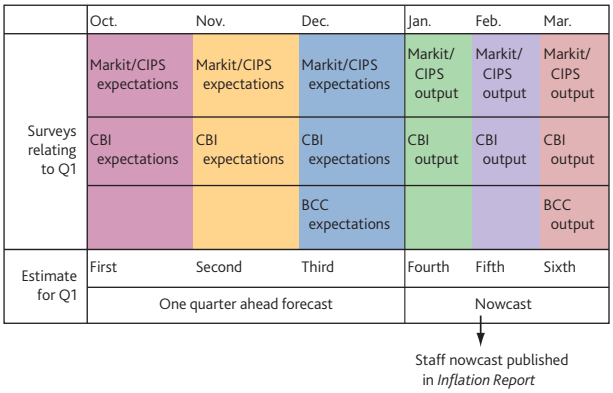
$$\textit{Preliminary GDP}_t = \alpha + \beta_1 BCC^o_t + \beta_2 BCC^e_{t-1} + \beta_3 CBI^o_t + \beta_4 CBI^e_{t-1} + \beta_5 CIPS^o_t + \beta_6 CIPS^e_{t-1} + \text{error}_t \quad (2)$$

Survey indicators of businesses' expectations tend to receive more weight early on in the data cycle, when no information is available on actual output. Survey measures of businesses' output generally receive more weight once businesses start reporting their actual output for the nowcast quarter.

Considerations in using estimation-based nowcasts

Purely estimation-based nowcast models have limitations, and Bank staff take these into account when producing their

Figure 2 Illustrative data cycle for forecasting and nowcasting Q1 using the weighted survey model[a]



(a) A forecast for Q1 is first generated when the Markit/CIPS survey expectations indicators, in October, are published. At this time, the other survey indicators are assumed to be the same as in the previous period.

nowcasts. In particular, issues may arise that affect the accuracy of the mechanical estimates from the nowcast models. There is also a more general consideration associated with using estimation-based nowcasts from statistical models: it is difficult to identify underlying economic reasons for changes in the estimates from such models.

Issues affecting model accuracy

Estimation-based nowcast models are normally estimated using a long history of data, and so do not always respond quickly to new information or take into account special events. This can affect their accuracy in particular quarters. Consequently, there are occasions when nowcast models do not adequately capture developments, and on such occasions Bank staff place less weight on these models to nowcast GDP.

Indicators sometimes diverge from data outturns

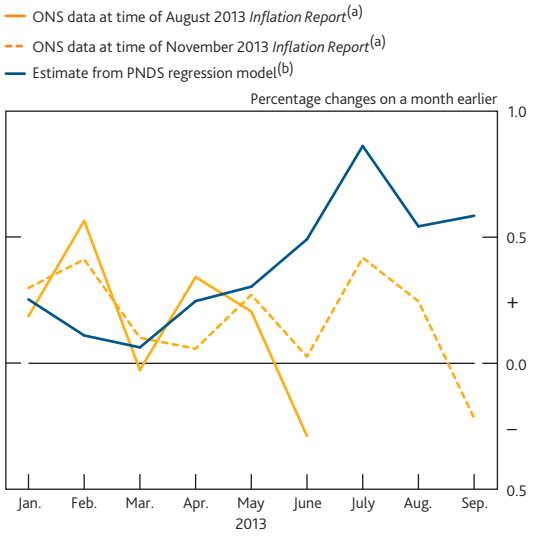
If an indicator starts to diverge noticeably from data outturns, then there may be a case to aim off a model that places a lot of weight on that particular indicator. Each of the industry nowcast models is re-estimated annually, and the weighted survey model is re-estimated throughout the data cycle, but on some occasions a change in the performance of indicators is noticeable over a relatively short period of time.

There was a noticeable divergence between data from the surveys and official data outturns in 2013. At the time of the August 2013 *Inflation Report*, for example, there had been a rise in the Markit/CIPS services PMI survey indicator in June 2013, but this had not been matched in the official ONS data available at the time (the solid orange line in **Chart 2**). Consequently, the regression model for PNDS output (see appendix) had overpredicted growth in Q2 (the blue line was well above the solid orange line). Moreover, the Markit/CIPS services PMI survey indicator had risen again in

(1) The performance is currently evaluated using a four-year rolling window. The weights on each indicator are constrained to be positive, but this constraint has little impact on the nowcast from the weighted survey model.

July 2013 and was suggesting that PNDS growth would be 1.3% in Q3 (and monthly growth would average 0.7%). That would have been a very large increase by historical standards, and it was not corroborated in other data. So in this particular example, Bank staff chose not to use the growth rate implied by the PNDS regression model. Instead, a gap was maintained between the model prediction and the nowcast for PNDS growth in Q3 that was of a similar magnitude to the difference between the model prediction and the ONS estimate for Q2. ONS estimates available at the time of the following *Inflation Report* showed that the official data for Q3 were indeed below the level suggested by the model (the dashed orange line was lower than the blue line in **Chart 2**), although it may be the case that the official data are eventually revised higher.

Chart 2 Model-implied nowcast versus first official estimate of PNDS growth in 2013



(a) Includes Bank calculations for the last month of the previous quarter, because the Index of Services data are not available for this month at the time of the *Inflation Report*. The monthly growth rate is calculated using the most recent Index of Services release and the quarterly growth rate from the preliminary GDP release.
(b) In-sample prediction up to, and including, 2013 Q1. Uses data available at the time of the August 2013 *Inflation Report*.

Using qualitative indicators for quantitative estimates

A difficulty faced in using business surveys in particular is that they are normally a qualitative measure of a variable. In other words, surveys ask businesses whether their output has increased, decreased or remained the same, but not by how much it has changed. This means, for example, that if all survey respondents suddenly change their response from 'no change' to an increase in output, but the volume of their output has only increased a little, then the pickup recorded by the survey measure will overstate the magnitude of the increase in growth.

Temporary and special events

Sometimes other sources of information may suggest that the models or survey data do not capture recent events. The Bank's Agents sometimes receive information about temporary events affecting output in a particular industry. For example, the Agents passed on information about maintenance that affected oil and gas production in the North Sea in 2012. Other events may affect output across a number of industries, such as the Diamond Jubilee and London Olympics in 2012. Typically, the impact of these sorts of events may be estimated using specific sources of information, for instance Olympic ticket sales, or by extracting information from the monthly profile of growth in the industries most likely to be affected by the special event.(1)

Unstable coefficients

Changes in output dynamics over time mean that the coefficients in nowcast models can, within a very short period of time, fail to capture the magnitude of movements in output. The sharp contraction in output in 2008–09 is a good example. Most of the monthly nowcast models are estimated using data that are available from the 1990s onwards. The contraction in output in 2008–09 was unprecedented over the model estimation period, and the coefficients in the models generally failed to capture the depth of the contraction in output.

Understanding the reasons for changes in nowcasts

In general, statistical models rarely provide an underlying economic reason for why they produce the estimates that they do, even though they often help to reduce nowcast and forecast errors. This is one reason why structural models are important: they provide a framework for understanding the workings of an economy.(2) For this reason, the MPC use both structural and statistical models to produce their forecasts.

Statistical models are likely to have an advantage over structural models for nowcasting, however, by directly incorporating more timely sources of information about the evolution of the economy, such as data from business surveys. During the recent financial crisis, for example, very few structural models forecasted the sharp contraction in output.(3) By contrast, statistical models that incorporated information from business surveys were generally better at forecasting the downturn, although they still made large errors.

The staff nowcast and its performance

Bank staff use a variety of models and indicators to provide a nowcast for the MPC. This nowcast is produced using estimation-based models, including the industry model and the weighted survey model. It also incorporates other sources

(1) Details of Bank staff estimates for the contributions of the Diamond Jubilee and the London Olympics to quarterly growth in manufacturing and services output are provided in the November 2012 and February 2013 editions of the *Inflation Report*.
(2) A structural model is essentially a system of behavioural equations that derive from decisions made by optimising economic agents, such as households and firms.
(3) See Hendry and Mizon (2012).

Nowcasting different measures of GDP

This article focuses on statistical models that are designed to nowcast the output measure of UK GDP, but both nowcasts and official estimates of GDP can also be estimated using expenditure and income data. This box explains why those alternative approaches are informative, and summarises some of the methods used by Bank staff to nowcast using these measures.

A key reason for nowcasting using the expenditure data is that structural models, such as the central organising model in the MPC's forecasting platform (COMPASS), are consistent with that framework.(1) Structural models are based on the behaviour of optimising economic agents, such as households' consumption and businesses' investment decisions. So it is not sufficiently informative to have a GDP nowcast based solely on output data: its breakdown across the expenditure components of demand is also important.(2)

Based on the information used in the Bank's structural models, therefore, Bank staff nowcast the main expenditure components: consumption, investment, government spending, exports, imports and stockbuilding. A simple regression approach, similar to the industry model on the output side, is used to nowcast each of these components. These expenditure-component nowcasts complement the estimates based on the expenditure models within the suite of models in the Bank's forecasting platform. As described in Burgess *et al* (2013), there are a range of expenditure models in the suite. For example, the suite contains several 'Keynesian' consumption functions, which model household spending as a function of current labour income.

The performance of the expenditure models tends to be worse, however, than the output-based nowcasting models. Unlike the output data, there is relatively limited monthly official data available on the expenditure side. Nor are most alternative indicators of expenditure components as comprehensive or timely as the information available for the output of the economy. So the expenditure models tend to rely more heavily on past data, and the performance of the models is typically worse than for the equivalent output models. In part reflecting that data availability, however, some expenditure models tend to perform better than others. For example, the performance of consumption models tends to be better than those for investment, stockbuilding, exports and imports.

There is normally a difference between the staff nowcast based on output measures of GDP and the sum of the individual expenditure nowcasts. That is not surprising: early official estimates of the output and expenditure measures of GDP are rarely equal for the most recent years of data. An alignment adjustment is added to the expenditure measure of quarterly GDP to make it equal to GDP implied by the headline GDP measure.(3) So, in a similar way, any discrepancies between the output-based GDP nowcast and an expenditure-based GDP nowcast may be allocated to an alignment adjustment. But, as with the ONS data, a large difference between these two measures might be informative. For example, it might suggest heightened uncertainty around the estimates.

(1) The platform is described in detail in Burgess *et al* (2013). The central organising model is a New Keynesian general equilibrium model similar to those used at other central banks and policy institutions. This model has been in use since the end of 2011.
(2) In principle, income data may also be used to nowcast GDP, but in practice these data have not tended to be used for nowcasting. But income measures remain important for structural models, see Burgess *et al* (2013).
(3) The alignment adjustment contributes to quarterly GDP growth, but the level of the alignment adjustment sums to zero over each calendar year. For more details, see Williams (2009).

of information to allow for limitations associated with estimation-based models, as discussed above.

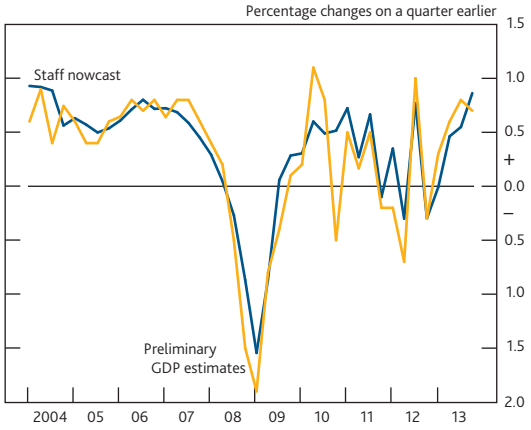
Since May 2013, the staff nowcast has been reported in the *Inflation Report*. At this point in the data cycle, no official data for the nowcast quarter are available. The official preliminary estimate for GDP growth is published around 10–11 weeks after the publication of the *Inflation Report*. The staff nowcast has captured the broad movements in the official preliminary estimates for quarterly GDP growth (**Chart 3**). Nonetheless, for particular quarters, the nowcast has sometimes been very different from the preliminary estimate of GDP growth.

The remainder of this section provides an overview of the performance of the staff nowcast relative to the nowcasts from the weighted survey model and a common benchmark model.(1) One of the most common summary statistics for evaluating forecast performance is the root mean squared error (RMSE). In this article we evaluate the performance of the nowcasts using the information set available at the point in time that the nowcast would have been estimated, sometimes described as 'real time' evaluation.

The RMSE can be thought of as the historical error band around the nowcast, and this is quoted in the *Inflation Report* alongside the staff nowcast. Since 2004, the RMSE for the staff nowcast has been around 0.3 percentage points. The RMSE for the weighted survey model nowcast has been higher, at around 0.4 percentage points (**Table C**).(2)

(1) For a recent assessment of the MPC's forecasting performance, see Hackworth, Radia and Roberts (2013).
(2) It is not possible to calculate a RMSE associated with the industry model over the past, because the models and indicators used to produce the nowcast from the industry model have changed over time, as staff review these regularly.

Chart 3 Staff nowcast versus ONS preliminary estimate of GDP[(a)]



(a) The chart shows, for each quarter at the time of the *Inflation Report*, the staff nowcast alongside the preliminary estimate of GDP growth, which is published around 10–11 weeks after the *Inflation Report*. For example, the final observation is for 2013 Q4 — the nowcast was published in the November 2013 *Inflation Report* and the preliminary estimate was published in January 2014. Chained-volume measures. GDP is at market prices.

Table C Nowcast errors relative to official UK GDP estimates since 2004[(a)]

Model	Root mean squared error, percentage points
Staff nowcast	0.30
Weighted survey model nowcast	0.43
Benchmark model nowcast[(b)]	0.57

(a) Errors are relative to the preliminary estimate of quarterly GDP growth. Chained-volume measures. GDP is at market prices.
(b) The benchmark model is an autoregressive model with two lags, often called an AR(2), where GDP growth depends linearly on its two previous values. To be consistent with the staff nowcast and weighted survey model, the benchmark model has been estimated in 'real time', such that it is re-estimated every quarter, after a new preliminary GDP estimate has been published.

A useful way to examine nowcast performance is to compare the results with those of a benchmark model. A common benchmark model is a simple autoregressive model for GDP growth, in which GDP growth depends linearly on its previous value(s). Such models tend to produce quite accurate nowcasts and forecasts during periods — such as 1993–2007 — when growth is relatively stable. But benchmark models can usually be improved upon when growth is more volatile.[(1)] Both the staff nowcast and the weighted survey model nowcast outperform the benchmark (**Table C**). Although the nowcast outperforms other models, a difference in quarterly GDP growth of 0.3 percentage points could nonetheless result in a materially different outlook for GDP growth, suggesting that there is considerable uncertainty surrounding the outlook even after taking a large amount of information into account.

Given the staff nowcast incorporates a large information set — including information relating to some of the limitations of a purely regression-based model — it is perhaps not surprising that it has a lower RMSE than the mechanical nowcasts produced by the weighted survey model and the benchmark.

For particular periods of time, it is possible to isolate reasons why the staff nowcast is likely to have performed better than the mechanical nowcasts provided by the models:

- First, the recession increased output volatility substantially. The largest error from the benchmark model occurred in 2008 Q4, when output contracted sharply (**Chart 4**). Both the weighted survey model and the staff nowcast performed better, because they both incorporated data from the business surveys. Moreover, the Bank's Agents were quick to pick up the marked change in business sentiment and sharp fall in orders in Autumn 2008 as the economy weakened, which was reflected in the staff nowcast.

- Second, there have been a number of temporary or special events that have affected output. In 2012 Q2 and Q3, the quarters in which the Diamond Jubilee and London Olympics occurred, the staff nowcast error was substantially lower than those from the benchmark and weighted survey models. Nonetheless, there were times when the staff nowcast did not adequately capture temporary events that affected output — its largest error occurred when there was heavy snowfall that disrupted output unexpectedly in 2010 Q4.

- Finally, there has been a period when data from the surveys and the official data outturns have diverged. In 2013, the staff nowcast outperformed the weighted survey model because data from the business surveys appeared to overstate GDP growth. As discussed earlier in the context of the PNDS model, staff chose to reduce the weight placed on the nowcasts implied by the surveys because the movements were large relative to historical standards, and not corroborated in other data. So far, that judgement appears to have reduced nowcast errors relative to the ONS preliminary GDP estimate.

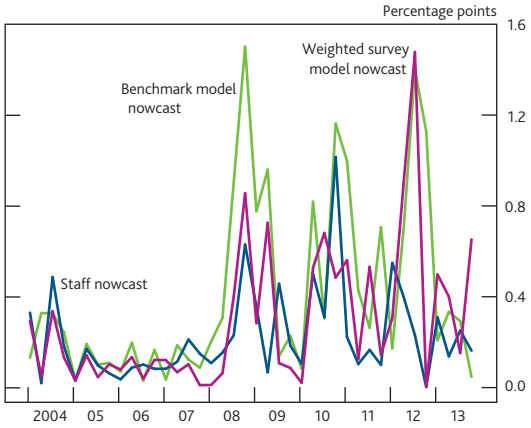
Conclusion

GDP growth is a key statistic in describing the state of the economy. It is therefore important that growth prospects are assessed frequently and rigorously in order to assist policymakers.

Bank staff use two main models and a range of other information to produce their nowcasts. The main advantage of the industry model for nowcasting is that it incorporates monthly official data as it becomes available and exploits the time-series properties of GDP growth. The industry level of granularity is also an efficient way to incorporate additional, and timely, sources of information on temporary and special events that may affect output in particular industries. Meanwhile, the advantage of the weighted survey model is

(1) See, for example, Mitchell (2009).

Chart 4 Absolute nowcast errors at the time of the *Inflation Report*[a]



(a) The chart shows the absolute difference between the nowcast at the time of the *Inflation Report* and the preliminary estimate of quarterly GDP growth, which is published around 10–11 weeks after the *Inflation Report*. Chained-volume measures. GDP is at market prices.

that it places full weight on the more timely sources of information available for UK output — business surveys — so it is particularly useful for nowcasting early in the data cycle.

There may be occasions when purely estimation-based nowcast models do not perform well, so a key aspect to nowcasting is assessing when models are likely to give a poor signal of GDP growth. In recent years, there have been a number of events that have led Bank staff to place less weight on the mechanical nowcasts from estimation-based models. This is likely to have been a key reason why the nowcasts produced by Bank staff have, on average, outperformed those from the weighted survey model and a simple autoregressive model over the period 2004–13.

Appendix
Description of output data and indicators currently used in the industry model approach

Industry	Frequency	Start year[a]	Estimated equation[b]	Indicator	Additional information
Private non-distribution services (PNDS)	Monthly	1997	**(1)** $PNDS_t = \alpha + \beta_1 PNDS_{t-1} + \beta_2 CIPSo_t + \varepsilon_t$ **(2)** $CIPSo_t = \alpha + \beta_1 CIPSo_{t-1} + \varepsilon_t$	CIPSo: Markit/CIPS Services PMI, Business Activity Index.	A forecast for the Markit/CIPS data is used for those months for which data are not yet available. Equation **(1)** contains dummy variables for the Golden and Diamond Jubilees.[c]
Government services (GOVT)	Quarterly	1997	**(1)** $GOVT_t = \alpha + \beta_1 GOVT_{t-1} + \beta_2 EMPF_t + \varepsilon_t$ **(2)** $GOVT_t = \alpha + \beta_1 GOVTM1_t + \beta_2 EMPF_t + \varepsilon_t$	EMPF: Bank staff's quarterly government employment growth forecast. GOVTM1: the first month of government services data for the quarter, published in the ONS Index of Services release.[d]	Equation **(1)** is used until the first month of government services data are published (monthly data are published with a two-month lag), after which equation **(2)** is used.
Retail (RO)	Monthly	1996	$RO_t = \alpha + \beta_1 RS_t + \varepsilon_t$ $RS_t = \alpha + \beta_1 RS_{t-1} + \beta_2 RS_{t-2} + \beta_3 BRC_t + \varepsilon_t$	RS: monthly growth in retail sales volumes including fuel, published in the ONS Retail Sales release. BRC: British Retail Consortium Retail Sales Monitor, total sales year-on-year.	A forecast for retail sales is used for those months for which data have not yet been published (monthly data published with a two-week lag).
Wholesale (WS)	Monthly	1995	$WS_t = \alpha + \beta_1 WS_{t-1} + \beta_2 WS_{t-2} + \varepsilon_t$	n.a.	n.a.
Motor trades (MT)	Monthly	1999	$MT_t = \alpha + \beta_1 MT_{t-1} + \beta_2 SMMT_t + \beta_3 CBIMT_t + \varepsilon_t$ $SMMT_t = \alpha + \beta_1 SMMT_{t-1} + \varepsilon_t$ $CBIMT_t = \alpha + \beta_1 CBIMT_{t-1} + \varepsilon_t$	SMMT: total car registrations (seasonally adjusted in-house). CBIMT: *CBI Distributive Trades Survey*, reported volume of sales in motor trades.	Forecasts for the SMMT and CBI survey data are used for those months for which data are not yet available.
Manufacturing (MANU)	Monthly	1993	**(1)** $MANU_t = \alpha + \beta_1 MANU_{t-1} + \beta_2 CIPSo_t + \varepsilon_t$ **(2)** $CIPSo_t = \alpha + \beta_1 CIPSo_{t-1} + \varepsilon_t$	CIPSo: Markit/CIPS Manufacturing PMI, Output Index.	A forecast for Markit/CIPS data is used for those months for which data are not yet available. Equation **(1)** contains dummy variables for the Golden and Diamond Jubilees.[c]
Construction (CO)	Monthly	2010	**(1)** $CO_t = \alpha + \beta_1 CO_{t-1} + \beta_2 CIPSo_t + \varepsilon_t$ **(2)** $CO_t = \alpha + \beta_1 CO_{t-1} + \beta_2 CIPSo_t + \beta_3 EXPIo_t + \varepsilon_t$	CIPSo: Markit/CIPS Construction PMI, Total Industry Activity Index. EXPIo: Experian Construction Activity Index.	Equation **(1)** is used until the Experian survey is published, after which equation **(2)** is used.
Utilities (UT)	Monthly	1993	**(1)** $UT_t = \alpha + \beta_1 UT_{t-1} + \beta_2 UT_{t-2} + \varepsilon_t$ **(2)** $UT_t = \alpha + \beta_1 UT_{t-1} + \beta_2 UT_{t-2} + \beta_3 TEMP_t + \varepsilon_t$	TEMP: UK mean temperature anomalies data from the Met Office. The anomaly period used is 1961–90.	Equation **(1)** is used until temperature data are published for the month, after which equation **(2)** is used.
Extraction (EXTR)	Monthly	1998	$EXTR_t = \alpha + \beta_1 EXTR_{t-1} + \beta_2 DECC_t + \beta_3 DECC_{t-1} + \varepsilon_t$	DECC: Oil and gas production forecasts from the Department of Energy and Climate Change (DECC), seasonally adjusted (in-house).	Oil and gas production is used as a proxy for total extraction.

(a) The start date varies across the different industry groupings because it depends on the availability of official data and indicators.
(b) All of the ONS output series in the equations are growth rates — that is, percentage changes on the previous month or quarter, depending on the frequency used in the model. Once ONS estimates of output in the first month of the quarter are released, these estimates are used for the first month of the nowcast, and the nowcasts for the second and third months are recalculated using the most recent data. Similarly, this process is repeated following the release of ONS estimates of output in the second month.
(c) Dummy variables are used in the following months: June 2002, July 2002, June 2012 and July 2012.
(d) Mapped into quarterly growth by assuming no change in output in the second and third months of the quarter.

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