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Agenda

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Uncertainty and long-term projections: a framework for postal sector demand

Academics at the University of Toulouse, in partnership with Frank Rodriguez, Oxera Associate, and Soterios Soteri, Head of Economic Forecasting at Royal Mail Group, have developed a framework for long-term projections of demand in situations with changing market conditions (where uncertainty is particularly likely). An example is given from the UK postal sector, but the framework could also be considered relevant to other industries that use long-term projections of demand

Projections of the demand for products over the long term (defined here as three or more years ahead) are required in many industrial sectors. This is particularly the case in regulated industries such as rail, water and postal services, where a major requirement for such projections is likely to be linked to periodic regulatory reviews. The settlements from these reviews lead to price controls set by regulators on regulated companies, which reflect efficiency targets and approved industry investment programmes, and typically apply for a duration of several years. Market valuations of such businesses also require a long-term assessment of demand prospects. However, as is generally acknowledged, projections of demand over the long term can have a high degree of uncertainty associated with them, particularly where significant changes are occurring in the market environment of an industry.

In many companies, quantitative models are a key input to the production of soundly based projections of demand. Models of this type which include, for example, econometric time-series models combined with a set of assumptions about the future values of the explanatory variables contained within the model (such as the rate of economic growth and prices over the forecast horizon) can then be used to project demand over the long term.

Once a decision has been made to sanction an investment programme or set a price control for a defined number of years, however, there may be little or no opportunity to revisit and change that decision. Updating the demand projection which helped to underpin that decision, then, cannot affect or change a decision that has already been made. In this sense, both the decision and the demand projection are 'irreversible' and, as noted previously, the latter is subject to considerable uncertainty.

As long as the factors affecting demand are stable, and the quantitative model (be it based on econometric or other types of statistical modelling techniques) is well specified and robust, the accuracy of the projection is likely to depend mainly on the accuracy or otherwise of the assumptions for the future values of the explanatory variables in the model. However, the forecasting problem becomes more complex, and the uncertainty associated with a given set of projections much greater, where the drivers of demand in that market are evolving and new factors may have an impact on demand in the future. In this situation, a quantitative model estimated using historical data alone cannot take account of possible new factors, and a projection using only the quantitative model may result in large forecasting errors.

An example from the UK postal sector

A recent example of such a situation arose in the UK postal sector. Long-term projections of the demand for mail are currently required for regulatory purposes as part of periodic price control reviews. Previously, it had been possible to model the demand for mail using an econometric time-series model, which estimated the historical drivers of demand to be principally economic and demographic growth and own and substitute prices.[1] During the 2000s, however, that situation began to change, mainly because of technology-related

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developments and, in particular, the widespread penetration of different types of digital and Internet-related communication technologies resulting in electronic substitution (e-substitution) of mail.

A set of demand projections was required by the then sector regulator, Postcomm, from Royal Mail, fairly early in the process for the third price control review for the period 2005/06 to 2010/11. These projections were prepared at the end of 2004, just prior to the rapid expansion of the Internet and, in particular, broadband-related activity. In 2004 it was fairly obvious that this new phase of e-substitution would have an effect on the demand for mail that was unlikely to be trivial or adequately reflected in past econometric relationships alone. However, the precise quantitative impacts of these developments, which themselves were evolving, were unknowable at that time.[2]

Approach to forecasting where demand is evolving

How does one establish an appropriate and practical framework for forecasting in an environment where an ‘irreversible’ long-term decision is to be made, such that the demand projection that helps to underpin that decision cannot be revised to change that decision, even though the structure of demand may be evolving significantly? A forthcoming paper (Fève et al., 2012) sets out an approach to projecting demand in such an environment, by developing and formalising an earlier version used in 2004 by Royal Mail in its projections for Postcomm.[3] Under this approach, the projection consists of two main components: a data-based forecast augmented by additional business information. The data-based forecast in this framework is prepared using quantitative models (such as econometric time-series models) based on historical data. However, this projection is augmented by making use of additional sources of information that seek primarily to anticipate changes that might occur to the future structure of demand. The overall demand projection is the sum of the data-based forecast and this additional information, whose inclusion can be described as being Bayesian in character (see the box below for a brief outline of the technical aspects of the approach).

Some might argue that the data-based forecast alone should constitute the projection, and that it would not be appropriate to augment this, but rather to wait until the changes anticipated through the use of additional information actually become part of the historical time series. This might be several quarters or years ahead, and hence can be modelled using quantitative techniques. However, the risk from disregarding the possibility of major changes in the future structure of demand is that this may lead to large forecasting errors and so reduce the quality of the decision which rested partly on that projection.[4]

A more technical presentation of the approach

Fève et al. (2012) develops an approach to projecting demand which is particularly relevant to a market environment undergoing structural change. It consists of two main components: 1) a data-based forecast, augmented by 2) additional business information—or, in technical terms, a set of Bayesian ‘informative priors’ contained in a ‘non-identified’ part of the model.

1) Data-based forecast
As an example, consider a model expressed in linear form:

$$Y_t = \alpha + \beta Y_{t-1} + \gamma Z_t + \delta t + U_t \qquad \text{Equation 1}$$

where Y is the variable to be forecast (for example, mail volumes), Z are explanatory variables, U is a random unobservable term, t (= 1,...T) denotes time, and α, β, γ and δ are model parameters. To prepare a data-based forecast using Equation 1: the model parameters are estimated; a set of assumptions is prepared for future values of the explanatory variables; and the random unobservable term, U, is set to zero. The model given by Equation 1 is assumed to be identified: that is, the (unknown) model parameters can be estimated using, say, econometric modelling techniques applied to observed historical data.

2) Non-identified model
However, models may be non-identified, at least in part, because they contain unobservable variables. An example in a postal context would be future changes in the impact of e-substitution on the pattern of demand.

The impact of the non-identified component of the model can be introduced into the model at Equation 1 and is denoted by Λ:

$$Y_t = \alpha + \beta Y_{t-1} + \gamma Z_t + \delta t_t + \Lambda_t + U_t \qquad \text{Equation 2}$$

where Λ is an informative prior that may be fixed (deterministic) or possess a probability distribution (with mean and variance). The informative prior is based on additional sources of information relating to these unobservable variables, and is then used to augment the data-based forecast at Equation 1. Where it is possible to revise a forecast after each time period, the prior knowledge on the non-identified part of the model would be updated sequentially (at least partially) using data from the previous period (see Fève et al., 2010).

Source: Fève et al. (2012).

In the example cited earlier, the central projection from the data-based forecast (that is, the quantitative model) would have projected an increase in market volumes for mail in the UK of about a quarter by 2010/11 compared with 2003/04. In fact, the impact of e-substitution not contained in the econometric model used at that time is estimated to have affected mail volumes adversely by about 30%, representing a very significant difference between the data-based forecast and the outturn. The data-based forecast in 2004 was augmented by additional business information in the form of additional net trend adjustments. These adjustments sought to anticipate these changes, although they captured only about 40% of the effect (an adverse impact of only 12% was allowed for instead of 30%).[5] Hence, while the use of such adjustments underestimated the future impact of e-substitution, the inclusion of additional business information within the forecast process substantially reduced the forecast error.

Additional information that seeks to anticipate changes to factors driving demand, and that is then incorporated into the overall forecast, should ideally be based on a number of transparent sources of information. These could include information from other countries or industrial sectors which are considered to be in advance of the entity being forecast or could represent leading indicators. A second source of information could be the most recent outturn data on demand, which, given practical constraints in a business environment on the possibility of continuous re-estimation of econometric models, might provide early indications of structural breaks and the direction and magnitude of differences between model projections and outturns. Where available and timely, the results of well-constructed opinion surveys of users, relating to prospective changes in their demand patterns, would be a valuable additional source of information. Finally, it might be possible to take account of possible impacts arising from discrete events, such as an announcement of a change in government policy affecting a particular factor in the market environment.

Ultimately, however, the process of augmenting the data-based forecast with additional business information must necessarily be judgemental. While this may appear to increase the uncertainty surrounding a forecast, additional information can instead be used to identify explicitly any risks associated with such uncertainty, and can help to reduce forecast bias substantially, for the approach directly addresses one potential area for major errors arising from a data-based forecast. The latter takes account only of historical data and trends used to estimate the quantitative model to prepare that projection, and the forecast values of variables in that model. However, it does not allow for the possibility of future changes in the factors affecting demand, for example due to structural changes in the external environment. In certain cases, as indicated by the above example for postal services, these effects can be very significant, leading to large forecasting errors.

Assessing the level of uncertainty

Although some users of projections (be they businesses, regulators or other interested parties) often seem uncomfortable with a situation where there may be a wide range of possible future outcomes, it is essential for all to recognise explicitly that, where a market is evolving, such a range is an inherent feature of a long-term projection. An important aspect of assessing uncertainty associated with any long-term projection, then, is the use of sensitivity analysis.

Such analysis applies both to the data-based forecast and to the additional information used to augment that forecast. Where possible, it is preferable to adopt a simulation approach with probabilistic specification of input variables using Monte Carlo techniques. These techniques are used in many applications. This approach provides a fuller reflection of the uncertainty surrounding a set of central projections, and can result in a wide range of possible outcomes.[6] The results from such simulations can be used to help define upside and downside scenarios more fully—for example, from percentiles of the modelled outcomes of the simulation, as well as tail risks.

Conclusions

The focus in this article has been on uncertainty and long-term projections of demand, in the context where decisions—and, hence, the demand projections that help to underpin those decisions—are 'irreversible'. Quantitative models (for example, econometric time-series models) are frequently used to produce such a set of projections, and Monte Carlo simulation techniques are an important tool with which to assess uncertainty surrounding a central projection.

This standard approach to forecasting is extended in Fève et al. (2012) to incorporate additional information which augments data-based forecasts generated by quantitative models. The extension seeks to anticipate the impact of new factors affecting demand which are reflected only partially, or perhaps not at all, in the historical time series used to estimate the quantitative model.[7] An example considered above was the prospective increase in e-substitution (caused mainly by the rapid development of Internet-related technology), and trying to incorporate its possible effect on the demand for mail prior to the change yet having had much of an impact on demand.

It is clear, though, that any long-term projection of demand in an evolving market environment is inherently very uncertain, however well-based that projection is, and it is quite possible that there will be significant errors in outturns relative to the central projection. It is therefore important that the high level of uncertainty is recognised explicitly in the use of such projections. In the postal case study considered, such uncertainty was sought to be addressed through a volume risk mechanism that directly linked the allowed revenue of Royal Mail's regulated services to differences in volume outturns relative to a set of projections included in its licence.[8]

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[1] See, for example, Nankervis, J., Richard, S., Soteri, S. and Rodriguez, F. (2002), 'Disaggregated Letter Traffic Demand in the UK', in M.A. Crew and P.R. Kleindorfer (eds), *Postal and Delivery Services: Pricing, Productivity, Regulation and Strategy*, Boston, MA: Kluwer Academic Publishers, pp. 203–18.
[2] An additional factor affecting Royal Mail's mail volumes during this period was the opening of the UK postal market to postal competitors between 2003 and 2006. However, entry to the market has been mainly through downstream access, with a limited effect on delivered volumes.
[3] Fève, F., Florens, J.-P., Veruete-McKay, L., Soteri, S. and Rodriguez, F. (2012), 'Uncertainty and Projections of the Demand for Mail', in M.A. Crew and P.R. Kleindorfer (eds), *Multi-modal Competition and the Future of Mail*, Cheltenham, UK and Northampton, MA: Edward Elgar (forthcoming). An earlier version of the paper was presented to the 19th Conference on Postal and Delivery Economics, St Helier, Jersey, June 2nd 2011. This is the third paper in a series examining the issues of modelling and forecasting mail volumes in an evolving market environment. The two other papers are Cazals, C., Florens, J.-P., Rodriguez, F. and Soteri, S. (2008), 'Forecast Uncertainty in Dynamic Models: an Application to the Demand for Mail', in M.A. Crew and P.R. Kleindorfer (eds), *Competition and Regulation in the Postal and Delivery Sector*, Cheltenham, UK and Northampton, MA: Edward Elgar, pp. 63–73; and Fève, F., Florens, J.-P., Rodriguez, F. and Soteri, S. (2010), 'Forecasting Mail Volumes in an Evolving Market Environment', in M.A. Crew and P.R. Kleindorfer (eds), *Heightening Competition in the Postal and Delivery Sector*, Cheltenham, UK and Northampton, MA: Edward Elgar, pp. 116–34.
[4] It can also lead to users of projections no longer having confidence in the outputs from quantitative models. This could, erroneously and very unfortunately, result in a view outside quantitative specialists that quantitative models have little to offer in a demand environment where demand conditions are changing or may begin to evolve rapidly.
[5] Fève et al. (2012), op. cit. As discussed in that paper, the UK recession of 2008–09 also had a very significant negative impact on volumes, resulting in a forecasting error arising from the assumptions made with respect to economic growth over the projection period (that is, the central projections formed in 2004 broadly assumed that the economy would grow in line with its historical trend over the projection period).
[6] See Cazals et al. (2008), op. cit., for an application of such techniques to long-term projections of the demand for mail, using stylised data, and potentially resulting in very wide confidence intervals around a central projection, where the possibility of a structural break in demand is introduced.
[7] Of course, if no change is expected, the adjustments to the data-based forecast can be set to zero, but this should be an explicit decision taken as part of the forecasting methodology.
[8] See Condition 21.14 of Royal Mail's licence, 2006.