

Probabilistic Forecasting: Definitions, Examples, and Applications

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Abstract

While commonly used, point wise and deterministic predictions are often sub-optimal forecasting methods. While they may make useful contributions to decisions making capabilities, they fail to capture the uncertainty inherent in any event. Unlike the more familiar forecasting methods, probabilistic forecasts and the connected field of uncertainty quantification attempt to numerically evaluate uncertainty and forecast a cumulative density function (cdf) or the equivalent probability density function (pdf) for a given event. While the value contributed by this predictive tool may be easy to see, arriving at a clear and concise definition has proven troublesome for practitioners. Additionally, with a myriad of methods for representing probabilistic forecasts, the question arises as to which technique is optimal. We attempt to solve these issues by providing a critical examination of current applications of probabilistic forecasting and proposing a definition for what a probabilistic forecast is. In doing so, we hope to add our contribution to the GasDay Lab's effort to incorporate probabilistic forecasts to their current product.

Introduction

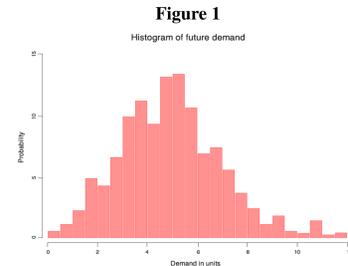
- We see numerous methods for representing these forecasts but all serve to predict the cdf of a particular event
- With minimal creativity one may conceive how these representations could be used in natural gas and energy forecasting
- We discuss and propose a definition for probabilistic forecast
- We conclude with a brief discussion of potential future work

Examples and Applications

- Probabilistic forecasts improve critical decision making capabilities
- Offers academics new insight into their analytics
- Can contribute to increasing business profit
- Used in a number of academic and industrial disciplines from social sciences to hard sciences

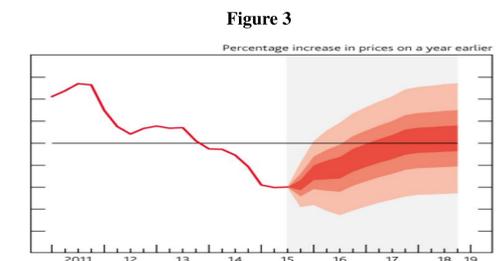
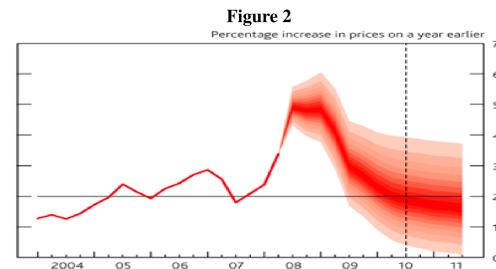
Single Time Horizons

- Probabilistic forecasts can also be used to assign probabilities to different quantities
- For example can be used in supply chain management [5]
- Assign probability of producer needing a certain quantity in order to meet demand
- Offers opportunity to save money and maximize profit

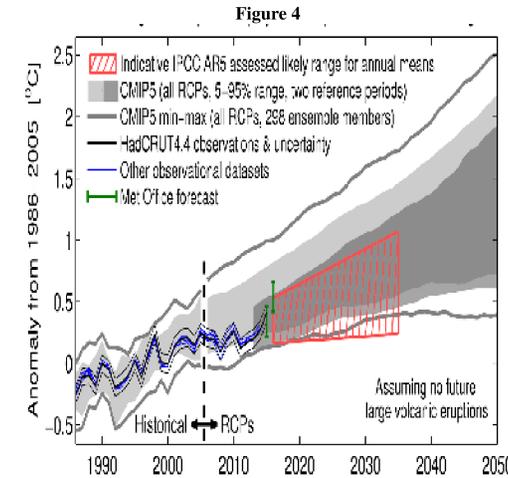


Applications with Multiple Time Horizon Events

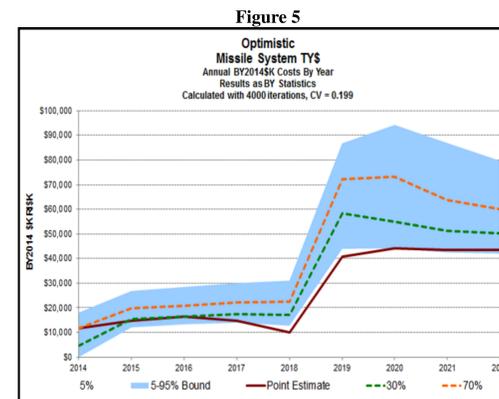
- Important distinguishing characteristic of many probabilistic forecasts is multiple time horizons
- Due to the cumbersome and expensive process of expanding the infrastructure of a distribution area, the accuracy of predictions for how much energy will be required in the coming decades is critical



- Figures 2 and 3 show the British Monetary Policy Committee's (MPC) forecasts for inflation [4]
 - The solid red line depicts actual recorded inflation
 - The fanning shades of depict the probabilistic forecast for inflation
 - This method of representing a probabilistic forecast is known as a fan chart
- Note in Figure 3 inflation in 2011 is beyond the forecasted region.
- Raises the question of how do we determine when a probabilistic forecast is mistaken



- Figure 4 shows actual data for global warming in the blue and black trend lines[3]
- The forecast made in 1986 is shown by the light gray shaded region
- In 2006 the forecast was updated (darker gray)
- Predicted mean values for the coming years is given in red fan
- Actual data fluctuates but stays within the bounds of the predicted range
 - Demonstrates the potential strength of probabilistic forecasting in accurately representing movement in empirical variables



- As a final example where we observe probabilistic forecasts we turn to cost analysis
- This graphic provides both point and probabilistic forecast [5]
 - Demonstrates the strength of combining forecasting methods
 - Shows likelihood of exceeding cost threshold
 - Culmination of multiple forecasting methods work together to improve decision making capabilities

Definition

- There are a number of proposed definitions from academics and practitioners of probabilistic forecasts
- All offer their own unique flavor and insight
- Common to all definitions is the concept that probabilistic forecasts capture the uncertainty

Ranjan defines probabilistic forecasting in the following manner: "Probabilistic forecasts take forecast uncertainty into account by giving forecast distribution or predictive probability density function (pdf) of the future quantity of interest." [Ran]

Conclusions and Future Work

- The ubiquitous nature of probabilistic forecasts affords abundant examples of probabilistic forecasts
- By incorporating a measure of uncertainty, probabilistic forecasts advance strategic decision making capabilities
- No census exists to ideal method to represent probabilistic forecasts
 - Each offers strengths and weaknesses
 - Due to their ability to clearly depict multiple time horizons for the purposes of GasDay we recommend fan charts
- Similarly a satisfactory definition is troublesome
 - The critical take away is that probabilistic forecasts factor in uncertainty to the prediction
- Future work:
 - Evaluation of scoring metrics
 - Optimal method for creating probabilistic forecasting engine

Acknowledgments

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References

- [3] *Met office forecasts 2016 to be hottest year on record - carbon brief*, <http://www.carbonbrief.org/met-office-forecasts-2016-to-be-hottest-year-on-record>, (Accessed on 06/22/2016).
 - [4] *Historical fan chart data — bank of england*, <http://www.bankofengland.co.uk/publications/Pages/inflationreport/irprobab.aspx>, (Accessed on 06/22/2016).
 - [5] *Probabilistic forecasting definition - lokad*, <https://www.lokad.com/probabilistic-forecasting-definition>, (Accessed on 06/22/2016).
- [Ran] Roopesh Ranjan, *Combining and evaluating probabilistic forecasts*, https://www.amstat.org/sections/bus/com/ranjan_hesis.pdf, (Accessed on 06/15/2016)