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economics as if people and the planet mattered

Model behaviour

Comparing climate science with economic forecasts

Every day, major economic decisions are made based on advice no more accurate than a coin flip. But when it comes to climate change, sceptics and media are fuelling distrust in forecasts that now have a 20-year track record of accuracy. It's time to end the double standard in how our most important decisions are made.

Uncertainty is the new denial

As the significance of climate change becomes more apparent and the timeline for action tightens, the arguments against action have shifted. Rather than flat-out denial, opponents of action on climate change now speak in terms of uncertainty.

Some of this opposition is implicit. A recent Oxford study on media coverage of climate change found that 80% of articles covering the topic contain uncertainty. Some is explicit, with commentators brandishing uncertainty as a way to undermine scientific research and the strong policy response it necessitates. The argument is that action on climate change should be delayed given the uncertainties.[1]

> *"Not only is much of the science behind the idea of global warming now being disputed, but, at a time of such widespread economic hardship, we simply cannot afford to misdirect scarce economic resources on such a massive scale.*
> **Dr Benny Peiser, Director of the sceptic Global Warming Policy Foundation writing in the *Daily Mail***

This emphasis on uncertainty has a negative impact on climate progress. It slows down environmental policy and corrodes public will to act. Research, especially in the field of psychology, notes that uncertainty is one of the most serious barriers to action on climate change.[2]

Climate forecasts: The scapegoat for uncertainty

> *"[A]ccording to increasing numbers of serious climate scientists, it does suggest that the computer models that have for years been predicting imminent doom, such as those used by the Met Office and the UN Intergovernmental Panel on Climate Change, are flawed, and that the climate is far more complex than the models assert.*
> **Climate sceptic David Rose writing in the *Daily Mail***

Supporting the uncertainty argument is the claim that climate change forecasts are inaccurate or flawed. Particular hostility is aimed at the Intergovernmental Panel on Climate Change

Table 1. Snapshot of IPCC reports so far[3]

Report	Year	Number of pages	Number of lead authors	Number of models	Detail of geographic unit (km)	Doubling CO_2 lead to…
First Assessment	1990	412	34	2	500	1.5–4.5°C
Second Assessment	1995	584	78	20	250	1.5–4.5°C
Third Assessment	2001	892	122	20	180	1.5–4.5°C
Fourth Assessment	2007	1006	178	20	110	2.0–4.5°C
Fifth Assessment	2013	2014	258	45	50	1.5–4.5°C

(IPCC). Drawing together the work of thousands of scientists from over 120 countries, the IPCC's forecasts are internationally accepted as the most comprehensive and authoritative climate predictions available. Yet last year, *Telegraph* headlines about the IPCC included: 'IPCC report is "full of hocus pocus science"'; 'Top climate scientists admit global warming forecasts were wrong'; and, 'Climate change: this is not science – it's mumbo jumbo'.

The suspicion extends to politics, too. Maurice Newman, the most senior business advisor to Australian Prime Minister Tony Abbott, has accused the IPCC of 'dishonesty and deceit' and labelled climate change predictions a 'scientific delusion'.

Tackling the misconceptions

The allegations are serious: the more people hear about climate forecasts being defunct, the less likely they are to support the drive to keep global temperatures below safe levels.

They also stand in stark contrast to the certainty the scientific community has expressed in the main issues relating to climate change. The release of the IPCC's 5th Assessment Report comes with a revised estimate of certainty – up to 95% – that humans have been the main cause of global warming from 1950 to present. This 95% has a precise scientific meaning. It is higher than the certainty that vitamins are good for your health and equivalent to the certainty that cigarettes cause lung cancer.[4]

This paper seeks to reconcile these differences by comparing climate forecast estimates to the actual measured data for the same time period. It investigates the notions regularly aired by politicians and media that (a) global warming forecasts are inaccurate, and (b) they are too inaccurate to inform major policy decisions.

Are climate forecasts accurate?

The effects of climate change can only be viewed over a long time frame. With over two decades of global climate observation data since the IPCC published its first report in 1990, we are only now in the position to begin assessing their track record for accuracy.[5]

Since 1990, the IPCC has published forecasts with increasing complexity and detail but with little change to many key measures like predicted climate sensitivity (what doubling the CO_2 concentration means for global temperature). By comparing its early forecasts to the actual climate observation data recorded over the past 20 years, we can start to build a picture of how accurate it has been so far.

What is accuracy?

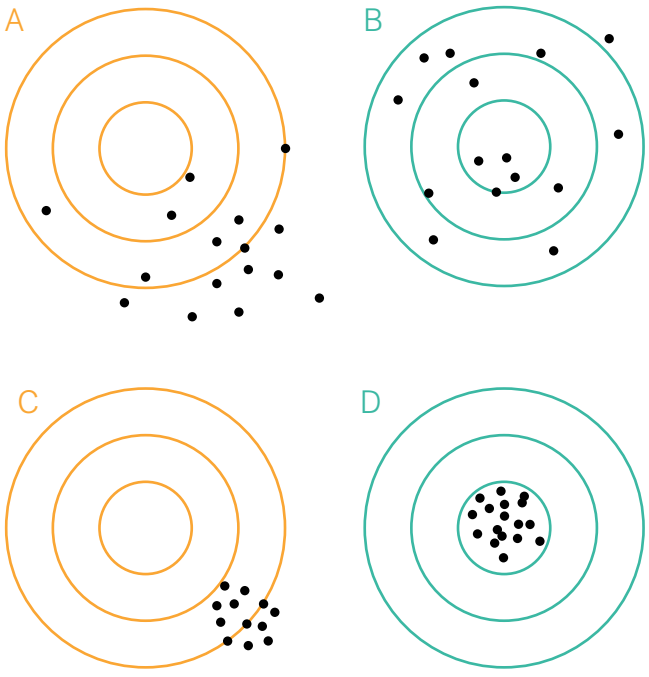
While often used casually, the term accuracy has a specific statistical meaning. For a forecast to be described as accurate it should be both unbiased (the repeatability of the result) and precise (closeness to the actual value). The target diagrams in Figure 1 illustrate the difference. The shots represent what was predicted to happen and the bull's-eyes represent what actually happened.

Target B represents unbiased but imprecise predictions. The shots were on target, although they did not all hit the bull's-eye every time. In other words, what actually happened was within the range predicted.

Target D represents predictions that were both unbiased *and* precise: the shooter hit the bull's-eye every time.

Targets A and C represent bias. The shots all fell to one side of the bull's-eye: what actually happened was completely outside of the range predicted.

Figure 1. Bias and precision[5]



What category do climate forecasts fit into?

Very few models – be they climate models or otherwise – fall into the unbiased *and* precise category. This is unsurprising as the use of models is for complex interactions that need to be simplified, so precision is often secondary to understanding a general trend.

Figures 2–4 test the accuracy of three key climate projections presented in the IPCC's 1995 Second Assessment Report (SAR): carbon concentration, surface temperature (as anomalies relative to 1961–1990) and sea-level rise. The shading shows the range of predictions made by the forecasts at that time and the dots show the actual recorded data for each year.[7]

Figure 2. IPCC carbon concentration

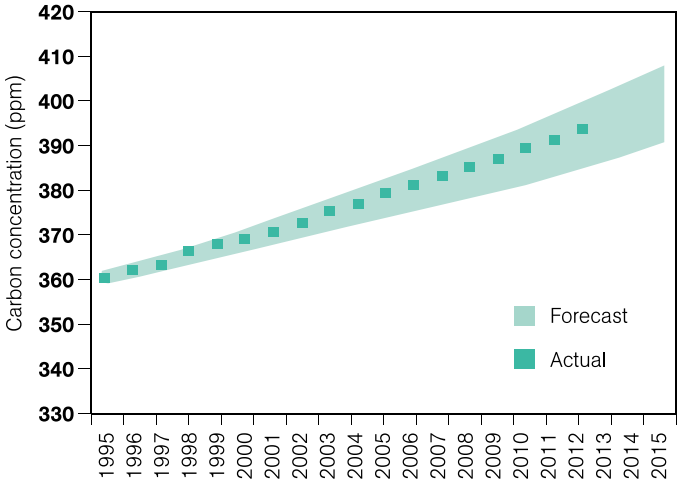


Figure 3. IPCC temperature anomaly

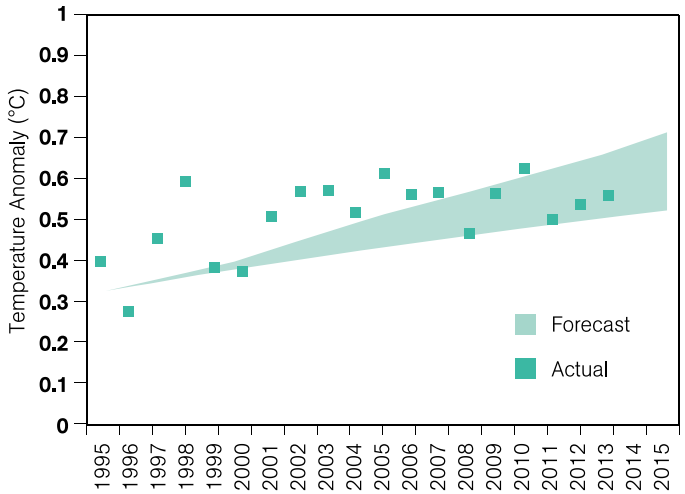
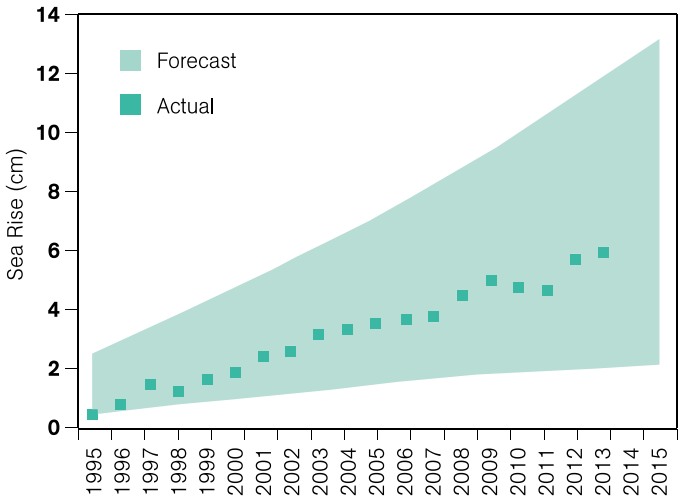


Figure 4. IPCC sea-level rise



We can see that the climate data points recorded between 1995 and 2013 are largely in line with the projections made in 1995. Not only have they followed the trend predicted (unbiasedness), but they are largely within the forecast range (precision). With this evidence climate models are shown to be quite accurate in their forecasts.

Already it's clear that the definition of inaccuracy is being seriously stretched by those attacking climate forecasts. Take the *Telegraph* article that last year reported a 0.01°C downgrade in the IPCC's decade-to-decade global warming forecast with the headline 'Top climate scientists admit global warming forecasts were wrong'. Never mind that climate modellers have accurately projected the all-important warming trend – accentuating a tiny imprecision to make the whole thing look defective makes for a much better story.

Yet, the precise temperature of a certain year in the trend is largely irrelevant when the general warming trend is clear. The truth is that, in the case of climate forecasts, accuracy is far more important than precision.

What is the standard of accuracy for policy-making?

So what about the second question: Are climate models accurate enough to inform long-term policy? To tackle this, let's consider the other kinds of forecasts used in major decision-making. How do climate change forecasts perform in comparison to these measures? Are they as reliable as economic and social indicators already in use? If yes, then it follows they have met the standard required to inform governance.

Economic forecasts and policy: an introduction

Around the world, decision-makers repeatedly consult the predictions of professional economists using complex economic models to make predictions about the economy. Not only are their forecasts regularly consulted, but there is evidence that major policy decisions, like central bank interest rates, are well explained as a reaction to forecasts.[8] Sometimes forecasts themselves are used as a key justification for policy – as when Chancellor George Osborne stated in his New Year's speech that Treasury forecasts required a further £12 billion in welfare cuts in the first two years of the next parliament.[9]

Recent history proves that even the most important predictions about the economy can be off the mark. Nearly all economic forecasts failed to predict the 2008 recession and continued to underestimate its existent and recovery time. And those few forecasters who *did* predict the recession have not been any more accurate in other forecasting predictions.

In financial economics – the branch of economics where much attention and reverence is given to forecasting – studies have shown that over a large sample size financial experts are no better at simple and falsifiable predictions than a coin flip. A study by CXO Advisory Group of 6584 such predictions by 68 experts from 2005 to 2012 has stabilised at 47–48% accuracy. The research led the group to conclude: 'forecasting isn't about predicting the market; it's about marketing the prediction.'[10]

Other studies of economic forecasting have analysed the accuracy of prediction based on the body making the prediction. While some studies have noted a bias towards optimism in government economic forecasts,[11] several others review datasets to show that non-governmental institutions are no more accurate in predicting economic variables and are often worse.[12,13] It also appears that forecast accuracy does not improve over time,[14] although forecasts are becoming more frequent and project further into the future.

Comparing climate forecasts to economic forecasts: do they made the grade?

Let's take a closer look at three measures commonly used in long-term government decisions and modelling: the ONS population forecast, the forecast of the HM Treasury's debt/GDP ratio, and the US Energy Information Administration oil price forecast.[15] Oil price forecasts are often used in economic models as a key cost to businesses and consumers that acts to dampen or strengthen economic activity. Population is a key variable that impacts economic models through many routes including likely changes in the labour market, consumer demand, and requirements for government services. The debt/GDP ratio is frequently used as a target in government decisions.

How does their track record for accuracy match up to the key climate projections we studied earlier?

You can see from Figures 5–7 that population, net debt/GDP, and oil prices all show a departure over this period from the projections, and all three measures appear to have missed the trend and fail account for the variance with an appropriate range – evidence of both inaccuracy and imprecision. Compare these to the climate forecast graphs from earlier, where all the observed data points fell within the forecast range, and we can begin to appreciate how out of proportion the charges against climate models are.

Figure 5. ONS population of England

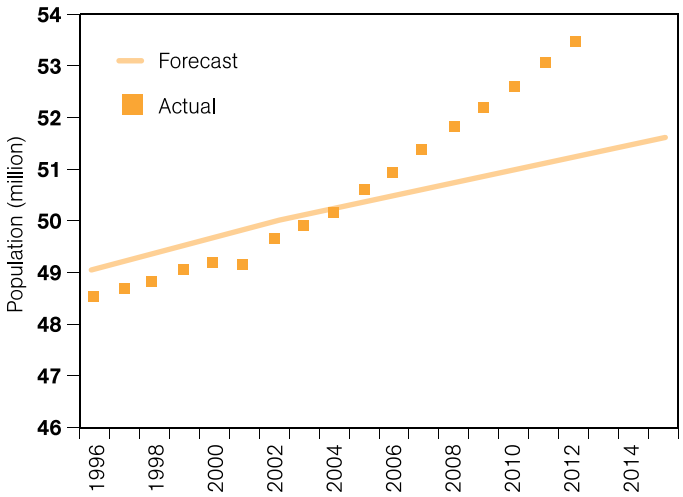


Figure 6. HM Treasury UK net debt as % GDP

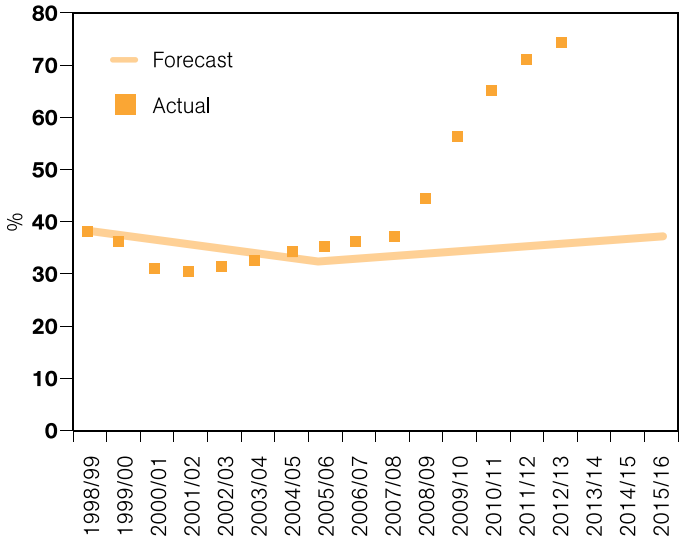


Figure 7. EIA oil price projection

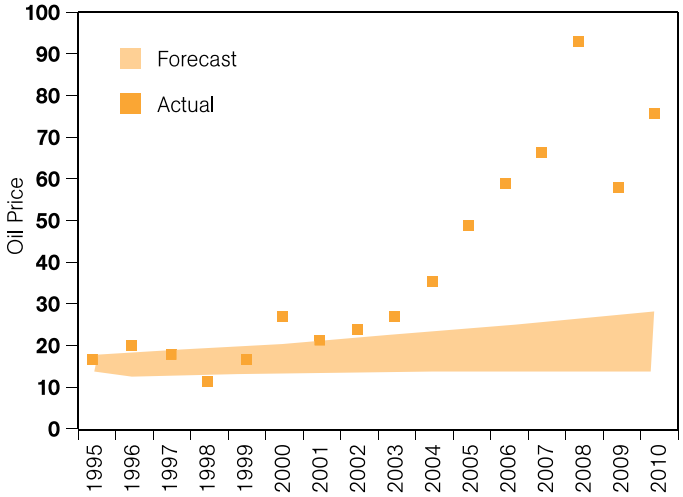


Table 2. Statistical tests comparing forecast accuracy

Test	Population	Debt/GDP	Oil Price	Carbon	Temperature	Sea Level
sMAPE	1.56	25.50	56.24	0.22	16.55	32.41
MdAPE	1.19	14.49	37.65	0.24	13.57	27.48
NRMSE	0.20	0.41	0.38	0.03	0.27	0.17

The three IPCC projections and the projections currently used in decision-making can also be compared statistically using tests of accuracy where lower results reveal less error (higher accuracy).[16] While different statistical tests show slightly different results, the IPCC projections show similar levels of accuracy and, in some cases, much higher levels of accuracy (lower levels of error) than some projections currently used in decision-making, as illustrated in Table 2.[17]

Box 1. Problems with comparability

Making like-for-like comparisons between climate models and economic models comes with a number of caveats.

First, there is a big difference in the timeline of forecasting. While some economic forecasts typically focus one and two years ahead, climate change forecasts are designed to forecast decades ahead and therefore deliver little certainty regarding the immediate future.

Similarly, there is an issue regarding inherent variability. In other words, some kinds of measures are easier to predict than others. For instance, the number of doctors in the UK is unlikely to double in size tomorrow but the number of people standing in Trafalgar Square might. Inherent variability makes the latter much more difficult to forecast. Comparing forecasts of different natures will inevitably encounter this issue of variability.

Most importantly, unlike the climate, the market is a human construction with components of our own design. Understanding of the mechanics is to be expected. Further, economic forecasts are often structured to be self-fulfilling as forecasts affect the outcome through various channels (e.g. confidence and investing).

Conclusion

In public policy, decisions have to be made with the information and tools that are available. Often, imperfect information is better than no information at all. The statistician George E. P. Box reached the conclusion that 'all models are wrong, but some are useful.'[18]

This paper shows that the accuracy of past climate change forecasts from the IPCC are comparable to some of the commonly used economic indicators in public policy, indicators that are published without criticism by newspapers and mainstream economic organisations. In many cases, they have even outperformed them.

Uncertainty is not a real reason for the resistance to action on climate change. Rather, it is being used as cover for entrenched interests as our response to climate change requires significant system redesign. If another area of scientific research threatened vested interests in the way that climate change does, there would still be sceptics claiming there is not enough certainty – that 95% certainty is still too low to take significant action.

Regardless of the exact reasons for why arguments about uncertainty are now being used so frequently by some commentators, the evidence now available shows that uncertainty about climate change can no longer be used as intellectual cover for inaction.

Endnotes

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7. Carbon concentration measurements are published by the National Oceanic and Atmospheric Administration. Temperature anomalies are published by NASA's Goddard Institute for Space Studies, the National Climatic Data Center, and the Climatic Research Unit of the University of East Anglia. Sea-level measurements are published by the University of Colorado Boulder and Commonwealth Scientific and Industrial Research Organisation. The 1995 IPCC forecast is used, as few long-term economic forecasts exist for comparison before this time. 1990 only being around this time.
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15. For these measures, the closest year to 1995 was used as a start date to minimise differences in the comparison.
16. For the forecasts that provided a range, the midpoint was used for comparison.
17. The symmetric mean absolute percentage error (sMAPE), median absolute percentage error (MdAPE), and normalised root mean square error (NRMSE) were chosen to compare the forecasts because of their normalised results and the additional advantages of each measure in protecting against symmetric results, outliers, and being in common statistical use.
18. Box, G. & Draper, N. (1987). *Empirical Model Building and Response Surfaces*, New York: John Wiley & Sons.

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