# Uncertain unknowns

The Great Tohoku earthquake in March has raised many important questions about catastrophe risk models. **Mr Bill Keogh** of **EQECAT Inc** explains why uncertainty still rules despite the presence of the modeling tools.

The unprecedented event of the Japan catastrophe in March included a set of cascading effects that are still unfolding, many of which were unanticipated. Such effects included a higher than anticipated event magnitude, a devastating tsunami and a catastrophic nuclear incident, a multiple fault rupture, and hundreds of aftershocks.

## Questions and more questions

Often, after an event of this magnitude, we are left with questions. How much of this was foreseeable? How can the insurance industry manage such risks? What should the insurance industry expect from catastrophe risk models regarding probabilistic output?

EQECAT recently revised our insured loss estimate to a range between US$22-$39 billion, a significant increase from our original estimate of $12-$25 billion. Why did the estimate increase? What should we expect from models for post-event loss estimation? To examine these questions is to better understand the role of models in catastrophe risk management for the (re)insurance industry.

## Uncertainty in modeling

To start with market expectations of catastrophe risk models, we ask: "What do (re)insurers expect from a model?" As modelers, our goal is to set *rational expectations about risk*. Models are essentially an analytical framework for exploring, quantifying and managing the uncertainty associated with catastrophe risk.

But why is there uncertainty? Is it because modelers are not sure of themselves? Is it because we have not done enough research? We employ many bright people - Ph.D.s, scientists and engineers, mathematicians and insurance professionals; one might wonder "Why is there uncertainty?" It seems like a reasonable expectation that models would be *accurate* given all the brainpower we have. So what is going on?

Looking at the Tohoku event, we should not be surprised about uncertainty in modeling. The fundamental question we are attempting to answer with catastrophe risk models is one of uncertainty.

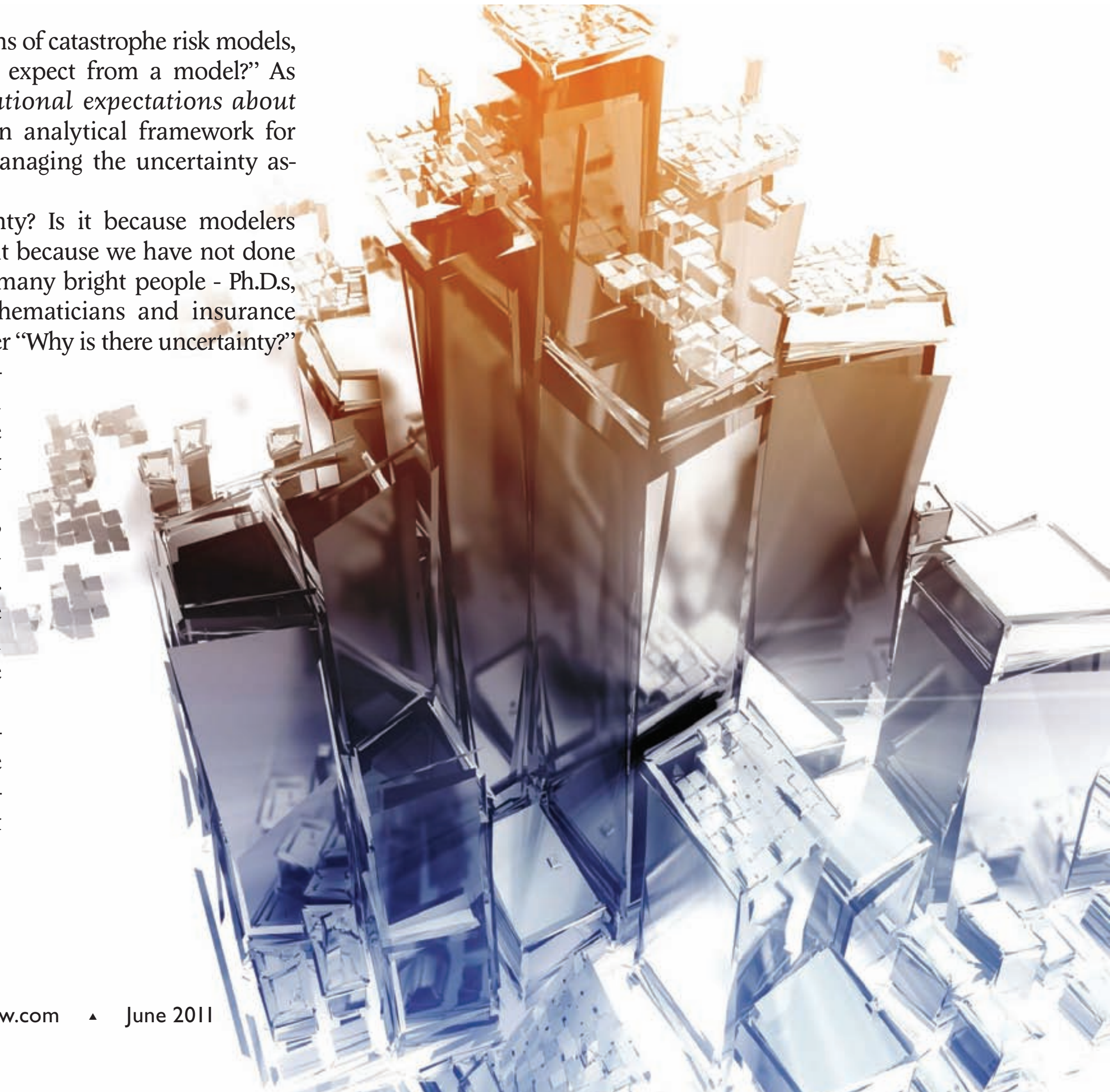
The uncertainty exists because that is what we are modeling. We do not actually know with *certainty* what events *will* happen. We know what has happened in the past. We know what *might* happen in the future. But we do not know what *will* happen.

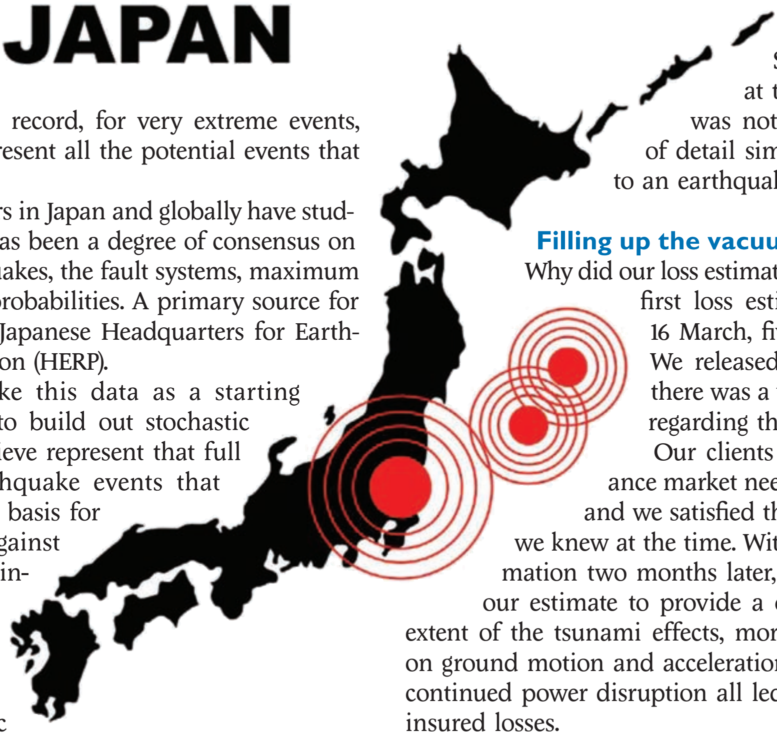
We also do not know for certain what every event will look like. We know what *has* happened. We know what *might* happen. But we do not know what will happen. From the billions of dollars of claims and exposure data we have analysed, we also know that building response is *highly variable*. The uncertainty is exactly why we need models. Logically, there are many consequences that either cannot be anticipated or might be understood but cannot be parameterized in a probabilistic model.

## Long history of earthquake activity records

To look at Tohoku, then, the starting point of understanding Japanese earthquake risk is to account for what has happened in the past.

Japan has an established culture with a recorded history of earthquake activity that goes back over a thousand years. While we do not have detailed measurements of earlier events, we do have historical references to events






going as far back as the year 684 AD. While this might seem like a long record, for very extreme events, the record does not represent all the potential events that might happen.

Earthquake researchers in Japan and globally have studied this risk and there has been a degree of consensus on the potential for earthquakes, the fault systems, maximum magnitudes and event probabilities. A primary source for this information is the Japanese Headquarters for Earthquake Research Promotion (HERP).

As modelers, we take this data as a starting point and interpret it to build out stochastic simulations that we believe represent that full range of possible earthquake events that *might* occur. This is the basis for models that are run against exposure data sets that include details of policies, including building, occupancy and insurance conditions. The model produces probabilistic output that (re)insurers use to manage their earthquake risks. Of course, the model will reflect our interpretation of the scientific consensus which is the foundation of the source data.

## Unanticipated intensity

In the case of Japanese earthquake models, while fire-following effects are included in the model, the effects of tsunamis are not. So understanding what is included and what is not included is extremely important in interpreting results.

The intensity of the Tohoku event was significantly higher than the scientific consensus. The maximum magnitude anticipated for the Japan trench was 8.0-8.3, with the actual event magnitude a 9.0. This difference in magnitude released approximately 20-30 times more energy than anticipated. In addition, the Tohoku event was a simultaneous multiple rupture event, for segments that were thought to be independent. This meant that the geography affected was significantly larger than anticipated.

## Tsunami and meltdown at nuclear plants not included in models

While the potential for a tsunami was understood, tsunami effects are not modeled. This is due to a lack of data to parameterise the risk probabilistically. Given the increased energy released from this event, the size of the tsunami was much greater than anticipated. Maximum inundation depths approached 80 feet with inland penetration as far as six miles. The Tokai nuclear plant was not designed for a tsunami of this size. In addition, the backup generators failed which led to the series of unfortunate events that are still unfolding.

What should we expect from catastrophe risk models for probabilistic output? To start, they will only model what they are built to model. In the same way that some were surprised that the levee breach was not included in models after Hurricane Katrina, some were surprised that tsunami effects were not included in Japan earthquake models. Similarly, the meltdown at the Tokai Nuclear plant was not anticipated. This level of detail simply cannot be built in to an earthquake model.

## Filling up the vacuum in early days

Why did our loss estimate change over time? Our first loss estimate was released on 16 March, five days after the event. We released this estimate because there was a vacuum of information regarding the insured loss.

Our clients in the global (re)insurance market needed timely intelligence, and we satisfied this need based on what we knew at the time. With more complete information two months later, we were able to revise our estimate to provide a clearer assessment. The extent of the tsunami effects, more detailed information on ground motion and accelerations and soil failure, and continued power disruption all led to higher estimates of insured losses.

We embrace models as essential tools because they are very good at what they do. But, as we can see from the Tohoku event, they do not do everything.

## Framework for thinking about uncertainty

In 2002, Mr Donald Rumsfeld suggested a framework for thinking about uncertainty where he discussed *known knowns*, *known unknowns* and *unknown unknowns*. Models characterise the *known knowns* and the *known unknowns*. They do not characterise the *unknown unknowns*.

Let's put this in the context of catastrophe risk models. *Known knowns* are events that have occurred. These events inform us about a given peril in a given region. They are a rich source of data that provides insight to the nature of extreme and rare events.

*Known unknowns* are those events we can infer from what has already happened. Creating a stochastic model is essentially building a robust set of possible events which is informed by what has happened but not constrained by what has happened. The constraints are based on our understanding of the physical world.

And the *unknown unkowns*? These are the things that either cannot be anticipated or cannot be parameterized in a model. While the Tohoku tsunami could be anticipated, it could not be parameterized in a probabilistic framework.

To expand on Mr Rumsfeld's thought – in the realm of catastrophe risk there are more things that we do not know, than things that we know: there are few *known knowns*; there are more *known unknowns*; and even more *unknown unknowns*. We learn from every event, and they expand our knowledge. The Tohoku event is a case in point. While a human tragedy of great proportion, the data generated from the earthquake and the tsunami is rich and will greatly expand our understanding of both perils.

Mr Bill Keogh is President of catastrophe modeling firm, EQECAT, Inc.
*EQECAT is the 2010 winner of the Asia Insurance Industry Awards' Innovation of the Year*