From Dice to Data: Exploring the Mathematics of Risk-Taking

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Risk is a word with quite negative connotations. It tends to be associated with being unreasonable and illogical to the public. However, we do not truly appreciate that risk is an unavoidable part of everyday life. Every movement and every decision involve an element of risk which people, most of the time, subconsciously deal with. Uncertainty and risk aren't the same thing. Risk is quantifiable. You won't know the outcome, but you do know the odds. Uncertainty is where you do not know either the odds or the outcome. Models don't show uncertainty; they show risk as maths can represent the potential outcomes. Mathematics and modelling are powerful tools to take risk-taking to a new and controlled level. It helps to envision and predict outcomes in a more representative way. It is important to clarify that this is not an essay discussing how mathematical models are able to make people unstoppable in casinos. Mathematics doesn't eliminate risk, it describes it. It shows us how something could function based on human assumptions. This has led to many occasions where we have seen benefits and issues with the reliance on modelling. This essay does discuss how mathematical models have shaped our everyday lives and will dive even further into its impacts on finances.

The 2008 Financial Crisis:

The event that truly intrigued me was the 2008 Financial Crisis. This shows how expecting models to eliminate risk can very easily backfire. It all began when banks at the time were giving out subprime mortgages. These were high interest home loans aimed at people with poor credit history. This was provided with collateralised debt obligations (CDOs) and this was sold to investors. The issue came when rating agencies such as Moody's and S&P used their model to assess the risk of these collateralised debt obligations. The model was designed to estimate the potential losses for mortgage pools and in the end, determine what rating would be assigned. However, there were many flaws with the model. The model failed to account for the national decline in house prices and instead assumed that house prices would never fall simultaneously. When an economy goes downhill, everyone suffers together and the model could not account for this. It instead treated mortgages as independent to each other and so the correlation it predicted was significantly underestimated. The tendency that these extreme losses would happen simultaneously nationwide was known as the tail correlations. In some cases, the models were predicting a financial crisis to be a 25 standard deviation event which would have made it a once in a universe sort of scenario. To top it all off, everyone used the same models, so no one was able to spot the error early on and instead it resulted in it backfiring for everyone. As house prices began to fall, the subprime defaults began to skyrocket.

Consequences:

The consequences were significantly bad. American International Group (AIG) were banking on the idea that the models were going to be correct and that defaults would remain low and uncorrelated and sold protection on $440 billion of assets. But as the defaults spiked simultaneously, AIG couldn't meet the obligations. This, looking back, was a true example of the counterparty risk. In the end, AIG required around a total of $182 billion to avoid collapse, which for then the world's largest insurance company, would have been catastrophic. The American investment bank, Bear Stearns, collapsed in March 2008 due to bankruptcy. Lehman Brothers followed in September 2008 as they also filed for bankruptcy at $639 billion in assets. Banks also stopped lending money to each other with a fear of who was exposed to what. Global GDP fell by an estimated $2 trillion, US unemployment peaked at 10% and Iceland's entire banking system collapsed.

A deep dive into the model:

A stochastic process is a model used to represent the random evolution of systems over a period. In 2008, most model followed the Brownian Motion (Wiener Process) which had some key properties.

1) What would change in the future was not affected by what has already happened in the past. This is known as the Markov Property.
2) As it changes over time, it would follow a normal distribution.
3) The model remains continuous with no sudden jumps.

The third point was what was wrong with this choice for the model. When markets and economics gets out of control and loses its continuity, the model would become unable to predict the large jumps (fat tails). These extreme events were assumed to be impossible based on the model, and it was a huge false assumption. The first point also had issues as the model would not also consider the past and use it to predict the change in future prices and this meant that it couldn't predict the snowball effect caused by the financial jumps. The Fundamental Theorem of Asset Pricing (FTAP) states that there is no risk-free profit if and only if a risk-neutral probability measure exists. Essentially, it would be impossible to buy something for £5 in one market and then immediately sell it for £6 in another market. This does not predict future prices but is instead a consistency check to ensure that prices are consistent. In 2008, this ensured that the prices were consistent which meant that the maths was correct. It was just solving the correct equations for the wrong world.

In conclusion, maths has always been involved in taking risks. The most important thing to remember is that models can describe risk and cannot eliminate it. Mistakes such as the 2008 Financial Crisis was not due to bad maths but instead a misunderstood usage and overreliance of a model. The stochastic process, Markov Property and the FTAP are a few of the mathematical ideas used in risk-taking that are incredibly efficient and quick to see real world situations. However, events such as the Financial Crisis will always remain a warning to the world that models are not the full picture and that it should not be what fuels dangerous confidence. On top of that, a larger variety of models should be used to ensure that blind spots are avoided in the future and that errors can be spotted. In a world that continues to throw randomness at us, we need to realise that as much as we can predict some things, there will always be things that we will not be able to foresee.