Headline: Is it risk or is it uncertainty?

In AI Alpha Lab, we have decided to use our blogs to give the reader an insight into the theory and knowledge that is the foundation of our AI-model. AI is about understanding the problem you are facing, as well as how it must be solved via the right type of data model.

In order to understand how our AI-model creates value, it is therefore crucial to understand the thoughts behind the development of the AI-model. Through the next blogs, we will take the readers through our thought process around the use of AI in investment. Our blogs will cover the following:

1) Investing is uncertain – so you need an uncertainty model (this blog).
2) Bayesian machine learning - why?
3) An uncertainty model enables you to invest like a loser – and that's a good thing!
4) How do you make choices based on probabilities? You already do, just not when you invest.
5) What creates a robust investment process? Process ensemble.
6) What creates a robust investment process? Rebalancing risk.
7) How is performance evaluated? A high return does not equal a good investment.

Risk or uncertainty?
Frank Knight was an idiosyncratic economist who formalized a distinction between risk and uncertainty in his 1921 book, "Risk, Uncertainty, and Profit". As Knight saw it, an ever-changing world brings new opportunities for making profitable investment decisions, but it also means we have imperfect knowledge of future events.

Knight distinguished between two types of uncertainty, risk and genuine uncertainty. According to Knight, risk applies to situations where we know the potential outcomes in advance and where we can accurately measure the odds associated with the individual outcomes. An example of risk is rolling a pair of dice. Before we roll, we know in advance what the odds are for each possible outcome (provided that the dice are fair). When we engage in a game of dice, one can make optimal decisions with regards to the outcome space, since the total future outcome space is known in advance as well as the associated probabilities.

However, one faces the risk that adverse random outcomes will materialize over finite time horizons. In any game of chance, in the short run, we are always faced with the risk of the right decision leading to the wrong outcome. However, convergence to the mean (the law of large numbers) ensures that managing risk in the long run is pretty straightforward. You match up your investment to the odds of it paying off.

When uncertainty is probabilistically measurable risk, it is possible to design policies that are optimal on average or in some quantile sense. Policy design under risk is based on first principles as expressed by economic theory and enables investors to distinguish between good, bad, winning and losing investments. Unfortunately, most real-life problems do not just face risk, they are also facing a much trickier endeavor, uncertainty.

Uncertainty occurs when we don't know the possible outcomes in advance, let alone their probabilities. Genuine uncertainty occurs in complex systems, where lots of actors interact over time and arises from the fact that in the physical reality more things can happen than will happen.

Investment professionals has so far been limited in their decision making by the choice of model that they employ. The models have been solely based on historical risk assessments (data risk), relying on maximum likelihood estimation and have not taken on the complex task of doing proper inference by also estimating the confidence in future model performance, i.e. defining model uncertainty.

Predictive uncertainty

In order to make optimal decisions under uncertainty, one needs a set of future scenarios and the associated probability of realization. Within investing the scenario could be the return expectations of a set of stocks and to calculate the future value of an investment in any given stock, one also needs what we call predictive uncertainty.

Predictive uncertainty is the sum of two types of uncertainty, aleatoric and epistemic uncertainty. Aleatoric uncertainty or data uncertainty is the inherent uncertainty in non-stationary data that translate into any model applied on the data. This is the only type of uncertainty investors have been able to quantify until today and therefore investors have, consciously or not, made the assumption that aleatoric uncertainty can approximate total or predictive uncertainty.

The approximation is only true if we further assume that the model of choice is the right model at all times i.e., the model can be expected to perform equally well at all times. This is hardly true and therefore the approximation of historical risk equaling predictive uncertainty is flawed at best.

We need to calculate epistemic or model uncertainty in order to get a better understanding of optimal investment decision making. This is admittedly a daunting task as it involves the calculation of all possible model or parameter specifications that are able to explain a given dataset in order to find the probability that the model of choice is the right one.

Baysian machine learning

So far this has not been possible, but the advent of machine learning models such as probabilistic multi-layer perceptrons, based on Bayesian thinking, has enabled us to quantify epistemic uncertainty and as such quantify predictive uncertainty.

The result is that we can now make investment decisions on much more informative grounds, creating value that was not possible just 5 years ago. The theory behind these machine learning models has

existed for a long time, but investors can only really take advantage of them now, as the necessary computational power has not been available before.

In other words, Bayesian machine learning gives us the ability to make optimal decisions in a world of uncertainty. That is why we have developed our AI-model.

In the next blog, we will dive more into what Bayesian machine learning is and why it gives us the opportunity to make optimal decisions in a world of uncertainty.

"Uncertainty is an uncomfortable position. But certainty is an absurd one."
- Voltaire

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