THE PRACTICAL SIDE: causal models for risk management and investing

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The development of causal models and discovery algorithms is considered a major scientific achievement. In the last five years the development of Generative Artificial Intelligence applications has created a surge of interest in causal modelling because it is hoped that causal modelling might make deep learning and other learning technologies more robust. However, there are interesting applications of causal models in business and finance.

This series of Executive Seminar sessions will discuss why causal models can be really useful in a number of business and financial applications. In this session we will look at risk management and investment management. We will discuss why causal models are useful and we will compare them with more classical tools.

Causal systems

First, a few important general considerations. We eschew discussing philosophical issues relative to causation. We assume that causation is not a law of nature, but it is a feature of some systems, either man-made or natural. A causal system is a system that can be controlled, that is a system where there is a causal relationship between one or more input variables and one or more output variables.

A variable X is said to have a causal effect on a variable Y if, after an arbitrary change of X there will be a corresponding change of Y, or of the probability distribution of Y, but not viceversa. Causation is an asymmetric relationship. Causation cannot be represented as functional dependence because it is asymmetric. An invertible functional relationship Y=f(X), X=g(Y) is not a causal relationship. Following the literature, we write a causal relationship as a structural equation: Y:=f(X) or Y:=f(X,e) if there is a random effect. A structural equation is not invertible.

The laws of physics are descriptive not causal: they describe the evolution of variables according to mathematical rules, in general differential equations. However, there are many causal systems. They can be engineered by human designers as systems that need to be controlled, or even designed by Nature.

A causal system is characterized by causal structural equations but also possibly by descriptive relationships. For example, a car is a causal system controlled by steering wheel, brakes and others eventual commands. But a car also obeys descriptive physical laws such as the laws of dynamics, thermodynamics, electromagnetism and also quantum mechanical effects.

In practice, there are many causal systems that are physical systems that obey physical laws whose internal structure allows to identify causal relationships. These systems are ubiquitous. From home appliances to power stations, from cars to planes there is a multitude of systems whose internal structure identifies causal relationships.

There are, however, other systems, including social systems, economies, financial systems, firms, that cannot be described by basic laws of nature plus structural descriptions. At least, this is the current situation. These “soft systems” are evolving complex systems. Thus far there is no way to represent these systems through axiomatic sets of equations. Mainstream

economics is an axiomatic system, but it describes an idealized economic system very far from reality. In practice, economists, investors and economic agents use a mix of global theoretical hypotheses and learning. The level of empirical validation of these theories is low in comparison with that of physical sciences. The question we want to discuss is whether causal models improve the level of validation and reliability of risk management and factor investing.

Causal models for financial risk management and investment management

In real life risk management is intended as a set of practices to reduce the possibility and severity of adverse events. For example, in sports, federations might constrain elements such as the type of figures that a gymnast can perform or the speed and power of cars. In hospitals there are strict rules to reduce the probability of errors, industrial processes are designed to reduce the probability of accidents and so on.

Financial risk management is a different enterprise. In finance, investors can only choose the assets in which they want to invest. In aggregate, investors have little possibility of reducing the source of risk. Policy changes might reduce the global risk but changing policies is generally beyond the reach of investors. Markets are self-referential, in the sense that decisions made by investors change the market itself. But, again, investors cannot really control self referentiality. For instance, large orders have an impact on market prices.

Risk management and investment management are really two faces of the same medal. Markowitz made it clear that investors should look for the optimal risk-return trade off given their risk appetite. Investors can achieve the optimal risk-returns trade off by choosing a portfolio of investment. The idea is that there is a portion of risk that the market does not remunerate because it can be eliminated by diversification, and a portion of ineliminable risk that can be redistributed among investors. In the last 50-60 years new assets specifically designed to create a specific risk-return profile have been added to the market. Options and a vast set of derivatives products are now available.

Investors perform causal actions. They have in input the forecasts of probability of returns and make decisions in function of their objectives. Investors face different uncertainties. First the uncertainty relative to the behavior of basic assets such as stocks and bonds, second the uncertainties relative to the behaviour of derivatives, third the cognitive biases of investors themselves. The uncertainty relative to the behavior of derivatives is double: uncertainty relative to the underlying plus uncertainty relative to the algorithms for computing the price of derivatives. Cognitive biases are programmed into algorithms to represent human behavior.

In principle, both investment and risk management are causal processes where a causal decision-making process is applied to make decisions based on fundamentally descriptive processes. A causal mechanism, that is, the investors' decision making process, is applied to descriptive models of prices and returns.

But reality is much more complicated. Making investment is not like piloting a plane. First, the investment decision-making process cannot be a clean optimization process. We have to consider investors' biases and the heuristics inevitable given the complexities of the optimization. But the real problems are the uncertainties due to forecasts. Forecasts are not well-established scientific processes. Many forecasts are based on learning processes that are based on associations.

The development of causal models and algorithms for discovering causal structures has raised the hope that at least a portion of the forecasting can be performed by causal models. There is no magic: causal models essentially select the most robust processes so that investors can hope to make decisions based on more reliable information. The key application of causal models both in investment and risk management is the selection and modelling of processes that can be considered causal processes even if there is no possibility of interventions.

Causal factors are an instance of these processes. Causal factors cannot be manipulated in practice. However, we assume that there is a causal mechanism that drive prices in function of factors. This is a stronger link than simple associations, that is correlations, that are prone to confounders, that is influences by exogenous variables.

One might ask why we need to switch to causal processes to improve the reliability of descriptive models. The reason is that we start from a joint probability distribution of random variables or from a covariance matrix. Causal models fit naturally into this descriptive framework. A more powerful purely descriptive set of equations would require switching to a dynamic descriptive framework. This is currently subject for research.

In summary

The critical importance of causal models for both investment and risk management is the discovery of true causal mechanisms that link variables as opposed to pure associations that might be critically dependent on the entire economic environment.

In our Executive Seminars we will discuss the discovery of causal mechanisms, be they causal factors or other variables, as a more robust learning process than usual estimation methods. The Seminar will be very practical, illustrated by examples created with TETRAD that can be easily reproduced by participants

The Practical Side Executive Seminar on Causal Modelling for Risk and Investment Management is designed and presented by Prof. Sergio Focardi, PhD.

It is an on-line seminar that lasts two hours.

The price of the seminar is 200 euros.

The seminar will be repeated three times:

December 13, 2024, from 17:00 to 19:00

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