RESEARCH & INNOVATION

HORIZON
The EU Research & Innovation Magazine

SOCIAL SCIENCES ICT

Cracking the maths behind the economy

16 October 2015

by Benedict O'Donnell

New models to forecast finance could help keep markets stable. Image credit: Shutterstock/ blackdogvfx

Omens of the 2008 financial crisis may have been all around us – we just did not know how to read them. Now, computer scientists, physicists and economists are studying the inner workings of complex networks to understand what went wrong and help stabilise tomorrow's financial markets.

'Macroeconomic models used by policymakers failed pretty badly during the crisis,' said Eric Beinhocker, executive director of the Institute for New Economic Thinking at Oxford University, UK. 'Key features like human psychology, contagion effects and the workings of the financial system were largely ignored. Many models didn't even have banks in them.'

As a response to this failure, in 2010 the European Union brought together researchers from a broad spectrum of disciplines to whip up new ideas on how to make sense of the world's increasingly complex economy.

The so-called Forecasting Financial Crises (FOC) project broke away from the traditional top-down simplifications of macroeconomics, which assume that human beings make rational choices and that differences in their behaviour average out over statistically representative samples.

Instead, it borrowed ideas from the emerging field of network science to produce a radical and entirely new model of the world economy built from the ground up. FOC's algorithms took into account individual households, companies and banks, studying their one-on-one relations to spot how chain reactions such as panic or debt contagion break out in the world economy.

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>
> *Prof. Guido Caldarelli, IMT Institute for Advanced Studies, Italy*

Network science is a comparatively young branch of mathematics that studies how the interaction between distinct elements gives rise to larger-scale trends. The field notably underpins the design of electricity grids, urban transport systems and computer networks.

According to Professor Guido Caldarelli, a theoretical physicist at the IMT Institute for Advanced Studies in Lucca, Italy, and coordinator of FOC, two networks may be very different in nature but still share enough similarities in how they behave for one network to offer insight into the inner workings of another.

For example, the study of rumours buzzing on the internet and of water seeping through rocks has recently shed light on feedback mechanisms in the earth's climate system, and on the containment of epidemics.

Prof. Caldarelli is part of a growing community of researchers who are now trying to use this approach to link the many markets, sectors and legal environments into a stack of parallel, interacting networks that can help make sense of how the economy ticks.

'The global financial market can also be seen as a network of networks,' he said. 'The challenge is that it has grown so interconnected that, while governments regulate their local jurisdiction, panic and insolvency can spread from all over the planet.'

Innovative mathematics

Network science is well suited to describe such intricate systems, but according to Prof. Caldarelli, addressing the complexity of financial markets will require innovative mathematics. He is busy developing more sophisticated calculation techniques to help understand multi-level complex systems, in a European project called MULTIPLEX.

In recent years, the European Union has funded over a dozen research projects on macroeconomic models that approach financial systems as complex, global networks of actors, several through its Global Systems Science initiative.

Oxford University's Eric Beinhocker is one of the leaders of one such project, called CRISIS, that is using bottom-up 'agent-based modelling' to simulate thousands of virtual households, firms and financial institutions in a more realistic way than traditional models. By taking into account individual behaviour and the network structure of financial systems, the models are designed to show how chain reactions in trading environments can spiral out of control and tip the system from stability to crisis.

'Our findings could help reduce the number and severity of financial crises in the future,' he said.

Members of the project are also developing a serious game out of the CRISIS model to offer policymakers and the public an online playground in which to field-test their own ideas on how to create a more robust financial system.

Investors and policymakers are taking interest in how network science is transforming the field of macroeconomics. Bottom-up models are already producing forecasts of systemic risk and the social impact of new legislation in ways that conventional, top-down theory never could, with results tending to offer a spectrum of expectation probabilities rather than a single categorical outcome.

Far from inconveniencing economists, this flexibility could nuance and complement expectations from top-down models. However, it won't be an overnight transformation, as the field has years of development and testing ahead of it before bottom-up macroeconomic models can be put to full use both for the design of new policies and the evaluation of existing ones.

In the meantime, the EU-funded MACROHIST project is concentrating on training a new generation of economists in the importance of an interdisciplinary approach, which takes into account history and context, rather than just narrow theoretical frameworks. It is bringing together some of the strongest history and economics departments in Europe to sensitise their graduate students to elements of politics, statistics and financial history.

According to Professor Marc Flandreau at the Graduate Institute in Geneva, Switzerland, who coordinates the project, a greater understanding of economic history will help a new generation of economists to think outside the box, so that mistakes from the past can help protect financial markets in the future.

He says there is a lesson that keeps getting lost and relearnt with every economic crisis: 'Stay on your guard, question everything and keep an open mind.'

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