"Simulation in Computational Finance and Economics: Tools and Emerging Applications."

Book Presentation

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Good evening. I am very pleased to be here tonight. I would like to thank the organizers of this event for the invitation and, on behalf of Banco de México, extend a warm welcome to all the participants that are here with us -in particular those that came from overseas- to share some of their insights, experiences, and knowledge.

The subject that occupies us today is the intersection of three fascinating disciplines, namely, simulation, computer science, and economics. They have all achieved impressive results; and have, jointly, got a lot of attention from academics, policy makers, and practitioners.

Having said that, as a way of introduction, let me first very briefly talk about the early stages of these three disciplines, and then I will talk more concretely about the book.

One can argue that simulation started in 1947 with the polish mathematician Stanislaw Ulam playing solitaire.[1] It occurred to him that by playing several times one could estimate the probability of various outcomes. After having access to one of the first computers, due to his participation in the Manhattan project, he realized that his approach could be implemented in practice. Mr. Ulam and his co-author, Nicolas Metropolis, published the first paper on the subject in 1949 and, thus, simulation was born, leading to an array of applications.[2]

Second, for many years any method that required several calculating steps was of no practical interest. In fact, it was not until computers were actually constructed that a systematic study of algorithms began. Computer science certainly includes

[1] As with many inventions and discoveries it is difficult to attribute them solely to one person. For instance, in this case, one can also think of Buffon's needle problem to estimate π in the 18th century as a prelude to simulation.
[2] The name Monte Carlo derives from the fact that Ulam's uncle went gambling to the casinos in that city.

areas such as programming, numerical analysis, and what has been called, for a lack of a better name, non-numerical analysis.[3] This last area refers to the study of algorithms, in terms of their efficiency and complexity. This discipline immediately brings to mind intellectual giants like Charles Babbage, Alan Turing, and Donald Knuth, to name only a few.[4]

Third, modern economics, which I am going to count as encompassing finance, was born with the well-known Scottish economist Adam Smith. Little did he know at the time about the different branches that would in due course develop from his brainchild.

In economic modeling, if one just considers the more general case and, in particular, the stochastic case, one is forced to leave the world of analytical closed solutions or, at times, is unable to solve the model at all. In this context, simulation in computational economics (and finance) lets us solve a greater set of models, which generally involve stochastic elements. In other words, with it, tractability for an important set of models has been and is being significantly extended.

Allow me now to present the book entitled: "Simulation in Computational Finance and Economics: Tools and Emerging Applications." It is divided into three sections, having a total of eighteen chapters. I will very briefly talk about each section and, in the interest of time, underscore a few selected chapters from each section. I apologize in advance to the authors of the papers that I will not be mentioning.

Payments systems are crucial to the conduct of monetary policy. In fact, in many cases, central banks have as an aim -by law- bringing about their adequate functioning.[5] They are -so to speak- the set of pipes and drains in the transmission of monetary policy. Thus, their study is of special interest to monetary economists and policy makers alike. There are several issues on payment systems one should be concerned about, from methodological to regulatory ones.

In this context, consider first the paper: "The use of simulations as an analytical tool for payments systems" by Martin Diehl. This is an excellent introduction to the material, explaining to the uninitiated reader in a straightforward way the use of simulations for payments systems. It lucidly compares the use of simulations vis-à-vis the use of analytical tools.

[3] Programming can be thought as the design, formulation, and execution of algorithms. Numerical analysis refers, loosely speaking, to the study of the behavior of numbers and operations in a computer.

[4] Babbage (1791 -1871) originated the concept of a programmable computer. Turing (1912 – 1954) is considered the father of computer science. Knuth (1938-?) can be considered the father of the analysis of algorithms.

[5] For example, part of Article 2 of the Banco de Mexico's Law states: "Serán también finalidades del Banco promover el sano desarrollo del sistema financiero y propiciar el buen funcionamiento de los sistemas de pagos."

As for the article “Preparing simulations in large value payment systems using historical data,” Heijmans and Heuver explain how the data associated to such systems could be used in the creation of stress scenarios. This study is aimed at the inexperienced researcher. In addition, it describes what can be called the best practices in the use of data in the simulation of large value payments systems.

In “Simulation Approaches to Risk, Efficiency, and Liquidity Usage in Payment Systems,” Laine, Korpinen, and Hellqvist propose the use of payment systems simulation as a regular activity in the analysis of payment systems’ stability. This is based on the fact that in modern economies nearly all the transactions are settled through payment systems. They consider key aspects in the study of payment systems such as: the liquidity usage by participants, the design mechanisms of liquidity requirements, and the identification of risks in payment systems. The authors are affiliated to an institution which has been a leader in the use of simulation in payment systems, the Bank of Finland.

In the article “Liquidity management in the Large Value Payment Systems (LVPS): need for an agent based model’s complex approach” Arciero and Picillo, make the case for the use of agent-based simulations to study complexity in the context of liquidity management for banks which interact in a LVPS. The authors highlight three areas in which agent based simulations are applicable, namely: i) the commercial banks’ strategies in a LVPS; ii) the design of LVPS, in particular, the evaluation of new and current policies; and, iii) the financial stability assessment of LVPS, as part of the financial infrastructure.

Finally, in this section, the article “Liquidity Saving in CHAPS (Clearing House Automated Payment System): A Simulation Study,” by McLafferty and Denbee, proposes a simulation methodology to assess the liquidity efficiency in the UK large payment system by the implementation of a Liquidity Saving Mechanism.[6] This type of simulations allows one to conduct experiments in policy variations, as part of a large payment system, to assess the extent to which a given change, in this case, the introduction of a Liquidity Saving Mechanism, might be economically beneficial.

In the second section, risk management is considered. This subject has a long and truly interesting history, perhaps starting with an epistolary exchange between a lawyer and a mathematician -Fermat and Pascal- on pricing a game with uncertain outcomes.[7] Nowadays, it encompasses a plethora of subjects.

Within this section, I would like to emphasize one article: “Systemic Risk, Stress Testing and Financial Contagion: Their Interaction and Measurement,” by

[6] The Clearing House Automated Payment System (CHAPS) is a sterling payments scheme that processes and settles both systemically important and time-dependent payments.
[7] For an interesting narrative on the topic see Bernstein, P.L. (1996). “Against the Gods, The Remarkable Story of Risk.” John Wiley and Sons, N.Y. For a translation of some of the actual letters see, for example, http://www.socsci.uci.edu/~bskyrms/bio/readings/pascal_fermat.pdf

Martínez, López and López. These authors present a network model for which a distribution of the losses for the banking system as a whole is obtained. It accounts for contagion and second round effects. Thus, they are able to estimate a plethora of risk measurements, in particular, those capturing systemic risk, as well as their dynamics.

More generally, network modeling has gained prominence in the area of systemic risk. It has deemed to be particularly suitable due to its flexibility and, in addition, the need to model complex phenomena. In effect, network models are akin to the structure some financial systems have. Thus, although in this type of models some elements are lost in terms of the incentives financial institutions face, it is their complex interaction -as captured by networks- that can potentially shed additional light on the properties of systemic risk and its propagation.

Agents based simulation is currently a popular modeling approach. It focuses on understanding the interaction's effects of many independent agents in a well-defined system. It has found applications in several subjects.

In my opinion two articles stand out.

First, consider the paper "Optimal Patent Design" by Brabazon. As economists we know the main justification for the existence of patents: to incentivize technological invention. Nonetheless, as the author himself claims, little is known regarding how patent policy affects the rate of technological advancement.[8]

In this context, relevant questions are the extent to which a patent holder should be given market power and for how long. A conventional answer is that these should be commensurate with the costs involved in the research process leading to the inventions. Nonetheless, empirical research in this area is difficult, as results are highly model-dependent and, particularly, because it is difficult to quantify the scope and protection across patents. In this context, this paper proposes an agents-based model which, by simulating, is capable of assessing various policies, and their impact on the rate of technical advancement.

The second paper, "Modeling the FX market Trader's Behavior," by Edward Tsang and Olsen, studies the collective behavior of foreign exchange traders using an agent-based model.

The study of foreign exchange markets using different approaches is essential, as it is nowadays widely recognized that much of their behavior in the short run is not completely explained by ordinary asset pricing models.[9]

[8] Additional relevant policies are subsidizes and preferential tax treatments for a company or individual involved in applied research. Furthermore, as known, basic research cannot be patented. Thus, governments typically provide generous resources to that end.

[9] As in the microstructure of foreign exchange markets literature, for example see Sarno, L. and Taylor, M. (2006). "The Economics of Exchange Rates." Cambridge University Press, U.K.

In effect, agents based models in some cases have more flexibility to capture more closely some of the features of the organization of FX markets, which are typically mute in more conventional models. Two features of these markets that are adequately captured by this type of models are: first, the fact that some of these markets are essentially decentralized and, second, accordingly, information is only sluggishly conveyed across market participants.

As for my final remarks, let me mention three points.

First, although these disciplines are interesting by themselves and intellectually challenging, at the end of the day they are only means to an end. They should allow us to have a better understanding of economic and financial phenomena. Thus, they should put us in a vantage point to design better policy and regulation, which, in turn, should provide us all with economic welfare.

Second, simulation in computational economics and finance is a very useful tool. Yet, it is in their complementarity that their usefulness increases. For instance, a network model is well served by supporting it with economic assumptions. In other words, it is in the interaction of these disciplines that one finds the cross-fertilization of ideas, which allows for a deeper and broader understanding of the challenging policy and regulatory difficulties we currently face.

Third, some have said that in the field of economics, well-established methods failed by not predicting and, perhaps, not preventing the crisis.[10] I beg to differ. I believe that most, if not all, of the phenomena that were conducive to the crisis, such as adverse selection, moral hazard, asymmetric information, mechanism design, price bubbles, herding behavior, liquidity risk, among many others, had been closely and intensely studied for quite a long time before the crisis. I think it was rather the misplaced belief in the markets' self-regulation capabilities, where externalities were known to exist that, to a great degree, sowed the seeds of the last global financial crisis. In effect, some members of the profession did raise their voices warning us of the incoming peril.

Without further ado, I applaud everyone for their efforts towards a better understanding of the subject and sharing your thoughts on the matter.

Thank you!

[10] For example, in the Motivation of the book, it says "In the field of economics, the application of simulation models has permeated slowly due to the preference of well-established methods over simulation, although these have failed to predict the recent financial crisis." (Page xvi).

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