Journal of
Applied & Computational Mathematics

Gomes, J Applied Computat Mathemat 2012, 1:4
DOI: 10.4172/2168-9679.1000e111

Editorial Open Access

Applied Mathematics and Economics: Tools for Addressing Rationality, Expectations and Related Phenomena

Orlando Gomes*

Lisbon Higher Institute of Accounting and Administration (ISCAL/IPL), Av. Miguel Bombarda 20, 1069-035 Lisbon, Portugal

Economics is a fascinating field of knowledge, essentially because it is capable of applying rigorous notions and tools from the exact sciences to the understanding of human behavior and of social relations, realities that clearly involve relevant traces of unpredictability. As a result, the economic science employs concepts that are unique to its own domain and that require a formal design that only mathematics can provide. These concepts include such powerful ideas as the ones of rationality or expectations. Traditional economic analysis makes use of a relatively simple benchmark model, according to which a representative agent resorts to all the available information in order to optimize her behavior. Typically, the agent maximizes expected consumption utility from the current period, t=0, to a pre-determined future date, subject to a resource constraint that can represent the way an individual household manages her budget or, alternatively, in a more broad view, the production possibilities frontier that the economy faces. The mentioned constraint takes the form of a differential equation or of a difference equation, depending on the notion of time that is more adequate to approach the problem under analysis.

A model as the one described in the previous paragraph is useful in addressing many economic issues and reveals the true nature of economics. Economics is a forward-looking science: it allows agents to take decisions today that have implications over a probably long horizon. In economics the past does not matter (costs incurred in previous time moments are sunk costs, which are irrelevant for current decisions). The focus on the future explains why expectations are of capital importance and why we need to base the analysis on some notion of rationality, since this is the only way to mitigate the underlying uncertainty of dealing with what is yet to happen.

The rational expectations revolution in economics [1-3] is one paradigmatic example of how the rigor of the exact sciences may assist economists in building the tools required to understand phenomena linked to human behavior in contexts of interaction. Under rational expectations agents are endowed with the ability to avoid systematic mistakes, what introduces a certain degree of predictability in their behavior.

Rational expectations have thrived in economic thinking because they correspond to an analytically tractable notion. But as the available mathematical tools have progressed, it became possible to sophisticate the way economists look at rationality and forecasting abilities of individuals and groups. Simon [4] has introduced the powerful concept of bounded rationality, allowing for a reinterpretation of many economic phenomena at the light of departures from full rational behavior. Rational expectations began to be addressed as a limit outcome of a process of information acquisition and learning [5,6] and the economic system started to be analyzed through a perspective less centered in the behavior of an average individual and more focused on the interactions that emerge within complex social networks [7].

Economics is today an extremely diversified science that makes use of multiple techniques that have emerged in many areas of knowledge. Methodologically, it always had a very deductive nature. Based on a series of strong assumptions on the behavior of individuals, this science was capable of developing models that explain relevant economic phenomena like economic growth, business cycles, effects of economic policy, unemployment dynamics, asset pricing or the market power of firms, just to cite a few. The way in which this progress was achieved has much to do with the modeling techniques that could be adapted from other fields as scientific knowledge evolved. Most of these tools have a mathematical nature.

As Stanley Jevons argued in his the Theory of Political Economy, in 1871, economics can only acquire and maintain a status of science if well founded in sound mathematical principles. It is precisely this path that the economic science has traveled in the last decades. Theoretical economics have today, at its disposal, a huge amount of mathematical tools to which it resorts to explain phenomena of the highest importance for the lives of those who need to take decisions and interact in a daily basis in order to improve their material well being. The cooperation between economics and mathematics is today stronger than ever, and it is probable that this link will become, in the future, even stronger.

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***Corresponding author:** Orlando Gomes, Lisbon Higher Institute of Accounting and Administration (ISCAL/IPL), Av. Miguel Bombarda 20, 1069-035 Lisbon, Portugal, E-mail: omgomes@iscal.ipl.pt

Received June 28, 2012; **Accepted** June 30, 2012; **Published** July 04, 2012

Citation: Gomes O (2012) Applied Mathematics and Economics: Tools for Addressing Rationality, Expectations and Related Phenomena. J Applied Computat Mathemat 1:e111. doi:10.4172/2168-9679.1000e111