# Neutrosophic applications in finance, economics and politics—a continuing bequest of knowledge by an exemplarily innovative mind

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It is not very common for a young PhD aspirant to select a topic for his dissertation that makes exploratory forays into a fledgling science — one that is still in the process of finding feet within the ramparts of academia. It would be considered a highly risky venture to say the least given that through his dissertation the PhD aspirant would need to not only convince his examiners on the merit of his own research on the topic but also present a strong case on behalf of the topic itself.

Sukanto Bhattacharya's doctoral thesis entitled "Utility, Rationality and Beyond — From Behavioral Finance to Informational Finance" not only succeeded in earning him a PhD degree but also went on to arguably become recognized as the first comprehensive published work of its kind on the application of neutrosophic logic in theoretical finance.

Bhattacharya postulated that when the long-term price of a market-traded derivative security (e.g. an exchange-traded option) is observed to deviate from the theoretical price; three possibilities should be considered:

(1) The theoretical pricing model is inadequate or inaccurate, which implies that the observed market price may very well be the true price of the derivative security, or

(2) A temporary upheaval has occurred in the market possibly triggered by psychological forces like mass cognitive dissonance that has pushed the market price "out of sync" with the theoretical price as the latter is based on the assumptions of rational economic behavior, or

(3) The nature of the deviation is indeterminate and could be either due to (1) or (2) or a mix of both (1) and (2) or is merely a random fluctuation with no apparent causal connection.

The systematic risk associated with transactions in financial markets is termed resolvable risk in Bhattacharya's dissertation. Since a financial market can only be as informationally efficient as the actual information it gets to process, if the information about the true price of the derivative security is misconstrued (perhaps due to an inadequate pricing model), the market cannot be expected to reconcile it just because it is operating at a certain level of informational efficiency.

Bhattacharya's statement that "financial markets can't be expected to pull jack-rabbits out of empty hats" beautifully encapsulates the neutrosophic element of market risk.

Bhattacharya coined the term irresolvable risk to represent the perceived risk resulting from the imprecision associated with decidedly irrational psycho-cognitive forces that subjectively interpret information and process the same in decision-making. He demonstrated that the neutrosophic probability of the true price of the derivative security being given by any theoretical pricing model is obtainable as $NP\ (H \bigcap M^C)$; where $NP$ stands for neutrosophic probability, $H = \{p : p$ is the true price determined by the theoretical pricing model $\}$, $M = \{p : p$ is the true option price determined by the prevailing market price $\}$ and the $C$ superscript is the complement operator.

Bhattacharya has since made significant contributions, either independently or collaboratively, to neutrosophic applications in various financial and economic problems ranging from financial fraud detection to portfolio choice and optimization.

However, arguably perhaps Bhattacharya's most significant contribution to the science of neutrosophy so far is the extension of the fuzzy game paradigm to a neutrosophic game paradigm and then successfully applying the same to model the vexing Israel-Palestine political problem, in collaboration with Florentin Smarandache—the father of neutrosophic logic.

Although he has written a few purely abstract pieces mainly on the forms of Smarandache geometries, Bhattacharya's major works are highly application-oriented and stand out in their brilliant innovation and real-world connection to business and the social sciences.

A bibliographical list of Bhattacharya's significant published works till date on neutrosophic applications in finance, economics and the social sciences is appended below:

[1] Bhattacharya S., Khoshnevisan M. and Smarandache F., Artificial intelligence and responsive optimization, Xiquan, Phoenix, U.S.A. (ISBN 1-931233-77-2), 2003. (Cited by International Statistical Institute in "Short Book Reviews", **23**(2003), No. 2, pp. 35.

[2] Bhattacharya S., Neutrosophic information fusion applied to the options market, Investment Management and Financial Innovations, **2**(2005), No. 1, pp. 139-145.

[3] Bhattacharya S., F. Smarandache and K. Kumar, Conditional probability of actually detecting a financial fraud-a neutrosophic extension to Benford's law, International Journal of Applied Mathematics, **17**(2005), No. 1, pp. 7-14.

[4] Bhattacharya S., Utility, Rationality and Beyond-From Behavioral Finance to Informational Finance, American Research Press, (ISBN 1-931233-85-3), 2005.

[5] Bhattacharya S., Smarandache F. and Khoshnevisan M., The Israel-Palestine question—A case for application of neutrosophic game theory", Octogon Mathematical Magazine, **14**(2006), No. 1, pp. 165-173.