World Academy of Science, Engineering and Technology
International Journal of Economics and Management Engineering
Vol:17, No:11, 2023

Fast Estimation of Fractional Process Parameters in Rough Financial Models Using Artificial Intelligence

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Abstract : The modeling practice of financial instruments has seen significant change over the last decade due to the recognition of time-dependent and stochastically changing correlations among the market prices or the prices and market characteristics. To represent this phenomenon, the Stochastic Correlation Process (SCP) has come to the fore in the joint modeling of prices, offering a more nuanced description of their interdependence. This approach has allowed for the attainment of realistic tail dependencies, highlighting that prices tend to synchronize more during intense or volatile trading periods, resulting in stronger correlations. Evidence in statistical literature suggests that, similarly to the volatility, the SCP of certain stock prices follows rough paths, which can be described using fractional differential equations. However, estimating parameters for these equations often involves complex and computation-intensive algorithms, creating a necessity for alternative solutions. In this regard, the Fractional Ornstein-Uhlenbeck (fOU) process from the family of fractional processes offers a promising path. We can effectively describe the rough SCP by utilizing certain transformations of the fOU. We employed neural networks to understand the behavior of these processes. We had to develop a fast algorithm to generate a valid and suitably large sample from the appropriate process to train the network. With an extensive training set, the neural network can estimate the process parameters accurately and efficiently. Although the initial focus was the fOU, the resulting model displayed broader applicability, thus paving the way for further investigation of other processes in the realm of financial mathematics. The utility of SCP extends beyond its immediate application. It also serves as a springboard for a deeper exploration of fractional processes and for extending existing models that use ordinary Wiener processes to fractional scenarios. In essence, deploying both SCP and fractional processes in financial models provides new, more accurate ways to depict market dynamics.

Keywords : fractional Ornstein-Uhlenbeck process, fractional stochastic processes, Heston model, neural networks, stochastic correlation, stochastic differential equations, stochastic volatility
Conference Title : ICMFE 2023 : International Conference on Mathematical Finance and Economics
Conference Location : New York, United States
Conference Dates : November 06-07, 2023