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Multi indicator approach via mathematical inference for price dynamics in information fusion context

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ABSTRACT

The modelling of financial market movements and the predictions of price are deeply linked to the complexity, non linearity and the dynamism of the market itself. Many hidden factors contribute to these two subjects, which refer to the different kinds of operators (as fundamentalist and behaviourist), the different objectives amongst the retails, the institutional and business operators, the different time ranges and the different allocation plans. Moreover, the news effects on shortest time range, the induced sentiment and market movers play a key role in the modelling of the financial market. Two decision variables, named Energy E and Entropy S are introduced. Some specific values of these two variables act as attractors in the state space E-S; conesequently these two variables are useful for describing the price dynamics during the different market status (i.e. up trend, down trend, accumulation, and distribution). The result is a new decision framework, where the investor, the trader and the analyst may perform their prospects and forecasts. A multi-parametric methodology for financial trading, investment and prospects analysis is defined and introduced, by following the Prospect Theory and by assuming the price fluctuations as a dynamical process in the stochastic context.

1. Introduction

According to the results in [10,17,19,25,48] with attention to very wide markets (i.e. Currencies, Metals and Commodities), the modelling of the Financial Market is a challenging and interesting task in Information Science. The market is an open complex dynamical system, composed by a high number of heterogeneous and interactive components. The components (i.e. the agents) operate with the aim of revenue, but with different motivations, different skills, different time ranges and driven by macroeconomic and fundamental parameters, including technical ones, news, methods, general sentiment, market mover decisions, and so on. The agents interact with markets, and consequently the price movements reflect the interactions. The complexity of this scenario explains why different approaches could be profitable at some times. In fact, while in [48] one finds a system adaptation framework for identifying stock market forces, in [24,25] one can see the news and the public mood effect on price movements. In [17,29] the authors demonstrate the power of using Soft Computing for modelling financial time series and market dynamics via fuzzy analysis, while in [2,9,11] the use of computational and artificial intelligence for modelling market dynamics is shown. In [31] the author uses a credibilistic entropy of the fuzzy returns to measure the portfolio risk, which inspires to use physical variables as entropy and energy in decision making. The above

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works just represent a small sample of the variety of approaches in literature. In addition, financial markets are neither affective nor predictable and will always exist as long as Finance will exists. These and other factors motivate our effort in proposing an innovative and effective model for decision making in Finance. The use of mathematical and computational models, together with methods and techniques for analysing and understanding financial time series, is a powerful and established practice. In Financial Computing, it is a fundamental aim among others to create conceptual and practical analysis tools. These tools serve to help and support agents to better understand and recognise market dynamics. As it is well known, Bachelier was the first pioneer to consider Brownian Motion to evaluate stock options during his Financial Mathematics studies. He considered fluctuations in the price, i.e. the price at the time $t-1$ plus some random change, in terms of Random Walks, in which the price variations were entirely independent from each others. Therefore, he formulated his price model based on various independent random variables. Nowadays, many works and studies start from the important assumption that the analysis of the price dynamics concerns a non periodic and non stationary process. As in other natural phenomena, we can consider the price dynamics of a financial instrument as a digital or quantum signal, composed of price levels at different sampling rates. From this perspective, volatility change is one of the most relevant questions to assess a good investment strategy. It is deeply studied in many works, starting from the analysis on the relation between the stock volatility and real and nominal macroeconomic volatility, economic activity, financial leverage and stock trading activity [36]. As reported in [3], other studies consider the relation between volume, volatility, and market depth. Volatility is one of most relevant parameters for trading strategies, while other studies focus their attention on price dynamics. These approaches are widely used in Econophysics, as in [15,28], where a detailed description of the Generalized Hurst exponent approach is introduced for investigating the scaling structure of financial time series. Moreover, in [32] several multifractal properties of equity returns are shown. While in [4,5] the prediction of currency pair trend, using forex indicator based on fractal market hypothesis, is considered. According to the work on the Prospect Theory of Kahneman and Tversky [21], a multiparametric model for decision making in trading context is introduced. Indeed, by taking into account Information Fusion techniques and starting from a parameter set (i.e. technical indicators named CSF), we build two discrete decision variables, E and S. These are conceptually comparable with energy and entropy. When the price moves into the plane E-S, these two variables describe different prospects; so that the investors may choose the best prospect according to their trading strategies and risk profiles. Moreover, one will see how some specific prices will act as global attractors. Consequently, the price tends to the attractors, or experiences strong repulsive effects. Since trading automation is a hotspot in the field of financial research, we studied and implemented many technical indicators, which gave us trading signals. The technical indicators and the trading signals implementation involve many research groups in Financial Computing (e.g. see [1,14,18,34,46,47]). Unfortunately, each technical indicator has its pros and cons. Consequently, single indicators usually produce false signals, which may result in large money loss. One of the main advantages of multiparametric analysis (obtained through the fusion of multiple technical indicators) is the noise reduction, i.e. the reduction of false signals. Assuming that each indicator reflects certain characteristics of the market movement, we are able to select an indicator from each class: price, volatility, price oscillation and volume. The development of a new modelling technique using optimized fuzzy sets through differential evolution, for the description of emergent and international financial markets is investigated in [17]. Indeed fuzzy sets and fuzzification processes are relevant for realising multiparametric information fusion systems (sometime with inhomogeneous parameters). Information Fusion (IF) is a relatively new research field [20]. It implies that the data coming from more than one source is finally merged together in order to obtain enriched information. This technique produces a richness of details; the data precision is greater than those which could be extracted from singular information. Consequently a high level of synthesis can be obtained through a methodological and non categorical reductionism. The Information Fusion is commonly considered as a multidisciplinary research field involving different research areas (i.e. Data Mining, Knowledge Discovery, Artificial Intelligence, and so on) and specific research communities (as reported in [13,42]). Not surprisingly, many definitions and terms are derived from the above research field. For instance, the military field was the first to appreciate and use its advantages (as described in [16,33,41,44]). In literature, scientists tend to make a distinction between low and high level fusion. Most of the research studies until now have dealt with the lowest level, such as elaboration of signals and multi sensor data fusion, whereas on a higher level, the field is still quite unexplored (see for example the work in [22] on methods and algorithm for managing uncertainty). In the multi sensor fusion research field, we can find the most relevant studies, where the combined information is captured by different sensors [27]. In financial markets, the price plays the role of signal coming from a sensor for the decision process. The literature proposes three possible levels of fusion [35]:

- Feature extraction level of fusion;
- Score level of fusion;
- Decision level of fusion.

As already noticed, a model that operates at the Score Level Fusion was proposed. Additionally, we normalised and used a fuzzy process to achieve the indicator homogenization before one performs the data fusion and to build the decision variables. Our fusion strategy belongs to JDL Data Fusion Model, widely described in [26,38,39,41] as a revision of the original version. The JDL Model aims at (as described in [37]):

- Giving a point of reference for discussions about IF;
- Making it easier to understand problems for which IF techniques can be used;
- Standardising the characteristics of problems linked to the fusion process;