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Forecasting price movements using technical indicators: Investigating the impact of varying input window length

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ABSTRACT

The creation of a predictive system that correctly forecasts future changes of a stock price is crucial for investment management and algorithmic trading. The use of technical analysis for financial forecasting has been successfully employed by many researchers. Input window length is a time frame parameter required to be set when calculating many technical indicators. This study explores how the performance of the predictive system depends on a combination of a forecast horizon and an input window length for forecasting variable horizons. Technical indicators are used as input features for machine learning algorithms to forecast future directions of stock price movements. The dataset consists of ten years daily price time series for fifty stocks. The highest prediction performance is observed when the input window length is approximately equal to the forecast horizon. This novel pattern is studied using multiple performance metrics: prediction accuracy, winning rate, return per trade and Sharpe ratio.

1. Introduction

Analysis and accurate forecasts of stock markets become increasingly more challenging and advantageous [1]. Globalization of the economy continuously requires innovations in the field of computational science and information technologies. Financial forecasting is often based on computational intelligence techniques that can analyse large amounts of data and extract meaningful information [2]. A predictive system that is able to forecast the direction of a stock price movement helps investors to make appropriate decisions, improves profitability and hence decreases possible losses. Forecasting of the stock market prices and their directional changes plays an important role in financial decision making, investment management and algorithmic trading.

Financial forecasting based on computational intelligence approaches often uses technical analysis (TA) to form features used as inputs to the approaches. Time series of stock price and trading volume are utilised to compute a technical indicator (TI) where a composition of open, low, high and close price values and volume size is taken over a certain time period. As reported by Atsalakis and Valavanis [2], approximately 20% of the financial market forecasting approaches use TIs as input features. In order to compute TIs, their parameters are required to be set. Every time a new predictive system is developed, its creators select a number of indicators suitable for their purposes and then choose appropriate parameters values to calculate them. The selection of indicators suitable for forming the input features and the choice of their parameters remains an area of active research. In order to overcome difficulties such as determining optimal combinations of indicators or tuning their parameters several efforts have been made [3,4]. However, there is no sophisticated well-established technique that allows the system's developers to easily select appropriate parameters. To date, the dependency of a predictive system performance on a forecast horizon and indicator parameters has not been fully investigated. To the best of our knowledge, there is no existing research investigating the relationship between the forecast horizon and the time frame used to calculate TIs. However, every researcher that is developing a financial forecasting system based on TA faces the problem of selecting appropriate values of parameters for the chosen TIs.

The current research sheds light on this topic and studies how the performance of a predictive financial system based on TA changes when the forecast horizon is intended for prediction and a time frame is varied for computing TIs. Time period used to

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calculate TIs is required to be set prior to the calculation. Later in this paper this time period will be referred as the input window length of an indicator. The paper investigates the dependency of the forecasting system performance on the combination of the input window length and the forecast horizon, and searches for the optimal combination of these parameters that maximizes the performance of the predictive system when predicting the direction of a price movement. A previously undiscovered pattern is revealed in the current study: for each horizon the highest prediction performance is reached when the input window length is approximately equal to the horizon. Sets of reasonable values of forecast horizons and input window lengths are selected for analysis. Three well-established machine learning approaches, Support Vector Machines (SVM), Artificial Neural Networks (ANN) and *k*-Nearest Neighbours (*k*NN), are utilized to forecast directions of future price movements. The presented research studies the relationship between the forecast horizon and the input window length utilising different performance measures that demonstrate that the observed pattern persists over a number of metrics. The prediction accuracy describes how good the developed prediction system is for the defined task. Return per trade, Sharpe ratio and winning rate characterize the prediction system from a trading point of view. These measures provide information about the potential profitability of the system and help evaluate the relationship between two examined parameters. The discovered pattern enables researchers to go for a simple solution when selecting an input window length for a specific forecast horizon. This pattern can be used to initialise the input window length for all TIs and then a separate approach can be used to adjust this parameter for each indicator by varying its value. Taking into account the popularity of the TIs, this research explores meaningful empirical rules, which should be considered when creating a predictive system based on TA.

The remainder of the paper is organized as follows. A theoretical background to financial forecasting is reviewed in Section 2 and related work is discussed in Section 3. Section 4 describes the raw dataset used, data pre-processing and data points labelling procedures. Section 5 provides details about the calculation of technical indicators, experimental model, parameter settings and employed algorithms. Section 6 discusses the obtained results and key findings. Finally, Section 7 concludes the paper and outlines directions for future research.

2. Market theories and trading philosophies

The efficient markets hypothesis (EMH) of Fama [5] is based on the idea that all the information available is continuously processed by the market and is embedded into asset prices which results in the instant assimilation of any piece of new information at any given point in time. There are three levels of market efficiency, strong, semi-strong and weak, defined by Fama's theory. The weak level claims that present market prices reflect all historical publicly available information. The semi-strong form of the EMH assumes that prices of the traded stocks already integrated and absorbed all the historical and present public information. The strong EMH supposes that even insider and latent information is immediately incorporated in a market price. The fundamentals of the EMH postulate that all historical, general and private information about an asset is embodied into its current price and that it is not possible to systematically outperform the market. In the Random Walk Theory, stock price fluctuations are inter independent and follow the same distribution. Consequently, historical information about an asset price has no correlation with its future movements and cannot be used for predictions. Conforming to this theory, a random walk is the most probable way the asset price moves, and accurate predictions are not feasible.

The question about market efficiency with respect to its extent and applicability to different markets remains an active and ongoing area of research where contradictory results are present. Recently researchers have proposed a counter-theory named Adaptive Market Hypothesis (AMH) in an attempt to align the EMH with behavioural finance [6]. Behavioural finance looks at the market price as a purely perceived value instead of a derivative of its costs. Market agents have cognitive biases including overreaction, overconfidence, information bias and representative bias, which implies that many human errors in information processing and reasoning can be predictable [7]. A comprehensive empirical study on the AMH is conducted in [8] where three of the most developed markets are examined: the UK, US and Japanese stock markets. The authors used long run data and formed five-yearly subsamples subject to linear and non-linear tests to distinguish various behaviours of stock returns over time. The results from linear tests reveal that each stock market provides evidence of being an adaptive market where returns are going through periods of dependence and independence. Non-linear tests reveal strong dependence for each market in every subsample although the magnitude of the dependence varies considerably. The overall results strongly suggest that the AMH describes the behaviour of stock returns better than the EMH.

According to the results of recent research [2], financial markets do not exhibit random behaviour and it is possible to forecast market changes. In the trading world, two major trading philosophies exist. A fundamental trading philosophy focuses on the analysis of the financial state of an entity that is determined through economic indicators. It studies the factors that influence supply and demand. The decisions are made based on the performance of the company, its competitors, industry, sector and general economy. The economic indicators taken into account include company's economic growth, earnings, debt level and return on equity as well as unemployment and inflation rates. On the contrary TA utilizes historical data to forecast future behaviour of an asset price. TA is based on the idea that the behaviour of preceding investors and traders is often repeated by the subsequent ones. It is supposed that profitable opportunities can be disclosed through computing the averaged movements of the historical time series of price and volume and comparing them against their current values. It is also believed that some psychological price barriers exist and their observation can lead to profitable strategies. TIs help the traders to estimate whether the observed trend is weak or strong or whether a stock is overbought or oversold. Traders have developed many TIs such as moving average (MA), rate of change (ROC), relative strength index (RSI), oscillators, etc. A comprehensive analysis of technical trading strategies and their performance is presented in [9]. The authors separate the studies into early studies (1960–1987) and modern studies (1988–2004). Early studies feature several limitations in the testing procedure, and their results differ from market to market. Modern studies are enhanced in relation to the limitations of early studies, and in most cases (approximately 60%) the profitability of technical trading strategies is affirmed. Mixed results are presented in approximately 20% of studies, whereas the rest demonstrate negative results and reject the usefulness of technical analysis. More recent studies show that the market predictability depends on business cycles and the performance of trading rules based on TA varies in time and depends on the financial markets conditions [10,11]. Lately TIs have become extensively used as input features in machine learning based financial forecasting systems [2]. These systems learn to recognize complex patterns in market data and forecast future behaviours of an asset price. In this study, TA is employed to form input features for machine learning techniques, and the importance of the time frame used to compute the indicators is examined.