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Heuristic learning in intraday trading under uncertainty ☆

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ABSTRACT

Until recently economists focused on structural models that were constrained by a lack of high-frequency data and theoretical deficiencies. Little academic research has been invested in actually trying to build successful real-time trading models for the high-frequency foreign exchange market, which is characterized by inherent complexity and heterogeneity. The present work opens new directions for inference on market efficiency in an attempt to account for the use of technical analysis by practitioners over many years now. This paper presents a heuristic model that efficiently emulates the dynamic learning of intraday traders. The proposed setup incorporates agent beliefs, preferences and expectations while it integrates the calibration of technical rules by means of adaptive training. The study focuses on EUR/USD which is the most liquid and widely traded currency pair. The data consist of a very large tick-by-tick sample of bid and ask prices covering many trading periods to enhance robustness in the results. The efficiency of a technical trading strategy based on the proposed model is investigated in terms of directional predictability. The heuristic learning system is compared against many non-linear models, a random walk and a buy & hold strategy. Based on statistical testing it is shown that, with the inclusion of transaction costs, the profitability of the new model is consistently superior. These findings provide evidence of technical predictability under incomplete information and can be justified by invoking the existence of heterogeneity caused by many factors affecting market microstructure. Overall, the results suggest that the proposed model can be used to improve upon traditional technical analysis approaches.

1. Introduction

In conventional economics, markets are assumed to be efficient if all available information is reflected in current market prices. The efficient market hypothesis (EMH) assumes that markets are populated with rational agents and in the absence of transaction costs the market price fully reflects all available information (Fama, 1991). EMH offered a way to test predictions on real world markets, by identifying three sources of information, corresponding to three degrees of informational efficiency that can be tested separately, namely the weak, semi-strong, and strong-form efficiency. The EMH was supported during the late 1960s by a large body of empirical

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works mostly based on daily frequency data. The proposed market pricing models were random walks, Brownian motion or more general Lèvy processes. However, it proved to be debatable whether any observed departure from market efficiency was due to genuine market inefficiency or whether pricing model deficiencies caused a divergence between actual and theoretical prices. Moreover, the non-predictability doctrine of the EMH was based on the additional assumptions that news and events hitting the market are normally distributed, and that markets are composed of homogeneous agents. More recent works, questioned the validity of EMH (Dacorogna et al., 2001; LeBaron, 1996). Instead of assuming a homogenous market, in which all agents interpret and react to the news in the same way, a heterogeneous market is proposed where agents act in different time horizons and in differing ways. Liu et al. (1999) and Cont (2001) suggested that random walk models are unable to explain properties of real world markets such as volatility clustering and extreme correlations. Gouree and Hommes (2000) and Kurz (1994) present new evidence that all market agents have in fact bounded rationality. Similar conclusions are reached by Farmer and Lo (1999) in their discussion of market efficiency. They base their analysis on a comparison with the evolution of ecological systems. Farmer (1998) develops a market model inspired by ecological systems that contains agents with various trading strategies. Eventually, Vernon Smith and Daniel Kahneman were awarded the 2002 Nobel Prize in behavioral economics suggesting that human psychology, not always rational, is intertwined with price processes.

Heterogeneity in expectations can lead to market instability and complicated dynamics of prices, which are driven by endogenous market forces. Boundedly rational agents using simple rules-of-thumb for their decisions, provide a more realistic description of human behavior than perfect rationality with optimal decision rules. Instead, according to the EMH, fully rational agents are considered the driving forces of markets, which in turn operate in a way to aggregate and process the beliefs and demands of traders reflecting all available information. Opponents of the EMH e.g., La Porta et al. (1997) and Shiller (2002) argued that predictability reflects the psychological factors and "fads" of irrational investors in speculative markets. This irrational behavior was emphasized by Black (1986) and Shleifer and Summers (1990) in their exposition of noise traders who are described as acting on the basis of imperfect information and consequently cause prices to deviate from their equilibrium values.[4] Moreover, Black claimed that noise traders play a useful role in promoting market liquidity. More theoretical work on financial markets with heterogeneous agents has also gained an important momentum in the literature. Specifically, Brock and Kleidon (1992) show how bid–ask spreads fluctuate over the day by firm size categories as a measure of "thickness" of the market. Brock and Hommes (1997) build a general theory of expectation formation that nests rational expectations in an econometrically tractable system. Hommes (2000) offers a review of recent work on heterogeneous agent financial theory. While there are many ways to describe heterogeneous expectations the most promising approach seems to differentiate the expectations according to time dimension or time scale of the market participants. In fact any differences in planning horizons, trading frequency or institutional constraints are neglected in the rational context of the EMH. The work of Lux and Marchesi (1999) on agent based models revealed that the interaction of agents with different trading/investment horizons gives rise to certain properties such as volatility clusters, trend persistence, fat tails and scaling laws, thus reproducing most of the empirical regularities observed in the financial markets.

Shiller (1989) argues that most participants in financial markets are not "smart" — following the rational expectations model — but rather follow trends and fashions. However, variation over time in expected returns poses a challenge for asset pricing theory because it requires an explicit dynamic theory in contrast to the traditional static capital asset pricing model (CAPM). Interestingly, recent studies provide evidence that price movements of financial assets for short and medium-term horizons are to some extent predictable. It is shown by Gençay et al. (2002, 2003) and Pictet et al. (1992) that financial returns substantially depart from the random walk model and can be predicted with some success. Real-time trading models, for instance, have been proven relatively successful in capturing the inefficiencies of the currency or stock market. New evidence on the stylized facts of financial markets reveals long periods of apparent price inertia which give the impression of predictability, yet with sudden violent interruptions. At the same time markets present anti-persistent features with ultra-fast mean price reversions, which seem unpredictable but actually fluctuate within limited trading ranges with a gradual adjustment to new market equilibria.

The EMH was probably never conceived for short trading horizons and high-frequency markets, as it takes an unrealistic view of market response to new information. It is reasonable to assume that the markets need a finite time to adjust to any information as opposed to instantaneous integration of new price information according to the EMH. Specifically, the contradictions and inconsistencies of the EMH regarding the stylized facts of high-frequency financial data cannot be explained by conventional econometric modeling and the Markowitz mean–variance framework. Short or long-term traders and decision makers, treasurers and central bankers, interpret the same information differently.[5] In addition, new technology now enables efficient information flow, optimal identification of trading opportunities while it also contributes to higher market volume and liquidity. The improved liquidity also introduces a shift in perspective, with agents starting to focus on short-term trading horizons and higher trading frequencies.

Until recently economists focused on structural models that were constrained by a lack of high-frequency data and theoretical shortcomings. In this work an attempt is made towards predicting short-term price movements in particular for the high-frequency currency market, which has the highest volume of all financial markets. There is a growing body of literature on intraday foreign exchange markets, which comprises short-term transactions from traders of various geographical locations, with different time-horizons, risk-profiles, or regulatory constraints. Structural economic models have been utilized to test various forms of market efficiency in currency markets (Baillie and McMahon, 1989; MacDonald and Taylor, 1992). Meese and Rogoff (1983) carried out the first comprehensive out-of-sample forecasting studies of these models for exchange rates. However, the absence of any theory for the short-term movements of the foreign exchange rates makes the structural models irrelevant for these horizons. An approach based on

[4] Arbitrageurs are also assumed to dilute a minor part of these shifts in prices, yet the major component of deviation is tradable.
[5] This might be due to agents utilizing variant heterogeneous priors, as reported in Morris (1996).