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# Exploring the dynamics of financial markets: from stock prices to strategy returns

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ABSTRACT

Exploring the dynamics of financial time-series is an exciting and interesting challenge because of the many truly complex interactions that underly the price formation process. In this contribution we describe some of the anomalous statistical features of such time-series and review models of the price dynamics both across time and across the universe of stocks. In particular we discuss a non-Gaussian statistical feedback process of stock returns which we have developed over the past years with the particular application of option pricing. We then discuss a cooperative model for the correlations of stock dynamics which has its roots in the field of synergetics, where numerical simulations and comparisons with real data are presented. Finally we present summarized results of an empirical analysis probing the dynamics of actual trading strategy return streams.

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## 1. Introduction

To set the stage of this paper, let us begin by taking a look at the big picture of financial markets and how traders interact with them. This is clearly an extremely interesting dynamical system which we sketch in Fig. 1. The dynamics of the stock markets themselves can be seen as the result of a complex joint stochastic process across time (yielding non-stationary, stochastic time series properties) and across stocks (with complex correlation dynamics), in conjunction with the effect of external news and fundamental information that affects the system. The price formation process of a publicly traded asset is the product of a multitude of evasive interactions. Individuals around the globe post orders to buy or sell a particular stock at a particular price. Transactions are cleared at a certain price at a given time, either by passing through the hands of a specialist on the trading floor, or nowadays increasingly automatically on the many electronic exchanges which have sprouted in recent years. Apart from fundamental properties of the company whose stock is being traded, factors such as supply and demand affect the price of stocks, as well as general trends in the particular industry in question. Stock specific events, such as mergers and acquisitions, have a big impact, as do world events, such as wars, terrorist attacks, and natural disasters. An example of this are the dramatic events seen in 2007 and 2008 which are perhaps due to fundamental flaws in our credit-based economy. The recent European debt crisis and the Chinese sell-out are other examples. Most publicly traded assets also have related derivative markets, with more or less complicated payout structures depending on the form of the derivative asset. These include for example futures markets (contract to buy an instrument at a specified price with delivery date in the future) and options markers. Options are traded instruments that give the right, not the obligation, to buy a stock at a later date at a certain price, called the strike price. The pricing of options depends on the price and volatility dynamics of the underlying instrument, and we shall review some ideas on this topic in Section 4.

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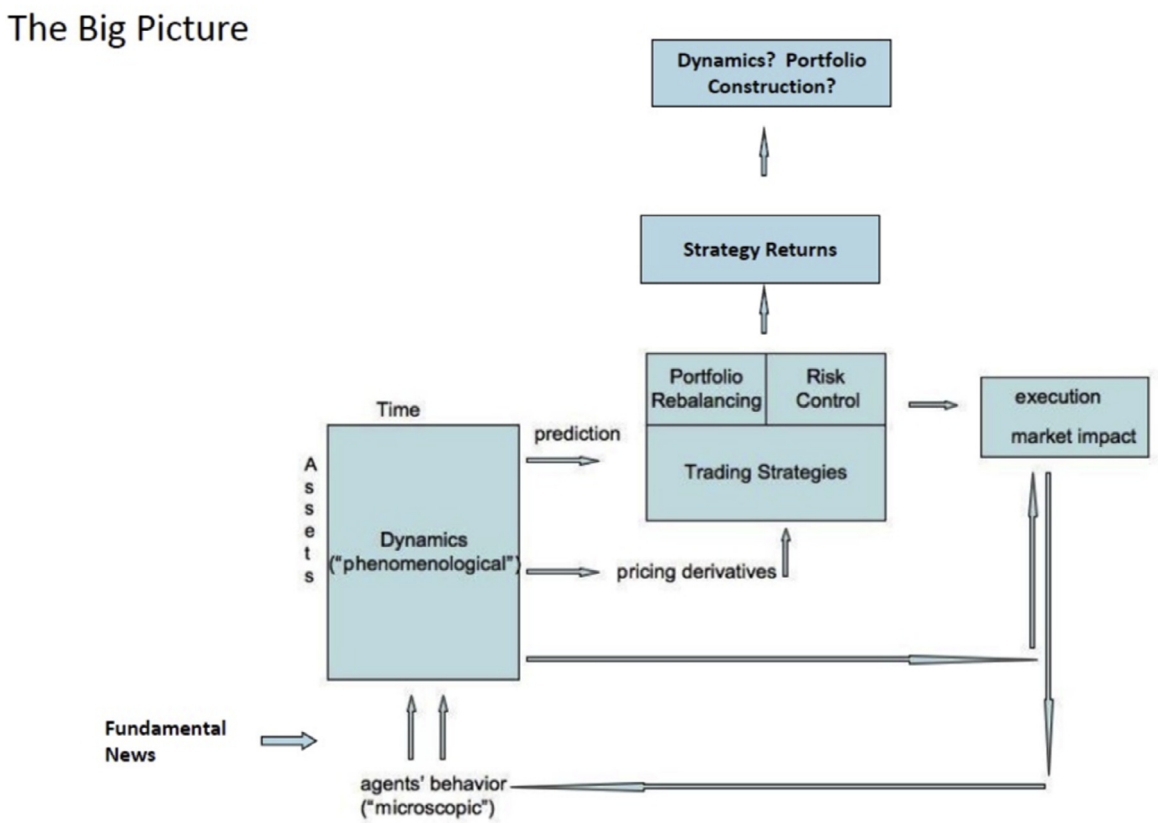


**Fig. 1.** The big picture: complex feed back loops in financial markets.

Stocks are traded for the most part on a central limit order book, such as the New York Stock Exchange. Modeling the intricate dynamics and micro-structure of this order book is a field of study which has gotten some traction in recent years [1,6,19]. When comparing to physics, that level of description can be seen as the microscopic level. However, it is often more tractable to use a meso-scopic description which aims at describing the price process as a stochastic Langevin equation where the key feature is how to capture the volatility, or noise, that drives the process. This is the most important effect since stock price changes (or returns) form moment to moment are essentially unpredictable so the deterministic part of the equation is less interesting (though of course, if you can predict it ever so slightly then you might become quite wealthy!) In fact, some successful hedge funds and traders mange to do just that. They spend a lot of time analyzing the dynamics and fundamental relationships driving the markets; Some then use this information to predict the expected future movement in prices, and will take this prediction into account while maintaining an (ideally) well-managed portfolio from a risk perspective. As the predictions or market conditions change the portfolio needs to be rebalanced to achieve the desired positions, hence the trader will need to periodically execute buy and sell orders in the market. This in turn can affect the market. For example if an enormous buy order is dumped into the market all at once, chances are the price will go up temporarily as a consequence, to the extent that it will end up costing more to buy the entire desired amount of the instrument. To this end, a lot of attention is paid to the actual execution tactics, given current market conditions and liquidity, the time over which one wants the order to be filled and so on. A recent interesting body of literature (pertaining to Hawkes models see e.g., [1]) discusses optimal execution strategies and market impact in an intuitive and thorough theoretical framework. Furthermore of course, at any given time, a multitude of similar traders (or "agents") are all acting simultaneously in the market, all with their own views on the future price, unique optimal portfolios, risk concerns and so on. The actions of all these market participants constitute complex feed back loops that ultimately drive the dynamics of the markets.

In addition, the return streams of trading strategies are increasingly offered out as investable instruments via hedge funds, managed accounts or ETFs for example. From the point of view of an investor then, the universe of investable instruments opens up from the underlying instruments themselves to include the return streams of trading strategies. Consequently, it would be interesting to be able to analyze the dynamics of trading strategies themselves. In contrast to the well studied universe of the underlyings (stocks, commodities and so on), not a whole lot is known here. This type of data is not easily come by and if it is, is often quite a biased sample. In unpublished work we analyzed two sets of proprietary data (presented at Quant Con

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