How can the fundamental structure of the stock market be utilized to predict market price fluctuations?

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Abstract:

Understanding the fundamental structure of chaotic, dynamic systems, such as the stock market, can facilitate tremendous steps forward in the field of chaos theory. In this paper, I investigate how one can utilize the fundamental structure of the stock market to predict market price fluctuations. This paper indicates a new framework for forecasting market price adjustments by using emergent intelligence and the true perceived security value (TPSV) of a stock. I conclude that the stock market is a dynamic, closed-loop discussion between investors, where the TPSV of a stock emerges from the market price trends. By using the TPSV, investors can identify if a stock is over or undervalued by the majority, allowing them to anticipate stock price adjustments using the fundamental analysis technique over a short time frame. To prove this theory, one would need to develop a program that produces the TPSV over different periods of time, on a multitude of stocks, to observe which value, if any, allows one to accurately predict stock price fluctuations.

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Introduction:

There are more atoms in the atmosphere than there are stars in the universe. Each particle is a cog in the system that manifests our climate. Although fully understanding the core principles of our atmosphere could drastically improve our weather forecasts, allowing better preparation for natural disasters, without knowing their initial position, momentum and the various forces acting upon them, understanding our atmospheric conditions enough to form dependable, long term weather predictions is virtually impossible. Similar to our climate, the stock market is a chaotic, dynamic system, where accurately predicting market price fluctuations could yield considerable advantages. There are infinite factors that affect the market price, making accurate predictions to nearly impossible.

Thousands of investors gamble their earnings, pouring their fortunes into this capricious system with the hope that their stock prediction model yields the perfect output. Similar to weather forecasting models, devices used to foresee stock price fluctuations hold some value but are limited in their capabilities. Without truly understanding the fundamental structure behind these seemingly random systems, consistently accurate forecasting is futile, but one prediction method may prove to carry great promise. Theoretically, market price fluctuations can be predicted by utilizing the stock market's swarm intelligence foundation to generate the true perceived security value of a stock.

Historical Context and Background:

Stocks are exchanged for monetary expansion and partial ownership in a given company. There are two ways for an investor to prosper financially, dividends and capital gains. Dividends are a portion of a company's earnings allocated to shareholders, while capital gains are the increases of a stock's market price over the period of ownership. Capital gains are the primary source of investor earnings (Evans 2-5).

The fundamental investment objective is to purchase shares of a stock while the price is low and sell when the price is high, an idea that stems from the principles of supply and demand (Evans). Figure 1 represents a basic supply and demand curve produced by Gary R. Evans that demonstrates Intel's (INTC) stock. The two lines in figure 1 represent the relationship between the price people are willing to pay for a share, and the price that shareholders are willing to sell for at any given time (Evans 2-5). The point of equilibrium, the intersection between the two lines, is equivalent to the market price.

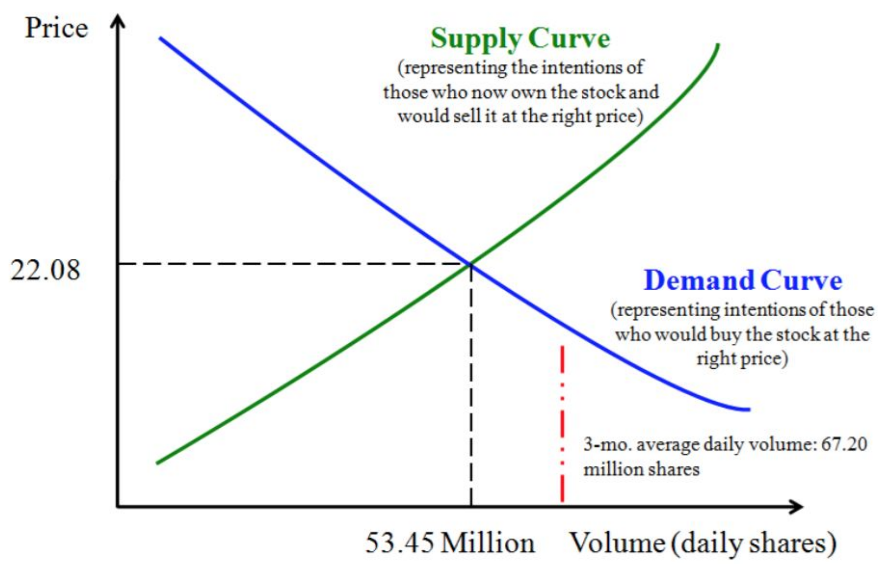

Figure 1 - "Hypothetical Supply and Demand Curves for INTC (Intel) Stock and end of trading day, June 2, 201." Evans, Gary. *Figure 1*. 9 Sept. 2012.

The market price emerges from a behind the scenes negotiation that occurs between shareholders and interested parties. Investors use a trading data processing unit, a program capable of communicating on the trading platform, to buy stock. Using an order form, the purchaser establishes their highest and lowest bids, the number of shares they anticipate, and which stock they want. Next the form is sent to the trading platform where it is marked with a timestamp and stored until it meets a matching sell form.

A sell form contains similar information to the order form: price willing to sell at (minimum and maximum), number of shares, and the stock is being sold. Upon completion, the sell form is transferred to the trading platform. Here it goes down the line of order forms in a chronological succession until it meets an order form displaying an offer within the range of their sell price (Gunzinger et al.). At this point the transaction is completed for the number of shares applicable. This transaction rate is equal to both the market price of a stock and the equilibrium point (Evans 2-5).

Figure 2 illustrates a hypothetical supply and demand shift that would occur if Intel were to publicize information that made their stock more desirable. As demonstrated, the release would have raised the perceived value, evoked investor sentiment, and ultimately elevated the point of equilibrium and the market price (Evans 2). Moreover, the desirability of a stock drives the market price, where changes in demand result in market price fluctuations.

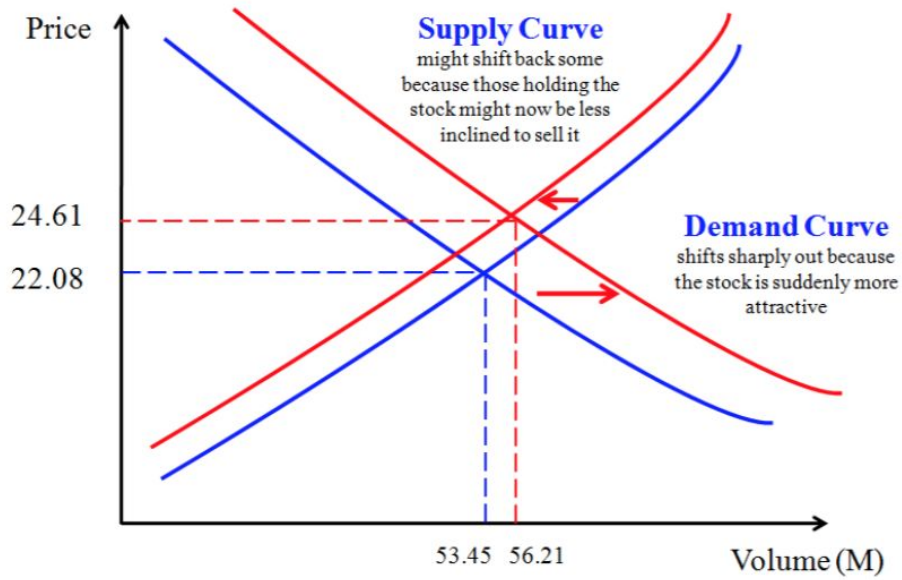

Figure 2 - Demonstrates a hypothetical supply and demand curve shift (red to blue) that could occur if INTC surprised the market with positive news. Evans, Gary. *Figure 1*. 9 Sept. 2012.

Research And Analysis:

Understanding that investor sentiment drives the market price of a stock, makes it intuitive to wonder what causes demand to fluctuate? There are currently three main hypotheses fueling investment decisions that are consequently responsible for stock apeal fluctuations: charting, fundamental analysis, and the Efficient Market Hypothesis (EMH).

Charting is a technique based upon the idea that history repeats itself. Investors watch stock charts, figures demonstrating the stock price over time, in an attempt to identify patterns. True chartists consider external factors influencing the market price, such as a company's earnings, to be irrelevant. Chartists believe that they will detect the next fluctuation based solely on past investment behavior (Fama 75).

Fundamental analysis revolves around the concept of perceived security value. In this theory, there are two values put on a stock. The first is the market price determined by the equilibrium point. The second is the perceived security value, the intrinsic value of a company divided by the number of shares. Fundamental analysts calculate the security value and then make investment decisions based on how it relates to the market price (Fama 75).

For example, if an investor determines that the perceived security value of a specific stock is $100 but the current market price is $40, they are going to classify the stock as undervalued. Fundamental analysts will then buy shares of this stock, based on the assumption that other investors will also purchase shares (Glasner 1; Murphy; Scott). Demand is going to rise due to the number of investors willing to purchase shares at that price, resulting in an elevation of the point of equilibrium, and in turn, the market price (Evans 2). Chartists will then identify the trend and hop on the bandwagon driving the price up further (Fama 75). If a stock is overvalued, this process can be repeated (Scott). In other words, if a majority of investors identify a stock's security value as above or below the market price, it directly affects investor sentiment and the market price. Moreover, in fundamental analysis, perceived security value drives both the investor decisions and ultimately, the overall market demand.

The Efficient Market Hypothesis (EMH) argues that the true security value of a stock is equal to the market price at any given moment, making stock market fluctuations a random process. Investors are continuously adjusting their interpretation of a stock's true security value and making investment decisions based on changes in that value. In doing this, the investors directly influence the market price. Furthermore, people who believe the EMH conclude that the current market prices account for all past and predicted events, but "in an uncertain world [like ours] the intrinsic security value can never be determined exactly," thus"...the actions of the many competing participants should cause the actual price of security to wander randomly" (Fama 76). The EMH, which proposes that market prices fluctuate randomly, directly contradicts the charting hypothesis that is based on behavioral history. That being said, both fundamental analysis and EMH revolve around security value (Fama 2).

Experts find that fundamental analysis is the superior hypothesis. The EMH does not account for the over and undervaluation of stocks by using the idea of *perceived security value* (as in the fundamental analysis theory), instead investment decisions are based around the *true security value.* Perceived security value is the worth of a security in the eyes of the majority, while true security value is the actual worth of the security. One of the most cited examples of this occurs when uncertainty enters the market. For example, if the release of a new product hits the market, there is an instantaneous market price adjustment, but "because there is vagueness or uncertainty surrounding new information… actual prices will initially over adjust to changes in intrinsic values as often as they will underadjust" (Fama 76). As time goes on, the stock price will eventually re-calibrate itself, a phenomenon referred to as Bayes' rule "which describes how rational agents update their beliefs after receiving new information" (Pastor 2). Thus, during these periods of instantaneous adjustment, the market price and the true security value will not be equivalent, as the EMH proposes (Pastor 1-4). Although there is some substance within the EMH, there are multiple other scenarios in which it is the inferior hypothesis.

This begs the question, what is more important, true security value or perceived security value? As previously established, the market price of a stock is determined by investor sentiment. In other words, investors drive the market price based on what they believe the stock is, or will be, worth (Evans 2-5). From this principle, one can determine all that really matters is what the majority believes (Glasner 1). This is also evident when looking at instantaneous adjustment as discussed above (Fama 76). As a result, we find that the stock market is, at least partially, a self-driven machine. The fundamental factors that influence market price are opinions(Glasner). Firms and investors derive investor sentiment or security value differently through utilizing different factors, prioritizations, and predictions (Rodak 3-7). Glasner states, "Stocks are even more susceptible than other markets to popular delusions and the madness of crowds" (1). If the majority of investors believe that a stock is overvalued and sell their shares, the price is going to go down whether it was overvalued or not (Glasner 1). Moreover, by knowing the *true perceived security value (TPSV)*, the value determined by the majority of investors, before the majority of investors do, one has an upper hand in investment decisions.

To find the TPSV, one must first understand how individuals determine security value. The fundamental method utilized involves the use of a valuation model that accounts for the different, quantitative factors that influence the market price of a stock. Both the model and the factors vary for each investor. For example, some investors use the price to earnings ratio, the relationship between "how much investors are willing to pay for each dollar of a firm's earning," while others utilize more complicated mathematical systems that account for a plethora of variables (Scott 2; Investors 1). Soon investors began to see that the market price is simply a ratio of the factors that contribute the worth of a stock. Using this foundation, learning algorithms, also known as "intelligent stock trading decision support systems," were developed to help identify how these different factors affect stock tendencies (Kuo 3).

To identify how different factors influence market price tendencies, learning algorithms encompass all of the possible parameters investors could use to calculate security value, and determine the models investors are using by assigning random weighting coefficients to the various parameters (Chen 3). The most successful learning algorithms, in terms of market forecasting, utilize patterns that occur with neural networks or genetic algorithms. Through an evolutionary process, the combinations of factors and coefficients, that are most frequently correct, develop more credibility within the system (Kuo 1). This reflects the development of the myelin sheath along strings of neurons to increase efficiency. By building and employing these credibile pathways, the algorithm can anticipate, to the best of it's ability, how the market is going to react to changes. In other words, by turning relevant inputs into variables, and identifying how much investors believe these variables are worth through computational evolutionary means, the programs develop an understanding of the factors and models that analysts are using (Chen 3).

Theoretically, these algorithms should be able to anticipate stock market fluctuations yet, because the models investors use constantly change, the algorithms can never make complete predictions. Although learning algorithms work well in scientific fields, they are not as successful in chaotic, dynamic systems such as the stock market. Learning algorithms were developed to identify set values. However, stock market specific learning algorithms look into the parameters and coefficients that investors use to determine security values, when in fact, these factors and their importance are constantly shifting. Research indicates that even though learning algorithms are trying to identify a moving target, they have had some success. For example, they increased Eureka Hedge Fund Index annualized returns from 3.43% to 8.44%

(Artificial). That being said, learning algorithms could have greater success if they evolved to identify a shifting value or identified something other than the parameters and their effects on market price tendencies. Ultimately, the parameters account for some changes in the market price, but it is TPSV driving these fluctuations. Accordingly, it does not matter how the outputs are determined, it only matters that they exist and that they are contributing to the TPSV. Therefore, the question is not how do specific factors influence the market price tendencies, but how do you determine the TPSV regardless of the factors and models being used to produce outputs?

A promising avenue for answering this question is emergent intelligence, a phenomenon that explains the superior intelligence of groups as opposed to individuals (Unanimous A.I. Staff). Emergent intelligence is divided into two sections, the wisdom of crowds and swarm intelligence. To understand the two subsections of emergent intelligence, one must differentiate between crowds and swarms. A crowd is a group of individuals that act independently of each other. A swarm is a cohesive entity that communicates at an elevated biological level, allowing the individuals to form a synchronized equilibrium of opinion. Ultimately a swarm has a discussion where contributions are influenced by other member's opinions, while crowds come to conclusions in isolation.

Wisdom of crowds is an elevated intelligence that emerges when one looks at the answer of the crowd rather than the individual. The most well known example of wisdom of crowds is a group's collective ability to accurately guess the number of beans in a jar. If a large group of individuals are asked to guess the number of beans in a jar it is highly unlikely that any individual would guess the correct value, but the average of the guess is often within 2% accuracy (Unanimous A.I. Staff).

Swarm intelligence is a unified, dynamic entity of social creatures that "amplify their collective intelligence by forming a real time synchronous system," through an elevated form of communication such as: body vibrations for bees, water vibrations for fish, and emergent motions within flocks of birds (Rosenberg, "Artificial Swarm Intelligence vs Human…" 2; Rosenberg, "Human Swarming…" 1). These behaviours have developed evolutionarily due to their survival benefits (Rosenberg, "Human Swarming…" 1). Similar to wisdom of crowds, swarm intelligence displays an intelligence that emerges when looking at the group rather than the individual. The only difference is that swarm intelligence emerges from swarms, not crowds.

When an individual reaches a conclusion without the influence of other members of the crowd through means of polls or surveys, as in wisdom of crowds, it is likely inaccurate. (Rosenberg, "Crowds vs Swarms…" 1). Where as in swarm intelligence, where the group is working as one cohesive entity, swarm, where the final conclusion is often within a small margin of the correct answer (Rosenberg, "Artificial Swarm Intelligence vs Human…" 2). Ultimately, by allowing themselves to have real time, closed-loop, dynamic discussions, where an intelligent consensus is established, these swarms "can outperform the vast majority of individual members when solving problems and making decisions" (Rosenberg, "Human Swarming…" 1). While both methods, wisdom of crowds and swarm intelligence are effective, swarm intelligence has been shown to be more successful (Rosenberg, "Crowds vs Swarms…" 1). Humans have not yet developed the biological ability to have these real-time swarming interactions, but have begun developing a technological aid with this specific goal (Rosenberg).

Unanimous AI is a company that generates systems based on emergent intelligence that allows humans to interact as a swarm (Rosenberg). Rather than polarizing individuals, where the answers are independent from each other, the company has generated an interactive program where individuals can have real-time negotiations.

In the unanimous interface, the screen is lined with six different answers. The collective "best guess," displayed as a magnet in the center of the screen, shifts dynamically until an equilibrium of opinion or intelligent consensus is established. Each contributor is given a virtual "participant magnet" of which they can change the size and location. The participants input their guess by attempting to move the center magnet with their own magnet. By changing the magnitude and direction of their magnet, they can adjust the effect or influence they have on the group decision. During this process all of the participant's magnets are displayed on the screen, allowing them to see what other people are thinking and to adjust their own magnet accordingly until it narrows in on an answer in syncrony (Rosenberg, "Emergent Intelligence from a Jar…" 3-5). Ultimately, this program: takes peoples opinions, converts them to inputs, and allows these inputs to have a specific and degree of influence over the ever changing compilation of inputs. The experiment is done in live time allowing people to revise their inputs. This program has, with great success, cultivated an environment in which humans can utilize the benefits of swarm intelligence (Rosenberg, "Intelligent Systems…" 5).

This swarm intelligence system has proven repeatedly to be the most precise mechanism for determining values and outcomes. In multiple studies, swarms of novice, sports fans have had higher accuracy ratings when forecasting game outcomes using swarm intelligence in comparison to both experts and SAM, the BBC employed supercomputer used to make expert-level, sports predictions (Rosenberg, "Intelligent Systems…" 5)(Rosenburg, "Artificial Swarm…" 1). In Lois Rosenbergs and Niccolo Pescetelli study, Amplifying Prediction Accuracy Using Swarm A.I., a group of random, isolated agents had a prediction accuracy of 55%.The outputs produced by swarms had a higher prediction accuracy of 72%, corresponding to a 131% accuracy amplification (1-5). Similar results were found in Louis Rosenberg's other study, Artificial Swarm Intelligence VS Human Experts, where experts had a 50% accuracy compared to a swarm of 75 random sports fans with a 70% accuracy (1). To prove that it was not simply the number of participants in crowd versus a swarm, a similar experiment was conducted that found, "the crowd, although 16 times larger in size, was significantly less accurate (at 47% correct) than the swarm (at 68% correct). Further, the swarm outperformed 98% of the individuals…" (Rosenberg, "Crowds vs Swarms…" 1). With this impressive success rate in mind, Unanimous A.I. decided to apply swarm intelligence to financial market predictions.

A study was completed where financial traders made weekly forecasting predictions using both a survey, wisdom of crowds method, as well as the swarm intelligence method. The participants were asked to anticipate not only which direction the market price was going to fluctuate, but also to what to degree. As expected, the results showed that swarm intelligence was a more accurate method for predicting fluctuation in financial markets. The data revealed that "individual participants, who averaged 61% accuracy when forecasting weekly trends on their own, amplified their accuracy to 77% when predicting together as real-time swarms." (Rosenberg, "...Financial Markets" 5). That being said, there is reason to believe that asking a different question would have led to greater results.

As has been established, if you know the TPSV, you can you anticipate the market price fluctuations and maximize your capital gains. Thus, the question should not be how will the market price fluctuate, but what is the TPSV?

Conclusion:

The Theory:

The stock market is a dynamic, closed-loop discussion between investors, where the true perceived security value of a stock emerges from the market price over a short period of time. By using the TPSV, investors can identify if a stock is over or undervalued by the majority, allowing them to predict stock price fluctuations using the *fundamental analysis technique*.

Fundamental Structure of The Stock Market:

The fundamental idea behind the stock market is to buy low and sell high by anticipating market price fluctuations before the majority, thus maximizing your capital gains. The market price is determined by supply and demand,which is driven by the TPSV. Each investor determines the security value of a stock and makes investment decisions based on this value output by purchasing or selling shares at a certain price and magnitude which directly influences the market price.

When an investor fills out a buy or sell form, it is the equivalent to moving their "participant magnet." The investor is pulling the market price (center magnet) up or down by either purchasing or selling shares. The size of the participant's magnet, or the significance of their pull, correlates to the number of shares bought or sold. Thus, market price fluctuations are a result of a dynamic, closed loop discussion between investors. Ultimately, the stock market is built upon a swarm intelligence foundation, where the TPSV emerges from the market price.

Role of Information:

The market price is a dynamically shifting discussion between investors, where buy and sell bids represent "votes" toward the TPSV. When critical information is introduced to the market, it alters the TPSV. Therefore, any event that results in an investor buying or selling shares directly affects the equilibrium of opinion. With an infinite number of critical factors influencing investment decisions, the TPSV must be an instantaneous value that is constantly shifting. In turn, to be effective te TPSV must determined and utilized over a short period of time.

Emergence of TPSV:

When humans swarm using the unanimous interface, they are having a real-time negotiation, where the best guess is dynamically shifting until an equilibrium of opinion or intelligent consensus is established. I propose that within a stock market simulation these shifts are represented by the relative extrema. The relative extrema of the market price over a short period of time are critical. I have identified the relative extrema as the important values, as these are the only points with tangible meaning. Maximums and minimums represent locations where the majority of investors have classified the stock as either overvalued and sold or undervalued and bought.

To calculate the TPSV by utilizing the relative extrema, I propose multiple mathematical models. The most elementary computation would be to average the relative extrema. A more sophisticated method would utilize the mean value theorem of integrals, which enables one to generate a rectangle with the same area as the space beneath a curve. This produces an average that accounts for not only the maximums and minimums but the period of time that a stock was of a certain value.

Proposed Research and Implications:

If this theory proves true, it proposes some interesting implications. Initially, it could hold great promise in the field of chaos theory. It would allow individuals with access to this value, in the proper time frame, to drastically increase their capital gains, but, due to the self-fulfilling tendencies of the stock market, the theory will only be effective if applied by relatively few investors.

As a preliminary conclusion, I have outlined how market price fluctuations are a result of the swarm intelligence properties woven into the market structure, where the TPSV emerges from the market price over short periods of time. To prove this theory, it would be necessary to develop a program that calculates this value, over different time frames, on a multitude of stocks, and observe whether the value produced enables accurate market price predictions.

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