The Omniscience Model: Equation Selection

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Abstract

We are living at the intersection of massive computing power and the nearly unlimited flow of financial information. Stock market returns are based on the change in price from one period to another. The business plan of nearly all equity funds is based on having high conviction regarding whether holdings will go up (those that hold long) or down (those that short). While the business plan is based on conviction, success is based on being correct. Statistical tools and theories are available to help understand relationships, such as correlation, as well as explain divergent behavior, such as mean reversion. Other fields such as physics and biology utilize models that could be relevant to prediction of future events. This paper takes the formulae from the various fields and sorts them to determine which may be useful in the prediction of stock prices versus those that are descriptive and evaluative.

Keywords: Stock Market, Stock Price, Stock Price Prediction

1. *Introduction*

The key to successful investing is the ability to identify stocks that will be going up in price and being able to detect the inflection point when they will be going down in price. This is very simple to state, extremely difficult to do. Active investing is based on the ability to select stocks that will outperform a benchmark (usually a relevant index). And despite the vast number of fund managers, substantially less than a majority are consistently successful. For all the advances in computing power, informatics and financial and statistical models, the ability to predict the movement of individual stock prices has been elusive. Investors and fund managers continue to debate whether active management can outperform a passive benchmark, and whether managers possess skill that can translate into alpha.

In the simplest sense, there are only three things that can happen to a stock price from one period to the next: it can go up, it can do down, it can stay the same. So, at worst, a random guess should be right 1/3 of the time, if the three possibilities are equally likely. If they are not equally likely, then the odds should get better. For instance, stocks generally do not remain unchanged from time t to t_{t+1}. That leaves just two choices, up or down, with the odds now at 50/50 (again assuming equal likelihood). Predicting the magnitude of the change would represent another, and more difficult, challenge. The stock market (defined as a single stock exchange) functions as a closed system. The maximum availability of stocks to purchase on the exchange only varies when there are new offerings and de-listings. To be sure there are other investment options aside from the stocks available on a particular exchange – a multitude of other exchanges, derivative products, commingled funds, debt securities, etc., but in order to sell a stock there needs to be someone to buy that stock. To get out, someone else must get in, and vice versa.

We are at the crossroads of massive computing power and the free flow of financial information. So why is there such difficulty in making accurate, robust predictions? There is the possibility that this question has been solved, just not shared. But I find that hard to accept. Someone who has an accurate model of when to buy and sell should be able to geometrically build their wealth. This would not go unnoticed. Physical laws can also play a part in accurate predictions. Newton's laws of motion can be used to explain a portion of stock market movement (momentum theory, contrarian views, etc). Simon-Pierre LaPlace, extending an idea first put forth by Gottfried Leibniz, stated:

"We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect, nothing would be uncertain and the future just like the past would be present before its eyes."[1]

Simply put, LaPlace was saying that with enough information about the placement and movement of every atom we should be able to predict the future placement and movement of every atom, and therefore know where everyone and everything will be. This paper will attempt to develop the framework for a robust, reliable model of predicting the movement of stock prices utilizing a variety of modalities, drawn from philosophy, statistics, finances, biology and physics. This paper takes the various equations used across a variety of fields and sorts them into the categories of predictive, descriptive or evaluative.

1. Background

The various literatures that provide tools for analysis are:

List 1: Analysis Tools from the Finance Literature

Financial mathematics
Algorithmic trading
Stock price probability
Technical analysis
Swing trading techniques
Gaussian mixture models
Dirichlet processes
Weiner processes
Stochastic processes
Behavioral economics
Sentiment theory

List 2: Analysis Tools from the Physics Literature

Econophysics
Quantum finance
Quantum trading
Natural market laws
Newton's Laws

List 3: Analysis Tools from the Ecosystems Literature

Ecosystem movement
Ecology of ecosystems
Shoaling and schooling

Any model that is useful for predicting future events might have relevance for stock price prediction. While there are many models that have been developed for stock prediction, there are few models that integrate components from a variety of disciplines.

2. Finance Literature

There are various models contained within the "financial mathematics" category. These will be individually described and sorted

1 https://en.wikipedia.org/wiki/Laplace%27s_demon#cite_note-Truscott-3, which referenced Laplace, Pierre Simon, A Philosophical Essay on Probabilities, translated into English from the original French 6th ed. by Truscott,F.W. and Emory,F.L., Dover Publications (New York, 1951) p.4

2.1 Correlation

Correlation is ubiquitous in the investing literature. Correlation involves the calculation of a relationship between two streams of data so that knowing the movement of one stream will allow inference of the movement of the other. Correlation does not suggest a causal relationship. There are many variations of the standard formula for calculating correlation. A common one is given by:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y},$$

No matter how the various versions may be specified, they all can be described as the covariance of X and Y divided by the standard deviation of X times the standard deviation of Y times (n-1). Correlation ranges from -1.00 to +1.00, where +1.00 indicates perfect positive correlation (as one stream moves up or down, the other stream moves in the same direction), and -1.00 indicates perfect negative correlation (as one stream moves up or down, the other moves in the opposite direction). A correlation of 0 (or close to 0, either positive or negative) indicates the lack of a linear relationship. Correlation as just described is not a good metric for stock selection because the streams of data occur simultaneously. As you calculate the correlation it is too late to be investable. The calculation is based on where the two stocks are at the same moment, and an investor is concerned with where the price is going. That makes the basic correlation calculation descriptive. This gives rise to a variation of correlation that is predictive – lagged correlation. Lagged correlation is where the streams of data are not for the same period. One stream is the indicator stream; the other is the target stream. The data for the indicator stream will be for period *t*, whereas the data for the target stream will be for *t+1*.

2.2 Regression

Regression analysis is widely used to estimate the value of a dependent variable based upon the known input(s) of an independent variable(s). Where there is one independent variable this is known as regression, where there are multiple independent variables it is known as multiple regression. Regression can be based on an expected linear or non-linear relationship. Regression based on a linear relationship is simpler to calculate, but might be less useful. Regression is both descriptive and evaluative, and can be predictive if the estimated dependent variable lags the independent variables used to predict it.

The standard linear regression equation has the form:

Y = mX + b
Where:
Y = dependent variable
m = slope
X = dependent variable
b = Y intercept

Current convention uses "a" to represent the slope, but I prefer "m" based on how I learned the equation.

Regression is predictive and evaluative. It is evaluative since you can assess how accurate the predictions were by analyzing the errors between the predicted value of Y and the actual value. It is predictive since you can extend the regression line and estimate future values.

2.3 Autoregressive Models

Auto regression is a form of linear regression where the values are regressed on former values of the series. The autoregressive model specifies that the output variable depends linearly on its own previous values.[2] The formula for regressing the value of a time series at period *t* on the values from one period prior (*t-1) is:*

$$y_t = \beta_0 + \beta_1 y_{t-1} + \epsilon_t$$

[2] en.wikipedia.org/wiki/Autoregressive model

The autoregressive model is predictive.

2.4 Moving Average Models

"A moving average is a technique to get an overall idea of the trends in a data set; it is an average of any subset of numbers. The moving average is extremely useful for forecasting long-term trends."[3] A moving average tempers the change from one period to the next by looking at the change in the average by adding a new observation.

Moving average models are predictive and can be useful if the number of observations that are used in calculating the average is adjusted to provide optimal predictability.

2.5 Sharpe Ratio

The Sharpe Ratio calculates a risk-adjusted return. The calculation provides the return above a risk-free rate per unit of risk.

The formula for the Sharpe Ratio is given by[4]:

$$= \frac{\bar{r}_p - r_f}{\sigma_p}$$

Where:

$\bar{r}_p$ = Expected porfolio return

r_f = Risk free rate

σ_p = Portfolio standard deviation

The Sharpe Ratio is evaluative and not predictive.

2.6 Sortino Ratio

The Sortino Ratio is a modification of the Sharpe Ratio. The Sharpe Ratio uses all returns whereas the Sortino Ratio only uses those returns above a specific (investor prescribed or required rate of return) target.

As with the Sharpe Ratio the Sortino Ratio is evaluative and not prescriptive.

2.7 Treynor Ratio

The Treynor Ratio can also be thought of as a variation of the Sharpe Ratio where the unit of risk is not total risk but systematic risk. The formula for the Treynor Ratio is:

$$T = \frac{r_i - r_f}{B_i}$$

Where:

r_i = Portfolio return
r_f = Risk-free return
B_i = Beta of portfolio

The Treynor Ratio is evaluative and not prescriptive.

2.8 Jensen's Alpha

In an investment context, "alpha" refers to the risk-adjusted return above a benchmark, often an index. The index is the no-cost return an investor could have received. Alpha is the contribution of the investment manager to garner a return in excess of this no-cost return. Alpha is a large part of the justification for paying a management fee. Jensen's Alpha modifies this basic calculation of alpha by using something other than an index as the minimal expected return.

Jensen's Alpha is evaluative and not prescriptive.

[3] http://www.statisticshowto.com/moving-average/#MADefinition
[4] http://www.investopedia.com/terms/s/sharperatio.asp?lgl=no-infinite

2.9 Algorithmic Trading

Algorithmic trading is simply a trading strategy based on using pre-set trigger points based on previously identified quantified formulae. Once the algorithmic trading equation(s), parameter(s) and trigger point(s) is established human intervention is at a minimum.This paper is the first step in developing an algorithmic investing system. Unlike other algorithmic trading systems, which are keep secret (if they work), by developing this model as academic research it will be in the public domain. While a successful algorithmic trading strategy is not publicly available, important considerations in developing an algorithmic model are widely shared by investment management firms that do develop such models.

Daily FX has their "7 Essentials for Developing an Algorithmic Trading Strategy:"[5]

1. Risk management
2. Market selection, time frame and portfolio construction
3. Utilize advanced order types
4. Position sizing
5. Back testing
6. Optimization
7. Risk tolerance

Algotrades has three basic strategies that their algorithmic trading program utilizes:[6]

1. Short term momentum shifts between overbought and oversold market conditions, which are traded using long and short positions allowing, potential profits in any market direction.
2. Trend following takes advantage of extended multi month price movements in either direction up or down.
3. Cyclical trading allows potential profits during a range bound sideways market. Some of the largest gains are encountered during choppy market conditions with this strategy.

There is no shortage of online resources to help develop an algorithmic trading strategy, including information sources, software programming language, delineation of the steps in the development process as well as the order these steps should be undertaken, as well as others.

The Omniscience Model is intended to be a model for stock price prediction. With the addition of rules regarding buying, selling and holding thresholds the Omniscience Model can also be an algorithmic trading strategy.

3.10 Stock Price Probability

The importance of discussing stock price probability is to understand the variety of probability distributions that are available to interpret results. All stock price predictions models result in either a point prediction or a range, as well as an inherent probability of accuracy. In order to accurately state the probability, the correct distribution needs to be specified.

The normal distribution is the most common distribution used in probability. In this distribution about two-thirds of the observations will be entered around a central tendency (value) with the tails roughly equal in shape and area. The normal distribution could be appropriate if the model will produce estimates of future stock prices where the likelihood of the actual price compared to the estimate can be higher or lower by equal amounts.

The binomial distribution is a useful distribution when the outcome is one of two possibilities. For the purposes of this paper if the result of the model is either a "correct" or "Incorrect" result the binomial distribution would be appropriate. If the result of the model ultimately developed is to produce a distribution of possible future stock prices then the binomial model is not appropriate.

The Bernoulli distribution is a special case of the binomial distribution where the outcome is one of two possibilities designated as "0" or "1"[7]. If the binomial distribution is deemed appropriate, then the Bernoulli distribution would be a matter of coding the result.

[5] https://www.dailyfx.com/algorithmic-trading/2016/02/25/7-Essentials-for-Developing-an-Algorithmic-Trading-System.html

[6] http://www.algotrades.net/algorithmic-trading-strategies/

The Rademacher distribution is another variation of the binomial distribution "…which takes value 1 with probability 1/2 and value −1 with probability ½."[8]

There are quite a few other probability distributions. Below is List 4, taken from Wikipedia.[9]

List 4: Probability Distributions

- The beta-binomial distribution, which describes the number of successes in a series of independent Yes/No experiments with heterogeneity in the success probability.
- The degenerate distribution at x0, where X is certain to take the value x0. This does not look random, but it satisfies the definition of random variable. This is useful because it puts deterministic variables and random variables in the same formalism.
- The discrete uniform distribution, where all elements of a finite set are equally likely. This is the theoretical distribution model for a balanced coin, an unbiased die, a casino roulette, or the first card of a well-shuffled deck.
- The hypergeometric distribution, which describes the number of successes in the first m of a series of n consecutive Yes/No experiments, if the total number of successes is known. This distribution arises when there is no replacement.
- The Poisson binomial distribution, which describes the number of successes in a series of independent Yes/No experiments with different success probabilities.
- Fisher's noncentral hypergeometric distribution
- Wallenius' noncentral hypergeometric distribution
- Benford's law, which describes the frequency of the first digit of many naturally occurring data.
- The beta negative binomial distribution
- The Boltzmann distribution, a discrete distribution important in statistical physics which describes the probabilities of the various discrete energy levels of a system in thermal equilibrium. It has a continuous analogue. Special cases include:
- The Gibbs distribution
- The Maxwell–Boltzmann distribution
- The Borel distribution
- The extended negative binomial distribution
- The extended hypergeometric distribution
- The generalized log-series distribution
- The geometric distribution, a discrete distribution which describes the number of attempts needed to get the first success in a series of independent Bernoulli trials, or alternatively only the number of losses before the first success (i.e. one less).
- The logarithmic (series) distribution
- The negative binomial distribution or Pascal distribution a generalization of the geometric distribution to the nth success.
- The discrete compound Poisson distribution
- The parabolic fractal distribution
- The Poisson distribution, which describes a very large number of individually unlikely events that happen in a certain time interval. Related to this distribution are a number of other distributions: the displaced Poisson, the hyper-Poisson, the general Poisson binomial and the Poisson type distributions.
- The Conway–Maxwell–Poisson distribution, a two-parameter extension of the Poisson distribution with an adjustable rate of decay.
- The Zero-truncated Poisson distribution, for processes in which zero counts are not observed
- The Polya–Eggenberger distribution

[7] http://optimierung.mathematik.uni-kl.de/mamaeusch/veroeffentlichungen/ver_texte/bm_aktienkurse_e.pdf, p 6

[8] https://en.wikipedia.org/wiki/List_of_probability_distributions

[9] https://en.wikipedia.org/wiki/List_of_probability_distributions

- The Skellam distribution, the distribution of the difference between two independent Poisson-distributed random variables.
- The skew elliptical distribution
- The Yule–Simon distribution
- The zeta distribution has uses in applied statistics and statistical mechanics, and perhaps may be of interest to number theorists. It is the Zipf distribution for an infinite number of elements.
- Zipf's law or the Zipf distribution. A discrete power-law distribution, the most famous example of which is the description of the frequency of words in the English language.
- The Zipf–Mandelbrot law is a discrete power law distribution which is a generalization of the Zipf distribution.
- The arcsine distribution on [a,b], which is a special case of the Beta distribution if a = 0 and b = 1.
- The Beta distribution on [0,1], a family of two-parameter distributions with one mode, of which the uniform distribution is a special case, and which is useful in estimating success probabilities.
- The logit normal distribution on (0,1).
- The Dirac delta function although not strictly a function, is a limiting form of many continuous probability functions. It represents a discrete probability distribution concentrated at 0 — a degenerate distribution — but the notation treats it as if it were a continuous distribution.
- The continuous uniform distribution on [a,b], where all points in a finite interval are equally likely.
- The rectangular distribution is a uniform distribution on [−1/2,1/2].
- The Irwin–Hall distribution is the distribution of the sum of n identically distributed. U(0,1) random variables.
- The Bates distribution is the distribution of the mean of n identically distributed. U(0,1) random variables.
- The Kent distribution on the three-dimensional sphere.
- The Kumaraswamy distribution is as versatile as the Beta distribution but has simple closed forms for both the cdf and the pdf.
- The logarithmic distribution (continuous)
- The Marchenko–Pastur distribution is important in the theory of random matrices.
- The PERT distribution is a special case of the beta distribution
- The raised cosine distribution
- The reciprocal distribution
- The triangular distribution on [a, b], a special case of which is the distribution of the sum of two independent uniformly distributed random variables (the convolution of two uniform distributions).
- The trapezoidal distribution
- The truncated normal distribution on [a, b].
- The U-quadratic distribution on [a, b].
- The von Mises-Fisher distribution on the N-dimensional sphere has the von Mises distribution as a special case.
- The Wigner semicircle distribution is important in the theory of random matrices. The von Mises distribution
- The wrapped normal distribution
- The wrapped exponential distribution
- The wrapped Lévy distribution
- The wrapped Cauchy distribution
- The wrapped Laplace distribution
- The wrapped asymmetric Laplace distribution
- The Dirac comb of period 2 π although not strictly a function, is a limiting form of many directional distributions. It is essentially a wrapped Dirac delta function. It represents a discrete probability distribution concentrated at 2πn — a degenerate distribution — but the notation treats it as if it were a continuous distribution.
- The Beta prime distribution
- The Birnbaum–Saunders distribution, also known as the fatigue life distribution, is a probability distribution used extensively in reliability applications to model failure times.
- The chi distribution

- The noncentral chi distribution
- The chi-squared distribution, which is the sum of the squares of n independent Gaussian random variables. It is a special case of the Gamma distribution, and it is used in goodness-of-fit tests in statistics.
- The inverse-chi-squared distribution
- The noncentral chi-squared distribution
- The Scaled-inverse-chi-squared distribution
- The Dagum distribution
- The exponential distribution, which describes the time between consecutive rare random events in a process with no memory.
- The Exponential-logarithmic distribution
- The F-distribution, which is the distribution of the ratio of two (normalized) chi-squared-distributed random variables, used in the analysis of variance. It is referred to as the beta prime distribution when it is the ratio of two chi-squared variates which are not normalized by dividing them by their numbers of degrees of freedom.
- The noncentral F-distribution
- Fisher's z-distribution
- The folded normal distribution
- The Fréchet distribution
- The Gamma distribution, which describes the time until n consecutive rare random events occur in a process with no memory.
- The Erlang distribution, which is a special case of the gamma distribution with integral shape parameter, developed to predict waiting times in queuing systems
- The inverse-gamma distribution
- The Generalized gamma distribution
- The generalized Pareto distribution
- The Gamma/Gompertz distribution
- The Gompertz distribution
- The half-normal distribution
- Hotelling's T-squared distribution
- The inverse Gaussian distribution, also known as the Wald distribution
- The Lévy distribution
- The log-Cauchy distribution
- The log-Laplace distribution
- The log-logistic distribution
- The log-normal distribution, describing variables which can be modelled as the product of many small independent positive variables.
- The Lomax distribution
- The Mittag-Leffler distribution
- The Nakagami distribution
- The Pareto distribution, or "power law" distribution, used in the analysis of financial data and critical behavior.
- The Pearson Type III distribution
- The Phase-type distribution, used in queueing theory
- The phased bi-exponential distribution is commonly used in pharmokinetics
- The phased bi-Weibull distribution
- The Rayleigh distribution
- The Rayleigh mixture distribution
- The Rice distribution
- The shifted Gompertz distribution
- The type-2 Gumbel distribution
- The Weibull distribution or Rosin Rammler distribution, of which the exponential distribution is a special case, is used to model the lifetime of technical devices and is used to describe the particle size distribution of particles generated by grinding, milling and crushing operations.

- The Behrens–Fisher distribution, which arises in the Behrens–Fisher problem.
- The Cauchy distribution, an example of a distribution which does not have an expected value or a variance. In physics it is usually called a Lorentzian profile, and is associated with many processes, including resonance energy distribution, impact and natural spectral line broadening and quadratic stark line broadening.
- Chernoff's distribution
- The Exponentially modified Gaussian distribution, a convolution of a normal distribution with an exponential distribution.
- The Fisher–Tippett, extreme value, or log-Weibull distribution
- Fisher's z-distribution
- The skewed generalized t distribution
- The generalized logistic distribution
- The generalized normal distribution
- The geometric stable distribution
- The Gumbel distribution
- The Holtsmark distribution, an example of a distribution that has a finite expected value but infinite variance.
- The hyperbolic distribution
- The hyperbolic secant distribution
- The Johnson SU distribution
- The Landau distribution
- The Laplace distribution
- The Lévy skew alpha-stable distribution or stable distribution is a family of distributions often used to characterize financial data and critical behavior; the Cauchy distribution, Holtsmark distribution, Landau distribution, Lévy distribution and normal distribution are special cases.
- The Linnik distribution
- The logistic distribution
- The map-Airy distribution
- The normal distribution, also called the Gaussian or the bell curve. It is ubiquitous in nature and statistics due to the central limit theorem: every variable that can be modelled as a sum of many small independent, identically distributed variables with finite mean and variance is approximately normal.
- The Normal-exponential-gamma distribution
- The Normal-inverse Gaussian distribution
- The Pearson Type IV distribution (see Pearson distributions)
- The skew normal distribution
- Student's t-distribution, useful for estimating unknown means of Gaussian populations.
- The noncentral t-distribution
- The skew t distribution
- The type-1 Gumbel distribution
- The Tracy–Widom distribution
- The Voigt distribution, or Voigt profile, is the convolution of a normal distribution and a Cauchy distribution. It is found in spectroscopy when spectral line profiles are broadened by a mixture of Lorentzian and Doppler broadening mechanisms.
- The Gaussian minus exponential distribution is a convolution of a normal distribution with (minus) an exponential distribution.
- The Chen distribution.
- The generalized extreme value distribution has a finite upper bound or a finite lower bound depending on what range the value of one of the parameters of the distribution is in (or is supported on the whole real line for one special value of the parameter
- The generalized Pareto distribution has a support which is either bounded below only, or bounded both above and below
- The Tukey lambda distribution is either supported on the whole real line, or on a bounded interval, depending on what range the value of one of the parameters of the distribution is in.

- The Wakeby distribution
- The rectified Gaussian distribution replaces negative values from a normal distribution with a discrete component at zero.
- The compound poisson-gamma or Tweedie distribution is continuous over the strictly positive real numbers, with a mass at zero.
- The Dirichlet distribution, a generalization of the beta distribution.
- The Ewens's sampling formula is a probability distribution on the set of all partitions of an integer n, arising in population genetics.
- The Balding–Nichols model
- The multinomial distribution, a generalization of the binomial distribution.
- The multivariate normal distribution, a generalization of the normal distribution.
- The multivariate t-distribution, a generalization of the Student's t-distribution.
- The negative multinomial distribution, a generalization of the negative binomial distribution.
- The generalized multivariate log-gamma distribution
- The Wishart distribution
- The inverse-Wishart distribution
- The matrix normal distribution
- The matrix t-distribution
- The categorical distribution
- The Cantor distribution
- The generalized logistic distribution family
- The Pearson distribution family
- The phase-type distribution

It is outside the scope of this paper to discuss all the distributions.

3.11 Technical Analysis

“Technical analysis is the polar opposite of fundamental analysis. Technical analysts, or technicians, select stocks by analyzing statistics generated by past market activity, prices and volumes. Sometimes also known as chartists, technical analysts look at the past charts of prices and different indicators to make inferences about the future movement of a stock's price.”[10] In some ways technical analysis, as described above, is similar to the visual version of autoregression. Where technical analysis can differ from autoregression is by considering more variables than just previous stock prices. Technical analysis can also encompass additional models.

Some of the additional variables and models considered by technical analysis are delineated in List 5.

LIST 5: Additional Variables and Models Considered by Technical Analysis Are[11]

Indicators
Relative strength
VIX
Sentiment indicators
IPOs
Price targets
Tools
Stop loss
Point and figure
Screening
Timeframe
Reversals
Sector rotation
Dow Theory

[10] http://www.investopedia.com/university/stockpicking/stockpicking9.asp
[11] http://www.stockpickr.com/technical-analysis-page?cm_ven=sptext

Market strength
Breakout trading
GAPS
Trading volume
Support and resistance
Candlestick charts
Moving averages
Market momentum
Trendline support

3.12 Swing Trading

"Swing trading has been described as a kind of fundamental trading in which positions are held for longer than a single day. This is because most fundamentalists are actually swing traders since changes in corporate fundamentals generally requiring several days or even a week to cause sufficient price movement that renders a reasonable profit."[12] Swing trading is also known as "candlestick trading" for the type of chart used as part of the strategy. A candlestick chart shows the high, low and close for a particular stock. Swing trading is a short-term trading strategy where an investor seeks to take advantage of sentiment changes.

As a strategy swing trading is descriptive but not predictive.

3.13 Gaussian Mixed Models

Gaussian mixed models are essentially linear regression models with an error component represented by a Gaussian distribution for the random effects. The Gaussian mixed model is descriptive more than predictive.

3.14 Dirichlet Processes

A Dirichlet process is a distribution over distributions. It is a stochastic process where each observation is a distribution. This is a descriptive, not predictive model.

3.15 Wiener Process

A Wiener process is also known as Brownian motion. It is a continuous-time stochastic process. The Wiener process uses the normal distribution and therefore is also considered Gaussian. The Wiener process is both descriptive and predictive. As a predictor, the Wiener process is not initially included because it tends to be used to describe random processes rather than causal processes.

3.16 Stochastic Processes

"Discrete stochastic processes are essentially probabilistic systems that evolve in time via random changes occurring at discrete fixed or random intervals."[13] Stochastic processes are descriptive and predictive, and are a category for which a number of models have been identified.

3.17 Behavioral Economics

A concise description of behavioral economics is offered by Dan Ariely:

"Drawing on aspects of both psychology and economics, the operating assumption of behavioral economics is that cognitive biases often prevent people from making rational decisions, despite their best efforts."[14]

Whether behavioral economics is a useful addition to the model depends on who the population of investors are. If the majority of trades are made by computer algorithms (program trading) then the benefit of incorporating behavioral economics is minimal. If the population of investors is individual, non-professionals, then the model could benefit from the addition of a behavioral economics function.

3.18 Sentiment Theory

I categorize sentiment theory as a sub-set of behavioral economics. Sentiment theory can be described as:

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[12] http://www.investopedia.com/articles/trading/02/101602.asp
[13] https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-262-discrete-stochastic-processes-spring-2011/
[14] Ariely, Dan, "The End of Rational Economics," The Harvard Business Review, July-August 2009

"Recently, investor sentiment has become the focus of many studies on asset pricing. Research has demonstrated that changes in investor sentiment may trigger changes in asset prices, and that investor sentiment may be an important component of the market pricing process."[15]

Sentiment theory is the specific application of behavioral economics to stock market movement, and therefore could be relevant to stock price prediction.

4. Physics Literature

4.10 Econophysics

Econophysics is the intersection of physics with economics. It has the advantage of taking models common in one field and applying them in another. For instance, common in the physics literature is complexity theory and chaos theory. Both have application in econometric modeling.

4.10.1 Complexity Theory

A system is complex[16] when "… it is composed of many parts that interconnect in intricate ways"[17] and the system "… presents dynamic complexity when cause and effect are subtle"[18] and "… the degree and nature of the relationships is imperfectly known."[19] I would argue that this definition exactly captures the difficulty in stock price prediction. Complexity theory requires a variety of solving techniques, including computer simulation and different solutions for different scales and time frames. The importance for this paper is to understand that multiple functions might be needed, with a pre-condition filter to determine which should be operational.

4.10.2 Chaos Theory

The principles of chaos theory are[20]:

- The Butterfly Effect: This effect grants the power to cause a hurricane in China to a butterfly flapping its wings in New Mexico. It may take a very long time, but the connection is real. If the butterfly had not flapped its wings at just the right point in space/time, the hurricane would not have happened. A more rigorous way to express this is that small changes in the initial conditions lead to drastic changes in the results. Our lives are an ongoing demonstration of this principle. Who knows what the long-term effects of teaching millions of kids about chaos and fractals will be?
- Unpredictability: Because we can never know all the initial conditions of a complex system in sufficient (i.e. perfect) detail, we cannot hope to predict the ultimate fate of a complex system. Even slight errors in measuring the state of a system will be amplified dramatically, rendering any prediction useless. Since it is impossible to measure the effects of all the butterflies (etc.) in the World, accurate long-range weather prediction will always remain impossible.
- Order / Disorder Chaos is not simply disorder. Chaos explores the transitions between order and disorder, which often occur in surprising ways.
- Mixing: Turbulence ensures that two adjacent points in a complex system will eventually end up in very different positions after some time has elapsed. Examples: Two neighboring water molecules may end up in different parts of the ocean or even in different oceans. A group of helium balloons that launch together will eventually land in drastically different places. Mixing is thorough because turbulence occurs at all scales. It is also nonlinear: fluids cannot be unmixed.

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[15]Bandopadhyaya, Arindam and Jones, Anne Leah, "Measuring Investor Sentiment in Equity Markets" (2005). *Financial Services Forum Publications.* Paper 6.
http://scholarworks.umb.edu/financialforum_pubs/6

[16]The following definition is pieced together from the presentation "Tracing Complexity Theory" by Pedro Ferreira, 2001 (web.mit.edu/esd.83/www/notebook/Complexity%20Theory.ppt) which was drawn from the research seminar paper of the same name (web.mit.edu/esd.83/www/notebook/ESD83-Complexity.doc).

[17] "Complexity and Flexibility," Moses, Joel. Though quoted numerous times in different presentations I can only find a working paper under this title.

[18] "The Fifth Discipline," Senge, Peter, 1990.

[19] "The New Transportation Faculty," Sussman, Joseph.

[20]http://fractalfoundation.org/resources/what-is-chaos-theory/

- Feedback: Systems often become chaotic when there is feedback present. A good example is the behavior of the stock market. As the value of a stock rises or falls, people are inclined to buy or sell that stock. This in turn further affects the price of the stock, causing it to rise or fall chaotically.
- Fractals: A fractal is a never-ending pattern. Fractals are infinitely complex patterns that are self-similar across different scales. They are created by repeating a simple process over and over in an ongoing feedback loop. Driven by recursion, fractals are images of dynamic systems – the pictures of Chaos. Geometrically, they exist in between our familiar dimensions. Fractal patterns are extremely familiar, since nature is full of fractals. For instance: trees, rivers, coastlines, mountains, clouds, seashells, hurricanes, etc.

These characteristics are transferable to stock price prediction. The description of "feedback" argues for different decision paths when different circumstance is present, and "fractals" argue for a relationship to momentum theory, until momentum is lost, then a switch to a different theory.

4.11 Quantum Finance

Quantum finance is a discipline that has developed, because despite the incredible leaps in computing power, there has been a commensurate increase in available data and a geometric increase in possible combinations. Imagine the already staggering number of possible chess combinations when played on an 8x8 chessboard – now think of the chessboard going to a 12x12 then 16x16 then … you get the idea.

"No matter how fast and powerful DCs [digital computers] may become, some problems are simply intractable. Finance has a good lot of them. A few examples:

- Dynamic portfolio optimization: Computing an optimal trajectory for a portfolio under realistic assumptions is a NP-Complete problem.
- Clustering: Clustering algorithms often rely on heuristics. It would be desirable to replace some of these heuristics with a brute force search over an unfathomably large number of combinations. Good clustering methods have applications on risk management and regression analysis.
- Scenario analysis: Often investors would like to evaluate the distribution of outcomes under an extremely large number of scenarios, generated at random. Current approaches, like copulas, are too unrealistic/restrictive.
- Option pricing: Some complex derivatives are path-dependent. Evaluating a large number of paths can be computationally expensive.

There is no hope for solving these problems in polynomial time, much less ever finding a closed-form analytical solution. Quantum Computing (QC) offers the promise of being able to solve these problems in a matter of days, rather than in years."[21] These issues are relevant to stock price prediction. However, despite a solid argument against the probability of being to find a solution using digital computers, quantum computing will be reserved for a (possible) future paper. It is important to note that computing power is not unlimited, although it may seem that way. The vast amount of information available for stock price prediction is growing by every second (or millisecond or nanosecond) as new price information is available. The section on quantum finance argues for the use of overlaid parameters and constraints and stops to maximize the possibility of reaching an accurate result given the non-infinite computational power available.

4.12 Quantum Trading

As one would expect "Quantum finance is an interdisciplinary research field, applying theories and methods developed by quantum physicists and economists to solve problems in finance. It is a branch of econophysics."[22] Quantum trading involves quantum computing, which is outside the scope of this paper. Some of the work done in quantum trading includes[23]:

Shor's algorithm
Grover's algorithm
Schrödinger's equation

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[21] http://www.quantumforquants.org/quantum-computing/why-quantum-finance/
[22] https://en.wikipedia.org/wiki/Quantum_finance
[23] https://en.wikipedia.org/wiki/Quantum_finance

Feynman's path integrals
Wiener-Bachelier process
Ornstein-Uhlenheck process
Hull-White model
Cox-Ingersoll-Ross process

4.4 Natural Market Laws

Natural market laws provide a utile set of constraints:[24]

- All measurements are relative
- The future is unknowable
- All economies and markets are in relative motion

While simply stated, but integral to this paper is the statement:

"Although physics and economics both speak the language of math, there is one irreconcilable difference – human behavior can alter market laws, whereas we still haven't found a way to break the laws of physics. This means that observations, trading strategies and market theories may hold up for a long time and then suddenly fail."[25]An adaptable set of functions will be necessary to provide a robust model, rather than developing an accurate model that only works until it doesn't, then involves re-engineering to find a new, workable model that works until it doesn't.

4.13 Newton's Laws

Newton's laws of motion are:

Newton's First Law: An object in motion will stay in motion and an object at rest will stay at rest, unless acted upon by a force

Newton's Second Law: "Acceleration is produced when a force acts upon a mass. The greater the mass (of the object being accelerated) the greater the amount of force needed (to accelerate the object) "[26]

Newton's Third Law: For every action there is an equal and opposite reaction

All of Newton's laws of motion provide context and direction for stock prediction model development. The laws argue for inclusion of exogenous and indigenous forces in any path dependent model specification.

5. Ecosystems

5.10 Ecosystem Movement

Ecosystem movement considers the movement of elements through a particular system. Using various sets of hierarchies (one such hierarchy would be herbivore, carnivore, omnivore) this area of science describes the cycle of elements through the ecosystem. Such a description might be that rain brings air-borne particulates to the ground, herbivores eat the plant matter coated with the particulate, carnivores eat the herbivores (who now have ingested the particulate) and now the carnivore possesses the particulate, which they expel with their waste into the ground, and the cycle begins again.

If the particulate was a toxin, this movement would describe how the ecosystem would start to be destroyed. Carnivores that feed on carrion would become infected by eating the remains of herbivores, carnivores and omnivores that had ingested the toxin. Or carnivores would start to either starve or seek new territory once herbivores and omnivores start to die off.

Ecosystem movement does not provide a directly applicable model or consideration that can be utilized in stock market prediction. If the model grows to include investor sentiment ecosystem movement could be useful in describing how subjective investor feeling might flow through the investing population.

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[24]http://www.investopedia.com/articles/economics/09/financial-physics-laws-economy.asp
[25]http://www.investopedia.com/articles/economics/09/financial-physics-laws-economy.asp
[26]http://teachertech.rice.edu/Participants/louviere/Newton/law2.html

5.11 Ecology of Ecosystems

A definition of the ecology of ecosystems is "… the integrated study of living (biotic) and non-living (abiotic) components of ecosystems and their interactions within an ecosystem framework. This science examines how ecosystems work and relates this to their components such as chemicals, bedrock, soil, plants, and animals."[27] The ecology of ecosystems would be important to integrate into the model if ecosystem movement was determined to be relevant.

5.12 Shoaling

Shoaling has two basic definitions, the first related to fluid dynamics and the second related to ecosystems. From fluid dynamics: "In fluid dynamics, wave shoaling is the effect by which surface waves entering shallower water change in wave height. It is caused by the fact that the group velocity, which is also the wave-energy transport velocity, changes with water depth. Under stationary conditions, a decrease in transport speed must be compensated by an increase in energy density to maintain a constant energy flux."[28] It is interesting to consider whether shoaling can be analogized to a sell-off of large capitalization stocks with a movement into small-capitalization stocks (a wave from deep water entering shallow water) and the effect this could have on stock prices. Shoaling can be a function add-in or modifier to a momentum theory function under these circumstances.

5.13 Schooling

Schooling is the propensity for certain fish, birds, animals or insects to gather together to form masses (schools). Schooling generally occurs due to a biological instinct for survival against predators (schools of fish minimize the likelihood of any individual fish being eaten) or to minimize energy expended (v-formation of bird flight). A system consideration for stock price prediction could be based on a change in the population of investors. If individuals comprise the investing population they might behave in a way that displays schooling tendency (for reasons explained by behavioral economics). If the population of investors is mostly professionals, then schooling may not be pertinent. Schooling could be a consideration once the population of investors is determined.

6. Summary and Conclusion

The following are the functions and considerations that should be considered for inclusion into the model developed for stock price prediction.

List 6: Inclusion in an Integrated Model of Prediction

Correlation – for triangulation
Lagged correlation – for direct prediction
Regression
Autoregression
Momentum Theory

LIST 7: Inclusion as a Constraint, Parameter or Feedback Loop

Complexity theory
Chaos theory
Newton's laws

LIST 8: Possible Inclusion Depending Upon Identified Population of Investors

Behavioral economics
Sentiment theory
Shoaling
Schooling
There a number of next steps in development of the Omniscience Model.

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[27] https://en.wikipedia.org/wiki/Ecosystem_ecology

[28] https://en.wikipedia.org/wiki/Wave_shoaling. Wikipedia provides the following reference for this definition, but the reference could not be located:
Longuet-Higgins, M.S.; Stewart, R.W. (1964). "Radiation stresses in water waves; a physical discussion, with applications" (PDF). Deep-Sea Research and Oceanographic Abstracts. 11 (4): 529–562

1. A calculation of the amount of information that flows per second and the processing speed of the computers in use and the number of calculations required by the model will produce the frequency of the stock price predictions (i.e., every second, every 15 seconds, every minute, etc.)
2. The integration of the various components in a singular model, with consideration of the direct model, the filters, constraints and parameters

A rule for buying, selling and holding, if the model is to be used investing and not simply prediction.