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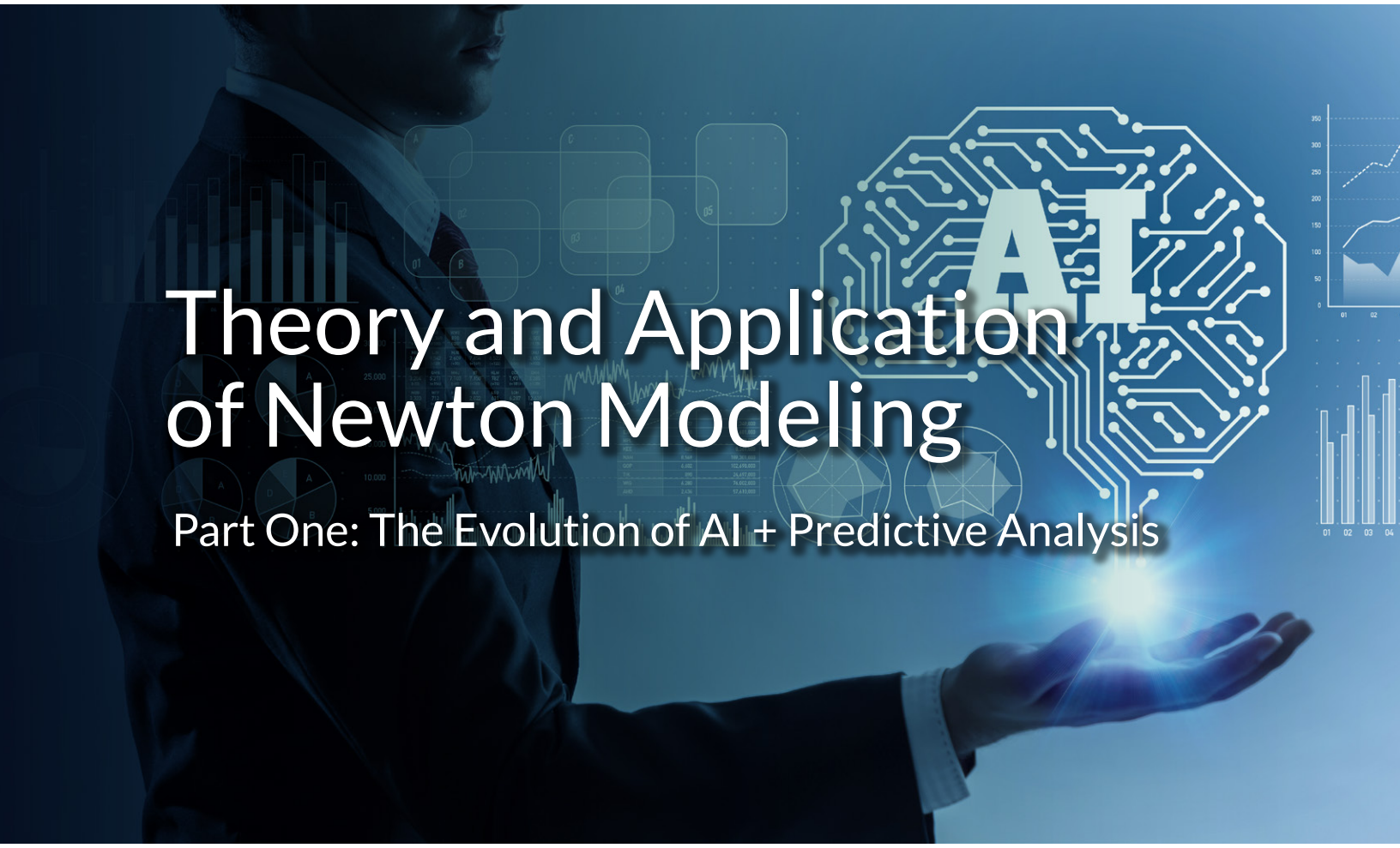

Theory and Application of Newton Modeling

Part One: The Evolution of AI + Predictive Analysis

Theory and Application of Newton Modeling

Bennett Woodward, CFA
CIO, Waterloo Capital

A groundbreaking article from *The Journal of Portfolio Management*[1] informs us that the stock market is a complex system, or a system that lies somewhere between the domains of pure order and total randomness. Ordered systems are simple and predictable, and random systems are inherently unpredictable.

Prior to this insight, academic investment theory primarily evolved around Eugene Fama's and Burton Malkiel's Efficient Market Hypothesis (EMH) from the 1960s. EMH, which has become gospel to many, states that it is impossible to beat the market because market "efficiency" causes existing prices to always incorporate and reflect all relevant information. On July 22, 2005, Burton Malkiel retired from 28 years of service as a Director of the Vanguard Group, the largest American investment management company that now manages well over $4 trillion in assets, almost all of which are passively indexed due to belief in efficient markets.

More recent theories from people like Jacobs and Levy hypothesized that simple theories, like EMH, do not adequately describe market returns, and that the returns are not purely random. Rather, Jacobs and Levy hypothesized that the market is permeated by a very complex web of interrelated effects, which require substantial computational power to disentangle, model, and exploit. We have arrived at a point where computational power can be used to capture more of the complexities of markets.

At Waterloo Capital, we have built on the foundation of this research to design a neural network-driven research tool that we call Newton. Through extensive testing, we have been able to show that Newton can provide an opportunity to exploit anomalies within the market's complex web of variable relationships.

> "… computational power has evolved to the degree where defining trends from chaotic systems is now possible."

1 Source: *The Journal of Portfolio Management* Vol. 16, No. 1, pp. 19-27, Fall 1989, Bruce I. Jacobs, Ph.D. and Ken N. Levy, Ph.D.

Understanding the differences in the concepts of randomness and chaos is crucial to our ability to make predictions about a multiplex system with chaotic properties. A random system, such as that supposed by the EMH, is totally unpredictable. For example, a coin that is tossed seven times in a row may land on heads each time. If you toss the coin an eighth time, the probability that it will land on heads again is still only 50%. Such stationary processes do not have a change in statistical properties over time and, therefore, cannot be predicted. EMH proponents base their philosophy of indexing on this simple stationary understanding of the markets. If markets are a stationary system then why attempt to disentangle and model price movements?

Decades of cutting edge research have shown that markets are not stationary processes, but are in fact "chaotic" systems. Chaos exacerbates statistical "noise", and to the untrained eye, it masks many discernible patterns. However, computational power has evolved to the degree where defining trends from chaotic systems is now possible. Natural processes, such as seismic events and population growth, are both examples of complex chaotic systems which over the long-term can be predicted with increasing accuracy.

Chaotic processes are controlled by several competing paradigms: **Stability, Memory, and Sudden and Drastic Change**. We can view each of these paradigms and their effects through careful observation of the stock market.

Stability can be observed by looking at stocks which have defined trends. The daily share price of a stock tends to bounce around a range like Brownian Motion would describe, but this noisy movement does not change the underlying defined trend. There is also a degree of instability due to what is called a "tired trend". As a stock continues to rise, there comes a point when investors start to question how long the trend can continue, which causes the trend to relax and lose stability. As people begin to lose confidence in a trend, stability decreases. When a trend becomes unstable, the expected effect of a small event can increase in magnitude and be substantial enough to reverse a trend entirely. The results of these reversals are typically fat-tail events which are rarely experienced under systems with normal distributions.

Memory is the influence that past events have on a current trend. For example, a stock that has consistently posted positive earnings surprises is more likely to continue exhibiting a similar pattern going forward. Additionally, studies on momentum have shown that the price movement of a stock over a specified period tends to repeat over similar future time periods.

Lastly, **Sudden and Drastic Change** can also occur and are capable of completely reversing a trend with little or no warning. Some refer to these as Black Swan events, as they seem both severe and unpredictable. Sudden and drastic change events are generally systematic, which makes them incredibly difficult to avoid.

These paradigms of cycles seem to be chaotic and unpredictable trends exhibiting varying periods of quiet followed by large jumps or collapses. Historically, the combination of these chaotic processes made it nearly impossible to accurately forecast changes in financial markets. Today, advanced computational power and statistical models introduced by the advent of the Second Digital Revolution have changed the way we think about and work with these competing paradigms. We can harness these new digital tools to comprehend chaos.

Nevertheless, creating a model of chaotic systems using mathematics is still difficult. This is due, in part, to what is commonly referred to as the Butterfly Effect, which theorizes that small changes that are seemingly unrelated to a system can cause drastic changes in the outcome. However, the presence of gradual trends and the rarity of drastic events in a system, such as we see in the markets, allow trends to be modeled well enough to exploit. The basic principle is that the magnitude of the event is inversely proportional to its frequency. In other words, the more frequently an event occurs, the smaller its expected impact on the system. Without advanced modeling, it is thus difficult to explain the exact cause and effect of correlations between events and market reactions.

Any number of arguments may explain how each unique factor is influenced by the others. However, through the use of artificial intelligence and machine learning, we are discovering that there is an intermediate state between random white noise and random walk noise which can be exploited. In chaotic processes, past events influence current and future events. In statistics, this connection between a series of data and its past and future values is called autocorrelation. Autocorrelation functions for random processes that decay exponentially, but for chaotic processes, they have a certain degree of persistence which we can leverage to make predictions and forecasts. This is crucial, as it allows us to examine the high ordered polynomial equations that describe trends in prices and relative performance.

Due to the complicated nature of modeling chaos using statistics, scientists look to computers to help solve problems. Artificial intelligence and machine learning have proven to be incredibly successful in modeling chaotic structures and ultimately in making predictions.

The purpose of machine learning is to generalize trends that most of us cannot comprehend. A computer can be programmed to take in large amounts of data, search for patterns within the data, and then project future outcomes based on the patterns that it finds. We have found that it is possible to make much more accurate predictions about future behavior using machine learning techniques. This approach is the core of our predictive price and trend algorithms which we have dubbed **Newton**.

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The Newton system has its origins in a 1968 project by Alexey G. Ivakhnenko at the Institute of Cybernetics in Kiev (then in the USSR). The first investigation of the method outside the Soviet Union was by R. Shankar, an Indian theoretical physicist who is now the John Randolph Huffman Professor of Physics at Yale University. Cybernetics began as an interdisciplinary study connecting the fields of control systems, electrical network theory, mechanical engineering, logic modeling, evolutionary biology, and neuroscience.

Today, almost every field of science is now employing big data and concepts stemming from cybernetics. Variations of cybernetic systems are being used to discover the basic principles underlying such things as Artificial Intelligence, Computer Vision, Learning Organization, and Robotics. Waterloo Capital is one of the earliest adopters of cybernetics in the investment field.

We constantly track market data and add it to our database of historical time series data. Then, employing this database, we use our proprietary Newton algorithms to make forecasts and predictions for market action over differing time horizons. As our computer receives additional data input, the algorithms learn from past successes and failures, and optimize high order polynomial curves to more accurately predict the future direction of incoming data. The Newton methodology attempts to forecast waves in market action and project possible future price trend trajectories.

Every day, our Newton algorithm analyzes raw data to generate an updated forecast for over one thousand Exchange Traded Funds (ETFs), and over 1,500 stocks. Newton then produces "noise filtered" signals that we can quickly analyze and act upon.

These signals represent predicted price movement direction – up, down, topping or bottoming - and the velocity of the increase or decrease for each asset. The model also calculates the statistical predictability of the historical correlation between the past Newton predictions and the actual market movement for each asset.

Newton models utilize artificial intelligence + machine learning to generalize trends that most systems or people cannot comprehend. Newton can filter large amounts of data, search for patterns in that data, and then project future outcomes based on the patterns that it finds. We found that it is possible to make far more accurate predictions about future behaviors using machine learning techniques built into our Newton models.

Newton tracks 1,500 equities and 1000 ETF's. Newton then recommends positions based on current market characteristics. We then uses our optimization software to build portfolios and recommended allocations.

Want to learn more?

Call us **(512) 777-5900** or email us at **info@waterloocap.com** to put the power of Newton to work for your investing.

For example, when we first fed our computer mountains of information back in mid-2014, Newton suggested a topping in energy prices and energy-related securities. Few analysts of any type were making forecasts predicting a reversal in energy prices and many maintained decidedly bullish views of industry. The price of oil and the energy sector subsequently fell over 50% and many high-flying energy companies went bankrupt.

As we watched this unfold in 2014 and 2015, we fed the computer more historical data from earlier in the decade and, low and behold, Newton generated accurate forecasts of both the coming financial crisis of 2008 and the dot-com crash of 2000, months before they happened. The results of these studies were too powerful to ignore. Over the next four years, we kicked research into overdrive and began perfecting the models that we run today. During my career, I've created some very good models that have helped me to produce market leading performance, but this is the best model that I have developed thus far. I will never attempt to manage money without its aid – it is that good.

The current market environment is unlike any we have experienced before. Valuations in both the stock and bond markets are hovering near historical highs. Prevailing pricing models have been broken by negative interest rates. The lines between politics, monetary policy, and the markets routinely shifts from blurry to non-existent. In the decade since the Global Financial Crisis, the rising tide of the global economy lifted all boats. Today it seems that everywhere we look we see unprecedented shifts in what is worrying, supporting, and leading the markets. In this environment, we feel that relying exclusively on passive management will lead to disappointing investment outcomes. Utilizing Newton to actively manage portfolios gives us an opportunity to capture significant upside and avoid unexpected drawdowns in all market environments. Newton enhances our ability to stay ahead of the curve and take advantage of the rapid changes that are becoming more prevalent as we charge towards the later stages of the market cycle.

About the Author

Bennett Woodward, CFA

Mr. Woodward is the Chief Investment Officer and head of equity portfolio management for Waterloo Capital. Bennett began his portfolio management career in 1982 at ING Investment Centre as the Chief Investment Strategist, managing equity, fixed income and balanced portfolios. During his tenure, he received the INDATA award for best 5-year performance out of 720 similarly sized pension funds.

Bennett was then recruited to be the Equity Investment Officer for the $100 Billion Teacher Retirement System of Texas, where he worked for nearly a decade. He went on to join Globalt Inc. as a Senior Portfolio Manager & Partner and most recently managed public equity portfolios at Raymond James & Associates for 5 years. He then co-founded Black Diamond Investment Partners, which subsequently merged with Waterloo Capital in 2016.

Many of the investment models that Bennett developed during his career are still being used today. He has built on his previous work by utilizing cutting-edge technologies, such as machine learning and artificial intelligence, to develop actively managed portfolios. Mr. Woodward studied botany and bacteriology at DePauw University and completed his MBA at Emory University.

About Waterloo Capital

We are a SEC registered investment advisor and fiduciary — always acting in our clients' best interests. Our holistic approach to wealth management creates intelligent wealth solutions to high-net-worth and institutional clientele. Our suite of internal money management, institutional level private investments and financial planning are all provided with a personal touch. Our focus is to help clients accomplish their unique goals by delivering superior service through personalized one-on-one experiences with each member of our team.

A Holistic & Dynamic Approach

Our holistic wealth management solution brings together financial planning, public market asset management, and private market/alternative asset management. We focus on our clients' unique needs and are vigilant stewards. We also provide business consulting and valuation services when appropriate.

Experience, Innovation & Trust

With over 150 years of combined experience, clients gain insight into opportunity. We've assembled the best and brightest minds in the industry coupled with cutting edge technologies, investment opportunities, and services. Our goal is to foster a culture of mutual trust and integrity in all we do.

Overview

Core Services: Financial Planning, Public Market Investment Management, and Private Market Investment Management

Firm AUM: Approximately $815,000,000

Working Together: We aspire to develop long-term relationships, as a result, we take the extra steps that are needed to determine whether we are the right fit with prospective clients.

Experience: Over 150 Years of Combined Experience

Locations: Austin, Texas (National Headquarters) and Atlanta, Georgia

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