

THE INTERNATIONAL JOURNAL OF APPLIED FORECASTING



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"Knowledge of truth is always more than theoretical and intellectual. It is the product of activity as well as its cause. Scholarly reflection therefore must grow out of real problems, and not be the mere invention of professional scholars." JOHN DEWEY, UNIVERSITY OF VERMONT

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Article Coding: General (GEN), Managers (MGR), Modelers (MOD), Planners (PLN)

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fall 2013 notes from the editor

The Fall 2013 Issue

Forecasting Support Systems (FSS) – essentially, decision support systems for forecasters – are being given increasing scrutiny in forecasting circles, including our recent half-dozen articles in *Foresight*. Additionally this year, there has been a special issue of the *International Journal of Forecasting* focused on the topic.

Keith Ord and Robert Fildes offer this definition of FSS in their new textbook, *Principles of Business Forecasting*:

A set of (typically computer-based) procedures that facilitate interactive forecasting in an organizational context. An FSS enables users to combine relevant information, analytical models, and judgments, as well as visualizations, to produce forecasts and monitor their accuracy (p. 398).

This 31st issue of *Foresight* contributes two new articles to the FSS literature. **Sujit Singh**, COO of software-services company Arkieva, leads with a comprehensive evaluation of the adequacy of Excel in forecasting support, **Supply Chain Forecasting and Planning: Move On from Microsoft Excel?** Sujit explains that Excel's shortcomings become more and more glaring as organizations grow in size and complexity. Then **Tim Januschowski**, **Stephan Kolassa**, **Martin Lorenz**, and **Christian Schwarz** present a systems development of intriguing potential in **Forecasting with In-Memory Technology**. The authors believe that this synthesis of analytical and transactional processing can enhance the use and acceptance of forecasting analytics within the organization.

In our **Financial Forecasting** piece, *Foresight* welcomes **Jeffrey Mishlove**, author of *The Alpha Interface* series of books and blogs on financial markets, who looks ahead to **The Future of Financial Market Forecasting: Five Trends Worth Watching**. Don't miss the interview with Jeff in this issue as part of our occasional "Forecaster in the Field" feature.

Our always popular **Book Reviews** look at a pair of interesting titles. The first is Professor Mark Moon's **Demand and Supply Integration: The Key to World-Class Demand Forecasting**. Reviewer **John Mello** examines Moon's contention that DSI represents the way Sales and Operations Planning should be practiced within an organization. The second review is on **Keeping Up with the Quants: Your Guide to Understanding and Using Analytics** by Tom Davenport and Jinho Kim, and is a follow-up to Davenport's *Competing on Analytics: The New Science of Winning* (coauthored with Jeanne Harris). **Jack Pope**'s review judges the book to be most appropriate for those "in non-quantitative roles that depend on others for the heavy analysis work." Our section on **Forecasting Principles and Practices** makes a convincing argument for greater application of statistical process control (SPC) in forecasting evaluation and planning. **Using Process Behaviour Charts to Improve Forecasting and Decision Making** is written by **Martin Joseph** and **Alec Finney**, longtime practitioners of SPC. They feel that process behaviour charts (PBCs) can bring significant new perspectives to S&OP meetings by distinguishing situations requiring action from those where changes are not really called for.

Then, **Chris Gray**, noted author of books on S&OP and Operations Management, provides his perspective on the evolution of the forecasting function in organizations. In **New Directions in Managing the Forecasting Process**, Chris observes that "businesses have shifted their focus away from the purely mathematical and statistical hammers and nails of forecasting and toward better management of the forecasting process." His article offers a set of seven requirements for effective forecast-process management.

We Welcome a New Editor and Two New Board Members



A hearty welcome first to **John Mello** as *Foresight*'s new **S&OP Editor**. John has been one of *Foresight*'s most prolific contributors,

with 10 articles and reviews – including his book review in this issue. Perhaps his most influential article was "The Impact of Sales Forecast Game Playing on Supply Chains" in our Spring 2009

issue. Special thanks go to **Bob Stahl**, stepping down as S&OP Editor after four years and numerous *Foresight* columns and articles on this





important subject.

Joining *Foresight*'s **Editorial Board** is **Jeffrey Mishlove**, whose article on the future of financial forecasting appears in this issue as well as his "Forecaster in the Field" interview.

And **Sujit Singh**, author of this issue's special feature article evaluating Excel as a forecasting support

system, joins our **Practitioner Advisory Board**. Sujit is Chief Operating Officer of Arkieva, where he is involved in software consulting, product management and, more recently, business development.





The Future of Financial Market Forecasting: Five Trends Worth Watching

JEFFREY MISHLOVE

PREVIEW Jeffrey Mishlove, author of The Alpha Interface series of empirical research on the financial markets, highlights five trends that have the power to alter the landscape of financial fore-

casting. His message is essential food for thought for all of us in the forecasting profession: only rarely is it possible – or even advisable – to stick to our tried-and-true methods of the past. It is crucial for forecasters to stay on top of advances in such areas as constantly increasing computer capability, "natural language" processing, and expanding the power and complexity of algorithms.

INTRODUCTION: ADAPTIVE MARKETS

There is a view that financial markets are ecological systems in which different groups ("species") compete for scarce resources. Called the *adaptive markets hypothesis* (AMH), it posits that markets will exhibit cycles where competition depletes existing trading opportunities, and then new opportunities appear.

The AMH predicts that profit opportunities will generally exist in financial markets. While competition will be a major factor in the gradual erosion of these opportunities, the process of learning is an equally important component. Higher complexity has the effect of inhibiting learning strategies so that the more complex ones will persist longer than the simple ones. Some strategies will decline as they become less profitable, while other strategies may appear in response to the changing market environment.

Profitable trading opportunities fluctuate over time, so strategies that were previously successful will display deteriorating performance, even as new opportunities appear.

In this article, I highlight five relatively new, complex approaches that I believe will come

to characterize the landscape of financial forecasting over the next several years.

I. THE RISE OF THE SUPERCOMPUTER

In this era of cloud computing, big data, server farms, and the smartphone in your pocket that's vastly more powerful than a roomful of computers of previous generations, it can be easy to lose sight of the very definition of a *supercomputer*. The key is "capability," or processing speed, rather than capacity, or memory.

For financial forecasters, the particular computing capability of interest is the probabilistic analysis of multiple, interrelated, highspeed, complex data streams. The extreme speed of global financial systems, their hyperconnectivity, large complexity, and the massive data volumes produced are often seen as problems. Moreover, the system components themselves increasingly make autonomous decisions. For example, supercomputers are now performing the majority of financial transactions.

High-frequency (HF) trading firms represent approximately 2% of the nearly 20,000

Key Points

Five trends likely to have the greatest impact in financial forecasting over the coming decade are:

- the lowered cost and greater power of parallelprocessing supercomputers
- breakthroughs in contextual, "natural language" processing via machine
- more powerful algorithms for pattern recognition
- ability to identify the unique characteristics of individual, expert forecasters
- advance warnings of bubbles and crashes

trading firms operating in the U.S. markets, but since 2009 have accounted for over 70% of the volume in U.S. equity markets and are approaching a similar level of volume in futures markets. This enhanced velocity has shortened the timeline of finance from days to hours to nanoseconds. The accelerated velocity means not only faster trade executions but also faster investment turnovers. At the end of World War II, the average holding period for a stock was four years. By 2000, it was eight months; by 2008, two months; and by 2011, *twenty-two seconds*.

The "flash crash" of May 6, 2010 made it eminently clear to the financial community (i.e., regulators, traders, exchanges, funds, and researchers) that the capacity to understand what had actually occurred, and why, was not then in place. In the aftermath of that event, the push was begun to try applying supercomputers to the problem of modeling the financial system, in order to provide advance notification of potentially disastrous anomalous events. Places such as the Center for Innovative Financial Technology (CIFT) at the Lawrence Berkeley National Laboratory (LBNL) and the National Energy Research Scientific Computing (NERSC) center assumed leading roles in this exploration.

Fortunately for many forecasters, you no longer need to affiliate with a governmentfunded megalaboratory in order to access high-performance computing power. Although the only way to get high performance for an application is to program it for multiple processing cores, the cost of a processor with many cores has gone down drastically. With the advent of multicore architecture, inexpensive computers are now routinely capable of parallel processing. In the past, this was mostly available only to advanced scientific applications. Today, it can be applied to other disciplines such as econometrics and financial computing.

It is worth taking a moment here to look at the size of the market data problem. Mary Schapiro, chair of the SEC from 2009 through 2012, estimated the flow rate of the data stream to be about twenty terabytes per month. This is certainly an underestimation, especially when one considers securities that are outside the jurisdiction of the SEC, or bids and offers that are posted and removed from the markets (sometimes in milliseconds). Nevertheless, supercomputers involved in scientific modeling such as weather forecasting, nuclear explosions, or astronomy process this much data every second! And, after all, only certain, highly specialized forecasting applications are going to require real-time input of the entire global financial market. Many forecasting applications do well enough with only a small fraction of this data.

Let's look at two unique and creative examples of financial-forecasting research that could not have been accomplished without the assistance of supercomputers.

"Reverse Engineering" a Financial Market

Wiesinger and colleagues (2013) of the Swiss Institute of Technology in Zurich developed a method to "reverse engineer" real-world financial time series. They modeled financial markets as being made of a large number of interacting, rational Agent-Based Models (ABMs). ABMs are, in effect, virtual investors. Like real investors and traders, they have limited knowledge of the detailed properties of the markets they participated in. They have access to a finite set of strategies to take only a small number of actions at each time-step and also have restrictions on their adaptation abilities. Given the time series training data, genetic algorithms were used to determine what set of agents, with which parameters and strategies, optimized the similarity between the actual data and the data generated by an ensemble of virtual stock markets peopled by software investors. By optimizing the similarities between the actual data and that generated by the reconstructed virtual stock market, the researchers obtained parameters and strategies that revealed some of the inner workings of the target stock market. They validated their approach by out-ofsample predictions of directional moves of the Nasdaq Composite Index.

The following five types of ABMs were employed:

- **Minority Game.** Here, an agent is rewarded for being in the minority. An agent has the possibility not to trade, thus allowing for a fluctuating number of agents in the market.
- **Majority Game.** An agent is rewarded for being in the majority instead of in the minority.
- **Delayed Majority Game.** Like the majority game, but the return following the decision is delayed by one time-step.
- **Delayed Minority Game.** This game is like the minority game, except for the delayed payoff.
- **Mixed Game.** Here 50% of the agents obey the rules of the majority game, with the other 50% obeying the rules of the minority game.



55%

60%

All Days

65%

Trending Days

Figure 1. Out-Of-Sample Success Rate of Agent Based Models Predicting NASDAQ Composite

50%

Non Trending Days

The models were trained on simulated market data using a genetic algorithm. They were then tested on out-of-sample, actual data from the Nasdaq Composite Index. The results are shown in figure 1.

All agent-based models performed to a level of statistical significance. This was largely due to the success of the models in trending markets. Interestingly, both the trendfollowing and contrarian strategies worked well during the trending markets. Similar results are reported by active traders.

CEO Network Centrality and Corporate Acquisitions

BoardEx is a business intelligence service used as a source for academic research concerning corporate governance and boardroom processes. It holds in-depth profiles of over 400,000 of the world's business leaders, and its proprietary software shows the relationships between and among these individuals. This information is updated on a daily basis.

El-Khatib and colleagues (2012) from the University of Arkansas used a supercomputer to analyze this data. They calculated four measures of network centrality – Degree centrality, Closeness centrality, Betweenness centrality, and Eigenvector centrality – for each executive connected into such business networks.

Degree centrality was the sum of direct ties an individual had in each year. Closeness centrality was the inverse of the sum of the shortest distance between an individual and all other individuals in a network. Betweenness centrality measured how often an individual rested on the shortest path between any other members of the network.

> Eigenvector centrality was a measure of the importance of an individual in the network, taking into account the importance of all the individuals that were connected in the network.

> The amount of computation was daunting and required storing information for each and every possible pair of business leaders in computer memory. Processing the Closeness factor, for example, took about seven days on the "Star

70%

of Arkansas" supercomputer at the Arkansas High-Performance Computing Center.

The final result, interestingly, showed that CEOs more centrally positioned were more likely to bid for other publicly traded firms, and these deals carried greater value losses to the acquirer as well as greater losses to the combined entity. The researchers followed the CEOs and their firms for five years after their first value-destroying deals, and found that firms run by centrally positioned CEOs better withstood the external threat from market discipline. Moreover, the managerial labor market was less effective in disciplining centrally positioned CEOs because they were more likely to find alternative, highpaying jobs. Ultimately, they showed that CEO personal networks could have their "darker side" – well-connected CEOs became powerful enough to pursue any acquisitions, regardless of the impact on shareholder wealth or value.

Figure 2. Acquisitions By Executives With Low and High Network Centrality



As shown in Figure 2, across all four dimensions of CEO network centrality, the research study clearly demonstrated that CEOs with the most social connectivity were those most willing to make risky, and generally unprofitable, acquisitions.

II. FORECASTING WITH NATURAL-LANGUAGE PROCESSING

IBM's Watson computer, which beat champions of the quiz show *Jeopardy*! in a wellpublicized face-off two years ago, is now being employed to advise Wall Street on risks, portfolios, and clients. Citigroup Inc., the third-largest U.S. lender, was Watson's first financial services client. The unique Watson algorithms can read and understand 200 million pages in three seconds. Such skills are well suited for the finance industry. Watson can make money for IBM by helping financial firms identify risks and rewards. The computer can go through newspaper articles, documents, SEC filings, and even social-networking sites to try to make some sense out of them.

This approach is not entirely new. Many high-frequency traders have trained algorithms to capture buzzing trends in the social-media feeds. The hitch here, however, is that they haven't been fully "taught" the dynamics of accurate context of the information being diffused. The results at times can be fascinating, odd, even comical – and, if you will, potentially ominous. A good example: on February 28, 2011, during the annual hubbub and media excitement of the U.S. movie industry's Academy Awards when actress Anne Hathaway hosted the event televised worldwide, stock prices of Berkshire Hathaway rose by 2.94%. Figure 3, of BRK.B stock, shows only one of many instances where the curves of Ms. Hathaway's career have shaped the stock price of this particular conglomerate. It is interesting to note that, in this instance, traders realized the error and the huge stock price jump reversed itself the very next day on March 1.

Figure 3. Daily Stock Chart



Berkshire Hathaway (BRK.B) daily stock chart, February 2011, showing an unusual price jump on the day that actress Anne Hathaway hosted the Academy Awards ceremony.

Recent events such as these demonstrate the shortcomings in the contextual discrimination of natural-language processing. Fortunately, things are changing rapidly. A Google search on the phrase "natural language processing" yields over 3.1 million results. This is a very hot area for forecasting, as natural-language processing of news stories, tweets, and message-board posts have now been the focus of dozens of research studies.

Although the original Watson computer contained \$3 million worth of hardware alone, IBM is now releasing a new server that can be purchased for about \$67,000 complete. It includes a scaled-down version of the brain IBM engineered to build Watson.

Reuters publishes 9,000 pages of financial news every day. Wall Street analysts produce five research documents every minute. Financial services professionals receive hundreds of emails a day. And these firms have access to data about millions of transactions. The ability to consume vast amounts of information to identify patterns and formulate subsequent hypotheses naturally

makes Watson-style computing an excellent solution to making informed decisions about investment choices, trading patterns, and risk management.

III. SMARTER PATTERN RECOGNITION AND PATTERN RECALL

The following example of a breakthrough in pattern-recognition technology is reprinted from my book *The Alpha Interface: Empirical Research on the Financial Markets*,

Book Two. It exemplifies the level of creativity and power available to the new generation of personal computers with parallelprocessing capacity.

Fong and colleagues (2012) from the University of Macau, China, and the University of Riyadh, Saudi Arabia presented a new type of trend-following algorithm – more precisely, a "trend recalling" algorithm – that operated in a totally automated manner. It worked by partially matching the current trend with a proven successful pattern from the past. The algorithm drew upon a database of 2.5 years of historical market data.

The system spent the first hour of the trading day evaluating the market and comparing the initial market pattern with hundreds of patterns from the database. The rest of the day was spent trading based on the match that was eventually made, and using sophisticated trading algorithms to avoid conditions where volatility was either too high or too low. The schematic of the trading system is diagrammed below.

Their experiments, based on real-time Hang Seng index futures data for 2010, showed that this algorithm had an edge in profitability over the other trend-following methods. The new algorithm was also compared to time-series forecasting types of stock trading. In simulated trading during 2010, after transaction costs, the system attained an annual return on investment of over 400%, making over 1,100 trades. Figure 4 compares the trend-recalling protocol to four other trend-following algorithms (as listed on the top of the chart):





Reprinted from Fong, Tai, and Pichappan (2012) with permission.

This mind-boggling result of a return greater than 400% is the most robust I have encountered thus far in my survey of the scientific literature on the financial markets. It requires the creation of a unique database for each market being traded. In all likelihood, not every market will provide results as strong as these found in the Hang Seng index. However, there are many potential markets that could be exploited in this manner. Considering the costs of developing trend-recalling algorithms and also creating unique databases for each market, the Figure 5. Out of Sample. Next Day Test Results for Per User Ranking



potential for success seems considerable for those who are equipped and ready to pursue this path.

IV. GREATER SKILL IN IDENTIFYING EXPERT FORECASTERS

Bar-Haim and colleagues (2011) from the Hebrew University of Jerusalem downloaded tweets from the StockTwits.com website during two periods: from April 25, 2010, to November 1, 2011, and from December 14, 2010, to February 3, 2011. A total of 340,000 tweets were downloaded and used for their study.

A machine learning system was used to classify the tweets according to different categories of fact (i.e., news, chart pattern, report of a trade entered, report of a trade completed) and opinion (i.e., speculation, chart prediction, recommendation, and sentiment). A variety of algorithms were then employed to determine if some microbloggers were consistently more expert than others in predicting future stock movement.

Figure 5 shows cumulative results for the first twenty users in the "per user" model. This model learned from the development set a separate Support Vector Machine regression model for each individual user, based solely on that user's tweets. The approach was completely unsupervised machine learning, and required no manually tagged training data or sentiment lexicons.

The results showed that this model achieved good precision for a relatively large number of tweets, and for most of the data points reported in the table the results significantly outperformed the baseline. Overall, these results showed the effectiveness of two machine learning methods for finding experts through unsupervised learning.

While the accuracy level declined as additional users were included, the results were statistically significant for the first eleven users, and again for users seventeen through twenty. Overall, these results illustrate the importance of distinguishing microblogging experts from nonexperts.

The key to discovering the effectiveness of individual microblog posters was to develop unique regression models for each poster, rather than relying on a one-size-fits-all heuristic. It was also important to understand the relevant time frames involved. Another study, for example, found that retail traders responded most favorably to recommendations of message-board posters who had been most accurate during the previous five days.

V. BETTER RECOGNITION OF BUBBLES AND CRASHES

The theoretical underpinnings of bifurcations and phase transitions in finance have been around for many years. In the 1970s, the mathematical framework of *catastrophe* theory became a popular field of research, as it provided one of the first formalizations that included notions both of equilibrium and nonlinear-state transitions. This formalism resulted in parsimonious descriptions of bull and bear markets and market crash dynamics. It employed a small number of parameters such as the relative proportion of technical traders (those who base their strategies on historical prices) and fundamentalists (those who base their strategies on the underlying business dynamics).

Since 1999, many researchers have argued that financial bubbles and crashes exhibit unique mathematical signatures known as *log-periodic oscillations*. This refers to a sequence of oscillations with progressively shorter cycles of a period decaying according to a geometrical series. The pattern has been documented in unrelated crashes from 1929 to 1998, on stock markets and currencies as diverse as those in the U.S., Hong Kong, and Russia, as well as for oil and even real estate. Recent refinements indicate that this approach is becoming increasingly sophisticated (Filimonov and Sornette, 2013), and with the onset of massive databases and high-performance computing, it has become possible to empirically study the more granular dynamics of the relationships between securities.

Researchers are coming to understand these processes with ever greater mathematical sophistication. As one example of several recently published, Quax and colleagues (2013) from the University of Amsterdam in the Netherlands have measured this selforganized correlation in terms of the transmission of information among units. They recently introduced the information dissipation length (IDL) as a measure of the characteristic distance of the decay of mutual information in the system. As such, it can be used to detect the onset of long-range correlations in the system that precede critical transitions.

The higher the IDL of a system, the larger the distance over which a unit can influence other units, and the better the units are capable of a collective transition to a different state. Because of this, they can measure the IDL of systems of coupled units and detect their propensity to a catastrophic change. As a demonstration of the IDL as a leading indicator of global instability of dynamical systems, they measured the IDL of risk trading among banks by calculating the IDL of the returns of interest-rate swaps (IRS) across maturities. and Israel. Most trends highlighted in this article will come to lose their potency as the market as a whole digests them. For the foreseeable future, though, computers will continue to operate at faster speeds allowing for greater granularity of analysis. And as for human creativity, it seems to be an almost infinite resource.

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CONCLUSION

The markets never rest. Almost all new developments eventually become incorporated into the collective intelligence of the market itself. Only in the rarest of circumstances is it possible for financial forecasters to stick to the tried-and-true methods of the past. For the most part, it is essential to stay ahead of the curve.

In today's global economy, as this article has shown, new creative forecasting approaches and solutions are coming from places such as Macau, Saudi Arabia, the Netherlands,



Jeffrey Mishlove is the author of *The Alpha Interface* series of books about empirical research on the financial markets. For 15 years he hosted the national public television series *Thinking Allowed*. He and his wife, Janelle Barlow, own the U.S. license for the international business consulting and training groups, TACK

and TMI. Jeff received an interdisciplinary doctoral degree from the University of California, Berkeley in 1980.

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Forecaster in the Field



Interview with Jeffrey Mishlove, author of *The Alpha Interface* series

How did you get started in financial forecasting? In the mid-1990s, I was serving as president of a nonprofit organization called the Intuition Network, which was dedicated to helping people cultivate and apply their intuitive abilities. A number of our members were active in the financial markets, and several were eager to instruct me in their approaches. Before long, I complemented the intuitive

approach with a study of technical analysis and neural networks. The results proved to be surprisingly successful in a short period of time.

How did you come to create The Alpha Interface book series? One day, my wife, Janelle Barlow, came to me and said, "I have a billion-dollar idea for you." In the course of our conversation, I realized that there was a huge body of recent, empirical research about the operation of the financial markets. Old theories concerning the random walk and the "efficient market" were being challenged on multiple fronts. Ironically, most traders, investors, and even economists were unaware of the full scope of this research. The financial forecasting landscape is changing rapidly. Because I have the ability to digest a large volume of information and make it understandable to the general public, I took this project on. Three books have now been released.

What other forms of forecasting have been important in your development? As a doctoral student at UC Berkeley with an interdisciplinary program in parapsychology, I became familiar with the research literature in such areas as precognition and remote viewing. Although I began as a skeptic in my inquiry into these topics, after carefully studying the evidence that's accumulated for more than a century, I became convinced that this is an important field. Some outstanding scientists have contributed to this area of study. My first book, *The Roots of Consciousness* (1975), dealt extensively with these phenomena.

I also had the privilege of hosting the national public-TV series *Thinking Allowed* over a 15-year period. During that time, I conducted intimate interviews with thought leaders in philosophy, psychology, health, science, and spirituality. Each of my guests in their own way was attempting to forecast – and to influence – the future of humanity. A number of them were professional forecasters. Their influence rubbed off on me. So it's fair to say my approach is interdisciplinary.

Do you work with businesses to improve their forecasting accuracy? As scientific as business forecasting can be, there's always a human element. My wife Janelle and I own the licenses in the United States for TMI and TACK, two international training and consulting consortiums. These businesses work with organizations to optimize the full potential of their systems and staff. We like to say that TACK is about getting customers, and TMI is about keeping them. Our clients are typically, but not always, multinational companies. Missed forecasts often occur when different branches of a business are not aligned with each other, nor with the brands they represent. We help them to identify and then correct these gaps in their organizational alignment and in the collective skill sets of their staffs.

Tell us about your other interests. In 2010, two friends and I discovered the first confirmed dinosaur footprints found in the state of Nevada. They were just a few miles from my home in Las Vegas, in the nearby Red Rock Canyon National Conservation Area.