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A New Framework for Risk and Return In Liquid Markets

By Richard Olsen

Action, reaction, and the echoes of uncertainty:
the R&D we **should** be doing, and how that will contribute
to true efficiency in the marketplace

Richard Olsen challenges three received notions that mire the global economy in counter-productive habits that destroy value: that market prices in gross time tell us everything we need to know; that such information as we have is a trustworthy indicator of things to come; and that the chain of events in price evolution is orderly and self-correcting.

Olsen Ltd. has discovered and validated 17 new power laws that prove this firm's long-held belief: much of the market's volatility is invisible to casual, low-resolution analysis. While much work remains to be done, Olsen is taking steps to encourage the accumulation and analysis of very-high-resolution data to fuel sophisticated models that leverage the insights and power of the new scaling laws. With two strategic objectives: to increase return as a product of the predictive capacity of better trading models, and to counter the effect of inevitably irrational behavior by providing liquidity in the face of skewed pricing patterns.

The motivation for this initiative is *economic* in the truest sense: simplistic analysis is out of step with the pace and expectations of the modern marketplace. First we must deploy technology to vastly improve the quality of what we know; then we have to apply that knowledge to combat opportunistic manipulation that distorts the value and utility of financial assets.

We measure economic health by reading a wide range of indicators, from the growth rate of countries' GNPs to the volatility of multiple financial markets. And then there are the balance sheets of the world's banks. Since June 2007 the "negative indicators" have been piling up: unprecedented price shocks in commodities—especially oil and rice, unusual volatility in the foreign exchange currency markets, and the crippling of many large banks due to USD 450 billion in losses incurred through sub-prime debt. The alarm bells are screaming, but we are obliged to ask: was this crisis

"Negative indicators" is of course a wild understatement in this context. But it is typical of the finance industry's obliviousness to the real human cost of the current global crisis. The spectrum of suffering ranges from higher costs at the gas pump in developed countries, and the loss or diminution of lifetime savings, to displacement and starvation in less-developed countries. *Negative indeed*.

inevitable, or could we have prevented it? Is this just a one-off event, or does it reveal a more permanent, more threatening flaw in modern finance?

The roots of failure

Finance is the cornerstone for the smooth functioning of the global economy. Unaware of the impact of their decisions, investors and traders large and small determine the relative prices of currencies, the level of interest rates, and stock prices. These market participants too often act on the basis of gut feeling or—in the best cases—on the basis of scenario-analysis from Excel spreadsheets. There is not much "science" to guide them.

Because finance is not treated as a science, financial institutions lack the research budgets that are common and indispensable in other industries. Just ask your banker if his organization spends 10% of revenue on R&D, as do his colleagues in energy, engineering and pharma. It's likely his argument will be that banks don't *need* to do research, and, in any case, they're already spending a fortune on IT to automate business processes and they can't afford to go out on a limb.

There is little incentive for banks to second-guess their investment decisions. Their focus is on short-term profits, not on fixing a system they don't perceive as broken. And this focus is perpetuated by a compensation scheme that rewards near-term results and the fundamental belief that markets are essentially efficient. Even the largest banks have invested primarily in hardware and technology to manage daily transaction flow, without stopping to question how their trading really works or why. Why take a risk on the dubious rewards of empirical research into the mechanisms of the marketplace when the trading desk can usually net out in the black?

Adam Smith, the founder of classical economics, shaped the general perception of how markets function. His theory of an "invisible hand" states that market participants are homogeneous and respond uniformly to events, which means that prices immediately adjust to outside factors and new information. Classical economics does not address the irrationality of the marketplace, or the fact that market participants form groups that respond differently to the same events and generate secondary reactions that may play out unevenly and over time.

The fallacy of the 90-day window

Banks, investment banks, and institutions with a vested interest in managing assets tend to see the world in fiscal quarters. To satisfy shareholders, investors and regulators, but also to sustain a stream of income that enriches the top end of the org chart and then quickly evaporates.

The universal mandate is to keep on keeping on. Finance and economics are too complex to allow such an approach. There are myriad instruments with complex pricing structures, costs, and counterparty relationships; change is continuous, potentially explosive, and a function of feedback processes and bad (or selectively disseminated) information that is not understood or is misperceived; exchanges and regulators impose rules that imply a sense of order and fair play but are easily skirted by huge players with hundreds of billions in assets at stake; there is no fixed point of reference because the 21st-century economy is stuck in an 18th-century perception of how free markets work.

New markets, new information, but where is the new theory?

Foreign exchange currency markets are the most liquid financial markets in the world, with a daily transaction volume

Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity in 2007. See http://www.bis.org/publ/rpfxf07t.htm.

of USD 3 trillion (about 50 times the combined daily turnover of the world's equity markets). Currency markets trade over-the-counter, with transactions executed directly through a market-maker and with no obligatory exchange that imposes constraining rules on market activity. The FX markets are open 24 hours a day and never come to a complete standstill.

FX is a perfect laboratory for research: the buying and selling of currency is at the core of the global financial system and its functioning determines the health of the world's economy. Comparable to a high-energy accelerator in physics for the study of atomic particles, foreign exchange markets offer the opportunity to research market behavior at very high transaction volumes.

With FX price updates coming nearly every second, researchers can follow market action in detail. Market-makers publish a stream of price updates that they skew according to the imbalances of their currency inventories; by studying the exact sequence of price changes researchers can make inferences about the behaviors of these market-makers and the traders they serve across rapidly changing market environments. This abundance of data in the context of high transaction volume is a propitious starting point for building models of how financial markets really work.

An abundance of data?

Yes, but we're not capturing all of it. Most of the biggest currency traders do not keep detailed records of every change in price (tick). We read the surface without understanding the cross-currents boiling beneath it. To derive a new theory that is more than an abstract formula we have to do research; in finance, research means creating models and immersing them in data. The lack of such experimentation—which would be unthinkable in the natural sciences—retards the growth of our discipline, with disastrous consequences.

What the data tells us

At Olsen Ltd. we have collected tick-by-tick data for more than 20 years. We have one of the largest collections of filtered currency pricing data in the world, and we have assembled a comprehensive database to organize and analyze this invaluable resource. So, what have we learned?

- Market participants are heterogeneous. They are active in different time zones, they have distinctly different risk profiles, and—most important—they trade according to very different time horizons. Some open and close positions within seconds, others in minutes, hours, days, weeks and months.
- There is no *a priori* preferred time horizon.
- The diversity of profiles leads to heterogeneous market reactions that lead to long sequences of secondary market reactions. These secondary reactions can invoke cascading events—analogous to freak waves in oceanography—where secondary reactions pile on top of each other, causing massive price breaks, and catapult the market price to a new price band far removed from the perceived equilibrium price.
- Market prices are distorted by secondary reactions that lead to price misalignments.

Now you see it, now you don't

Market prices do not reflect information about the fundamental value of underlying assets. "Equilibrium value" is arbitrary, and any movement above or below that point triggers position-covering behavior that dries up liquidity. Extreme situations result when liquidity droughts push prices even further, which sends erroneous information to the rest of the economy.

In 2007, between January 24 and August 11, USD/CAD dropped from a level of 1.1821 to 0.9145, nearly 30%. Why did this happen? Did it reflect a new interpretation of fundamental value?

One year later, on August 11 2008, USD/CAD was back to a level of 1.0670. The previous year's drop was clearly an overshoot…the result of market inefficiency…and not warranted by fundamentals.

- Because financial markets and the economy at large are in continuous motion, there is no one fixed point; misalignments caused by secondary reactions can persist for minutes, hours, weeks, months, years or even decades.

This is a very different story from Adam Smith's notion of markets absorbing information instantaneously.

We propose an alternative theory

Liquid markets are made up of participants who trade with different time horizons and profiles. These traders react to market events of which they are aware and to the price changes that relate to their specific trading horizons. Because they have widely different time horizons, they pay attention to different degrees of price change and therefore react differently. To model the behavior of traders we cannot rely on a universal time scale to define the sequence of events as they are perceived by individual traders; instead, we have to apply the concept of *intrinsic time*, which maps events according to their relevance for a given profile.

Because markets are not homogeneous, information is not disseminated instantaneously or evenly. Distorted market prices undermine investors' and traders' ability to rationally allocate resources on a global scale.

Time in the Market

Because real-time FX quotes are irregularly spaced in clock time, a higher-resolution measure of activity is required. *Intrinsic time* is relative to the flow of events themselves: it concentrates or contracts very active periods and expands less-active ones. Clock time "nets" changes by regularizing the interval of measurement; intrinsic or transaction-time analysis depicts the natural dynamics of the marketplace.

Trading models designed to measure price changes tick-by-tick in the foreign exchange market are the engines of high-frequency finance. That is, they measure change at the highest possible resolution. The purpose of such fine-grained analysis is to identify movements that can be expected (*and have proven*) to recur over different timeframes.

The dynamic framework

The meteoric rise of the Canadian dollar in 2007 was caused by a secondary reaction. It was not some fundamental realization that Canada is endowed with natural resources and that, therefore, its currency should be valued more highly. The cause was *margin calls* that triggered a whole avalanche of margin calls, forcing investors to liquidate their long USD positions and buy CAD—pushing the price of CAD well beyond any reasonable levels. When USD/CAD crossed parity, this triggered the margin calls that drove up CAD—but, not surprisingly, the price move was an after-effect.

To dissect such secondary reactions and to understand *and predict* the likely outcomes, we use the concept of *intrinsic time* to develop a relativistic view of the economy and its markets. Every market participant is viewed to have his own frame of reference, on the basis of which he makes his decisions—the root cause of the secondary reactions.

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What has to happen now

There is no getting around the fact that markets are heterogeneous and secondary reactions are the order of the day. To mitigate this impact we need to develop predictive services that understand and anticipate secondary reactions. Traders with access to reliable predictive services will incorporate forecast secondary reactions in their trading decisions and thereby cushion the impact of those reactions. *But that won't be enough*: we must also develop trading strategies that are specifically designed to dampen the impact of secondary reactions directly. Like waves, these reactions are a source of energy; on an ongoing basis they can be a source of profit for investors who allocate assets to strategies whose objective is to stabilize the evolution of prices.

Finance needs a new theory to deal with the more dynamic realities of the marketplace. This theory will have a lot in common with agent-based modeling approaches, but with one important enhancement: the concept of intrinsic time. Every agent has to have his own intrinsic time defined by the events that he experiences. Every trader tries to optimize his own strategy within his own frame of reference, even though to an outsider his behavior may appear irrational. The new theory must accommodate even the unexpected and the apparently irrational so that we can model the full diversity of market participants.

First we must acknowledge the inefficiency of the status quo. Outsiders who have never worked for a bank will find it hard to appreciate just how outdated the investment methodology of finance is. Despite the powerful hardware and processing capacity banks possess, the world has unleashed the genie of modern technology on the back of dysfunctional financial markets. Against the expectation that *all will be right*, it is obvious that our understanding of the mechanics of economics and the financial markets is pitifully inadequate.

We lack even the most basic resource for building a powerful economic theory: a comprehensive, tick-by-tick database for all the financial instruments traded worldwide. At Olsen we have built such a database for currency and other liquid markets; by researching this data we have been able to shed light on phenomena that have until now gone unexplained. But the real work has just begun. Tick data is not noise: careful investigation of the data lets us trace capital flows across instruments and markets. A more complete set of data for all markets will enable us to build a "weather map" for global capital flows.

Translating the energy of markets

Markets in discontinuous motion are a source of energy that can be translated into trading profits.

If we develop trading strategies that identify overshoots and take counter-positions, we can achieve two objectives:

- Reduce the size and severity of the overshoots
- Generate profits for investors

This is a win-win-win situation: it helps stabilize the global economy; it provides resources to address market dysfunctionality; and it rewards investors who have chosen to commit capital to market-stabilizing strategies.

What Olsen is doing now

To turn financial markets into mechanisms that work smoothly, without distorted pricing, we have to develop predictive services that are available to everyone. We propose a Wikipedia-like approach: let's build predictive services as a cooperative effort of likeminded people around the world. To succeed, we need a platform where participants everywhere can contribute in an even-handed way. At Olsen we're supporting such an effort by initiating two open-source projects that can make this vision a reality:

Open-source data repository

Today there is no open-domain repository with comprehensive data coverage that researchers can use to uncover the laws of financial markets and build predictive models. This repository should be accessible both for historical simulation and real-time operation; that means we have to start collecting tick-by-tick data from all the stock markets around the world and from over-the-counter markets as well. This is a colossal task, because it includes not only collecting raw data but filtering inputs to identify erroneous entries and patterns; no less imposing is the need to generate derived synthetic data such as yield curves, volatility smiles, and liquidity bands.

Open-source modeling environment: Olsen Routes

To develop predictive services that are reliable and add genuine value, we have to model not only the behavior of traders and their interactions but how trading activity relates to society in general. To create such robust models we need an event-based programming language that can accommodate a rich and far-reaching sequence of reactions. At Olsen we have developed a template for what we believe is an ideal framework. *Olsen Routes* software has been designed to enable the modeling of complex networks of interaction.

Olsen's research agenda

As we chart the research agenda for financial studies, we have to remember that economics and the financial markets in particular are in continuous motion, with no fixed point of reference. Therefore, our first concern is to create a framework to measure and correctly scale the events we observe. Only when we have this basic framework can we begin to investigate the pathways and parameters of secondary market reactions.

- *Scaling laws as a frame of reference*

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Scaling laws ("power laws") establish invariance of scale; they have played an important role in the understanding of complex systems. In finance there is one scaling law that has been widely discussed: *the size of the average absolute price change (return) is scale-invariant to the time interval of its occurrence*. At Olsen we have recently discovered 17 additional scaling laws.

The new scaling laws can be used to identify the intrinsic properties of price evolution. They provide definite answers to how far prices move on average per minute, per hour, per day, and so on, and they tell us exactly how big the overshoots for the respective time intervals are. We now know that daily overshoots are on average ten times the daily maximal price move, and that the events preceding tail events around a crisis are much more important that previously recognized.

Published research paper: *An Extensive Set of Scaling Laws and the FX Coastline*, J.B. Glattfelder, A. Dupuis, and R.B. Olsen; 2008.

Why scaling laws are so important

Scaling laws are rules that describe the dimensions and durations of change over time. For currencies, it is not unusual for an exchange rate to go up or down by as much as 10% to 20% in one year. But that is a cumulative measure of change over a very long period of time (very low resolution).

Measured at very high resolution—at every "tick" or change in price, either up or down—it is possible that the total amount of change in price of an exchange rate might be much greater than 10% to 20%. But how much greater? And under what conditions? The new scaling laws discovered by Olsen Ltd. can provide estimates that are surprisingly accurate.

In economics, where there are no fixed points, stable relationships such as those described by scaling laws offer a reliable foundation for models that analyze markets and guide investment decisions. Olsen's new scaling laws allow us to conclusively estimate maximum risk and relate this to all the ups and downs along the price path—the average opportunity for risk and return.

What scaling laws do

Contrary to the teachings of classical economics, information does not travel instantaneously through financial markets: *it propagates*. A signal event triggers primary reactions among diverse groups of market participants who are characterized by different trading horizons and imperatives. Secondary reactions ensue as these groups adjust to initial reactions and

to subsequent tiers of reactions by other groups who are driven by different trading imperatives.

Scaling laws describe market behavior *at the mean*, that is, on average over longer periods of time. At any single point in time markets will diverge from the mean; trading strategies designed to take advantage of these diversions, by betting on a reversion to the mean, need to calibrate their trades. Scaling laws are particularly valuable because they establish many average or mean relationships, which enables model builders to design tools—quantitative measurements that inform algorithmic agents—that are proven to be well-calibrated with real price behavior.

If price divergence over a particular period of time is small, we can infer the likelihood of a "rebound" or "catch-up." Think of scaling laws as metal springs that push prices back to an expected level, eventually correcting the divergence. These "springs" are particularly strong because they apply not just for one value but across a broad range of threshold values.

The new scaling laws enable us to analyze price behavior and explain how financial markets breathe.

The revolutionary benefits of scaling laws

The multiple scaling laws can be used to measure market movements along different dimensions. They are powerful tools for ascertaining, with some precision, the state of the market and making well-informed inferences about its future direction. They help us understand the dynamic behavior of markets: if we look at the smallest price movements, the pricing "coastline" turns out to be enormous—about 6.4% of daily price movement, on average.

This sort of information creates new opportunities in innovative risk management, the pricing of options, honing hedging models, and building better trading models for a variety of instruments. In the past these activities typically lacked any sound basis. The new scaling laws will change that.
Now we can replace gut feeling and ad-hoc programs with models based on empirical evidence and extensive testing. We believe this will lead to more enlightened investing: where we make more objective assessments of the economy and its finite moments and problems, where our recommendations are more timely and more consistent, in a world where we make better, more equitable use of financial assets.

Knowledge-based decision-making should address the imbalance of power that disproportionately rewards some investors while penalizing many others.

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Overshooting and True Value

In the foreign exchange currency market there is no fixed frame of reference, and so traders get by with bidding and asking more than a rational assessment of value would dictate. *They overshoot*.

Let's say that in one year the price of the U.S. dollar goes up or down by 15%; this gives us a framework to speak of its "value." But the more closely you analyze price changes, the greater volatility you find. If USD goes up or down by 0.1% in six seconds—which can happen several times every week—the annualized price change is 360,000%! Where, then, is the equilibrium value of the dollar?

The information is in the price, but what is it telling us? Any up-tick or down-tick is a signal, but an ambiguous one. Is this just a break in supply and demand, or does it signal a fundamental redefinition of value? Every change in market price—no matter how slight the volume—triggers the re-pricing of all open positions in the underlying instrument.

Data is the requisite oxygen for every trading strategy

To track financial flows and understand the responses of the economy, we need data. And the more complete the data, the more precise our analysis. Data is the indispensable "oxygen."

In the same way that large telescopes are built to screen and record events that occur across the universe, and powerful accelerators are constructed to analyze the structure of atoms, we must amass the digital data produced by financial markets and all other areas of the economy.

- *Building the richest, most comprehensive database*

  Our experience shows that this endeavor is far more complex than most people realize. But without it, we have little hope of creating models that embrace the broadest range of events in the marketplace. The more sensitive and sophisticated the models we create, the more they depend on high-quality information that has been filtered to identify outliers and erroneous data. In addition to building a database of observed data, we must also address models for non-observed data such as yield curves, volatility smiles, and liquidity bands to estimate transaction prices for different-sized transactions.

- *Expanding the universe of stylized facts*

  While much work remains to be done, the increasing availability of tick data has enabled researchers to begin to uncover stylized facts of financial market data, including not only scaling laws but also tail indices and patterns of seasonality. The whole new battery of scaling laws will facilitate deeper investigation of conditional relationships. We have yet to answer questions about the perseverance of scaling laws, for example, do statistical properties hold true late on Friday afternoon when many traders close out all their positions?

Weather forecasts for the financial markets

It is part of our everyday routine to check the weather map on TV, online, or in the newspaper. *Why not build the same kind of service for the financial markets and the economy as a whole?*

Instead of having individuals comment on market developments on the basis of hear-say, use large-scale forecasting models that can precisely evaluate market developments and highlight potential danger points.

Potentially catastrophic forces and situations can be identified in advance. Why not monitor their evolution and status—using the powerful tools we now have—and avoid the sort of havoc that is plaguing us today?

- *Modeling the behavior of traders and market-makers*

  Our ultimate goal is to track the flow of capital between buyers and sellers, long- and short-term traders, to gauge the pressure leading up to tipping points that trigger price cascades. Again, the rich resource of tick data embodies the footprints of market participants; once we learn to read this evidence we can make better inferences about likely future behaviors.

- *Predictive services*

  We have to leverage our understanding of statistical properties to develop viable forecasts. Like weather-forecasting services, in the financial arena these will operate on the basis of large computer models that analyze all available data and assess the likely paths of economic and financial activity.

- *Trading strategies that do right and do well*

  Quantitative trading strategies that stabilize market movements can achieve a double benefit. Price overshoots from the secondary reactions of market participants are a continuous source of potential profit for investors. Trading strategies that take advantage of these overshoots offer lucrative investment opportunities and at the same time contribute to market stability.

There are no easy conclusions. The one thing that seems certain is that increased regulation will not address the systemic shortcomings that got us where we are today. As an alternative, we propose a scientific initiative of exploration and discovery.

Adam Smith's theory of efficient markets has taken us down the wrong road. The ride was fine for as long as it lasted, but today the stakes are too high, the pace is too fast, and there is too much we simply do not know.

Our vision of the urgently needed remedy anchors in three areas of activity: new modes of investment in strategies that have the higher purpose of combating uncertainty and instability; open-source participation to collect comprehensive data and organize that information in the service of better, smarter models; and investigative research in the style of the natural sciences to discover intrinsic financial properties that will inform the first two mandates.

Dynamic systems need stabilizers

Who is aware that the human heart pumps 70 liters of blood every ten minutes? This colossal effort is necessary to provide fresh blood to the cells and transport oxygen from the lungs.

The financial markets and the global economy need the same: to achieve market stability, we need an abundance of circulation (read *transaction volume*) from trading strategies that are counter-trend and work to mitigate overshoots and the negative impact of secondary reactions.

Without such stabilizing strategies the markets are prey to extreme overshoot behavior. The dot.com bubble and the recent excesses in the credit and real-estate markets came about because the marketplace was one-sided—*everyone jumped on the same bandwagon*.

The counter-trend strategies we propose (*and apply*) are not one-sided. They do not generate profit for some investors while penalizing others. They add true value to the marketplace as a whole.

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Richard Olsen is founder and chief executive of Olsen Ltd and the Chairman of OANDA, a leading foreign exchange broker and market maker.

Olsen Ltd is a research and development company and investment manager based in Zurich, Switzerland. Olsen has yielded practical applications and managed accounts and third-party products, investing in currencies as a separate asset class or as an overlay to an existing currency exposure.

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