OPALESQUE FUTURES INTELLIGENCE

Futures Lab: Physicists and mathematicians are a growing presence in markets. Dr. Chekhlov demystifies the link between science and trading.

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Physics and Trading: Decoding the Link

Futures trading often attracts people with math or physics training. From an investor's point of view, this means that a manager has very impressive credentials but it may not be easy to understand how the academic background translates to the down-to-earth activity of trading.

We wanted an example that illustrates this transition in an easy-to-grasp way, to demystify it as much as possible. After the crisis of 2008, there were complaints that complicated financial instruments, designed in the abstract by mathematicians, wrecked havoc on the system. Does the trek from math and physics to finance work? Why and how does it work?

Alexei Chekhlov graciously took the time to explain the connection, as he sees it, between his earlier work in physics and the investment approach he subsequently developed. The five main themes he highlights below are determined by his particular experience and don't necessarily cover all the issues.

Still, these themes may be used as signposts for a conversation with a quant. One intriguing point is how human actors in markets differ from molecules in physics. This is where irrationalities – the topic of behavioral finance – come to play.

Mr. Chekhlov worked on theoretical physics in the Soviet Union before coming to the US. He has a Ph.D. from Princeton University in applied and computational mathematics and teaches financial price analysis at Columbia University's mathematics department in an evening class after his day job managing Systematic Alpha.

A discussion of the market-neutral statistical arbitrage strategy he uses as a commodity trading advisor is in the previous section.

Universal Descriptors of Fluctuations
In the past, scientists did not see finance as a worthwhile or noble enough field, while finance people thought scientists were out of touch with financial reality. Therefore there was little interaction. Starting in mid-1990s many theoretical physicists became interested in finance partly because the Soviet Union disappeared and the US Congress reduced its financing of research projects in physics. That released many highly skilled mathematicians and physicists, who found their application niches in finance.

In my work in physics, I focused on such problems as instabilities between two liquids and turbulence problems that arise in nonlinear systems in response to random fluctuations. We worked on statistical analytical methods and measurement techniques which helped either to solve and/or explain such problems as critical phenomena and fluid turbulence.

In physics, there is the notion of universality, meaning methods are frequently useful for problems other than those they were initially developed for. As it turns out, in finance as well, you can use the tools of statistical physics to describe price changes statistically without even knowing the details of individual fluctuations and what exactly causes them.

Price fluctuations can be studied as a statistical ensemble. One can start by defining a probability distribution function of two-point price differences. Does this description apply universally to many markets? Probably the same parameters do not describe all markets. There are some parameters that are universal across many markets and some that are market-specific.

The test is to define which parameters are universal and to define the set of markets they apply to—the universality class. Then one can go on to study more complex statistical properties, like how the price changes influence each other.

This is how I got interested in financial markets. In 1995, after studying the random-force driven Burgers equation, I thought of applying a similar approach to the S&P 500. I purchased the tick-by-tick futures price data for an exchange-traded S&P 500 futures contract and applied various physics-inspired measurements that had not been done before for that data. I found that the statistics of price changes had a lot in common with the statistics of the velocity differences that I had studied in the physics of turbulence.

Once you go deeper into statistical measurement, you get a much more accurate small-scale model than you can get by applying conventional assumptions such as Gaussian distribution and the Random Walk model. This can lead to better modeling of future market behavior, at least hypothetically.

A probability distribution specifically tailored for a market leads to a clearer understanding of risk, because the so-called fat-tail properties naturally appear and become part of your model rather than remain an outlier or a “black swan” of some sort. Extreme price changes are not outliers but rather an intrinsic part of the distribution function. So you can be prepared for jumps and gaps in short-term market price behavior.

This type of reasoning is not what the majority of finance professionals favor. But it is an advantage for a trading strategy if you are in a minority and yet your views are correct. When a trading methodology becomes widespread, the expected returns decline.

Market Education

When I started to work on Wall Street, I had to deal with a lot of immediate practical issues quite remote from studying the high-frequency statistics of price changes. But I continued to think that a more accurate, quantitative understanding of price fluctuations would lead to a better trading model.

At the time BNP Paribas was more open to hiring former physicists. There I was part of an small team, all physicists, who developed and executed proprietary trading strategies in a wide set of futures markets, including a contrarian trading component I worked on.

The experience taught me that going against the majority of traders can be profitable if you can develop a rational forecasting algorithm. We traded our statistical approach through the Asian and Russian crises of 1998. Even though we used a purely systematic strategy, we had to execute it manually, as automation was not possible with the technology of the time. Trading has changed so much in the past decade!

From a practical standpoint, I came to recognize that in one key respect the behavior underlying market price changes is different from the laws of nature that govern velocity differences in liquids, for instance. Unlike the universal laws of nature, large groups of humans do not always behave the same way. The statistical description of price changes is very useful but there are limits to its applicability, which have to be carefully understood. This may have been one of the most important lessons of my Wall Street education.

We currently trade against deviations of price changes from an efficient market—or, in other words, from a Random Walk. Our trades are taken in the direction that would bring the market into a more efficient state. Deviations occur because market participants do not always act in the most rational way, even if one assumes that the very notion of rationality is the same across all participants. For instance, there exist such simple behavioral biases as over-reaction or under-reaction to certain new market information. It is known that market participants frequently over-react to sudden new negative market information and under-react to certain new positive information.

A human trader’s decision may be dependent on his stress level, his other losses or gains, his personal emotional state, etc., which should not be the case in a fully efficient market. The more this type of behavior there is, the more opportunity there is for our trading models.

But the more markets are traded via fully rational automated algorithms, the more price changes conform to a Random Walk model. In that sense, traders like us make markets more efficient. For example, major exchange-traded currency futures markets like the British pound or the euro are quite efficient and – at least based on our research – offer no opportunities for systematic prediction.

Despite this trend, we expect that inefficiencies will persist in some markets for quite some time and that quantitative models will offer ways to exploit that. As has been noticed by many researchers, humans are not necessarily becoming more rational over time.

Skill Match

Our skills are best applied to high-frequency financial price fluctuations, therefore our approach is to model these fluctuations. We describe them in a way very similar to the way statistical physics describes physical phenomena. To efficiently use such information you need the financial instruments with the lowest transaction cost and the most liquid futures seem to be the best fit for this purpose.

Once you model a particular market, the next step is to turn this understanding into a robust trading strategy. This bring a host of problems related to out-of-sample performance and/or over-fitting. There is no single secret magic formula; you just have to diligently work on applying a wealth of appropriate statistical techniques in a disciplined way.

Weak Stationarity

Behind the statistical modeling approach described above lies an implicit assumption that the statistical properties you’ve quantified will persist in the future. In exact sciences this property is called stationarity. We believe that in financial markets this does not exist in a strict mathematical sense. It can be only understood in a weak, somewhat time-dependent way, so that one’s view on statistical properties can and has to be re-tested over time.

Some financial instruments may be more stationary than some others. For example, because equity indices are a weighted average of individual stock prices, one would expect them to be less dependent on the idiosyncrasies of particular components and therefore their distribution to be more stationary. The index futures market is, therefore, a significant part of our focus.

Even though we are a fully systematic trader, we do not take the systems and inferred statistical behavior religiously. Perhaps because we are former scientists, we continuously re-verify the model against financial reality. We can’t just assume our model parameters estimated from past data will stay constant over time. So we re-infer the parameters for the trading system using a new, ever-expanding financial dataset. Our goal is to find the most relevant parameters for the present.

Breakthrough Spotting

Unfortunately, as we have already pointed out, trading cannot be seen as a pure science that interprets unchanging laws of nature. It is probably more like medicine, which has significant scientific elements but also contains elements that cannot be mathematically proven, only estimated.

However, there are researchers in the quantitative finance field who are trying to advance the fundamental understanding – the first principles – of financial markets. They try to think of the “basic equations of motion” for high-frequency finance, even describing the price evolution process at the level of limit order book.

If such an understanding becomes possible, the fuller statistical physics of financial price fluctuations would be created and quantitative finance would change its status to a more rigorous scientific discipline. Multiple rigorous conclusions could be derived from the first principles and tested against the results of experiments, as in physics.

Some researchers think such an advance is within reach while others think it is not possible. But if it were to happen, a new class of significantly more accurate trading models would follow.