Quantitative Monographs

Models, Markets and Magic: The Assumptions behind Machine Learning

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Expert call on the assumptions behind models

We are happy to have hosted a call with James Weatherall, Professor of Logic and Philosophy of Science at the University of California, Irvine. He discussed the assumptions behind traditional and machine learning models and the implications for financial markets. This note is an edited transcript of the call.

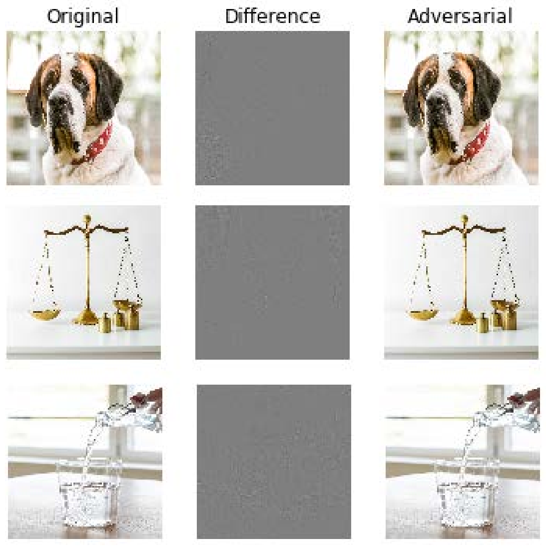
Traditional models and their assumptions

Traditional models – those that are based on some economic theory, begin with theoretical, simplifying or even idealizing assumptions. These assumptions are typically good enough, but under some circumstances they are more false than usual. This is when and why models fail – not because the underlying mathematics is wrong, but because the underlying assumptions are no longer valid.

Big data models: end of theory?

Big data models – those based on machine learning algorithms, don't make explicit theoretical or simplifying assumptions. However, they also make assumptions which can also fail: they are not magic. To understand the assumptions behind data-driven models and how and when they are likely to fail one will need to revert back to theory. This should not only protect against risks, such as model failure, but can also create trading opportunities.

Figure 1: Adversarial examples



Source: UBS Quant. The figure illustrates a type of a machine learning model failure. Leftmost images are correctly classified by a particular neural network. The rightmost figures are overlaid with noise (images in the middle) and are incorrectly classified as "coffee mug" in all three cases.

Introduction[1]

Models are generally effective but sometimes fail…

I am coming from a different perspective than many of the academics and professionals working in the financial industry. My own training and research is in mathematical physics and in philosophy of science. Hence, I will approach this talk as a philosopher of science, which means that I'm interested in understanding how and why mathematical models are generally effective in science.

…because the assumptions underlying them fail

In finance and economics I'm interested in understanding why, although models are generally very effective, they sometimes fail. My 2013 book, "The Physics of Wall Street"[2] explores this question. What I argue is that when we reflect on various examples of market crashes – very high profile cases of model failure – we see that models that are usually reliable and very sensible fail because the assumptions underlying them fail.

In this talk I want to return to this general topic, but with a somewhat different focus, namely *big data models* (predictive analytics and machine learning). The three main points of today can be summarised as follows:

- **Every model makes assumptions**. These assumptions are generally false, but they are usually good enough. Put differently, they are typically approximately true but under some circumstances they are more false than usual. What we can do is try to understand *why* and *when* the underlying assumptions may fail. This allows is to get an idea of *when the models* are likely to fail and get some control over them when they do.
- **Big data models are no different**: **they're not magic** (hence the title). Big data models also make assumptions which also can fail. The assumptions are of a somewhat different sort from the traditional models – the ones from economics and financial engineering textbooks, MBA courses and so on.
- **Understanding model assumptions creates opportunities**. Understanding the assumptions in both traditional and data-driven models is not only important for protecting against a certain kind of risk and model failure, but it also creates trading opportunities.

[1] This is our edited transcript of the Expert Call with Professor James Owen Weatherall. Produced with his permission. We have edited some of the slide content into the text for clarity.
[2] Published as "The Physics of Finance" in the UK.

Models are everywhere

When people talk about mathematical modelling in finance, it is very common to conjure up images of quants, quantitative traders, high-frequency traders – people who are using algorithmic trading of one sort or another, but that could be a misleading picture. Mathematical models are really everywhere; for instance, looking back at portfolio analysis and optimization; the early arguments by Markowitz are examples of mathematical models in finance. Even fundamental trading, which is based on valuation procedures, involve mathematical models – for examples IPO or M&A models.

Models fail

We have many dramatic examples of models failing, such as the 1998 failure of Long Term Capital Management, the 1987 Black Monday crash, the 2008 financial crisis, as well as many smaller examples. In order to understand how and why model failures happen, we need to step back and think about how a particular model works as well as the steps that we go through when we construct it.

Every model starts with simplifying assumptions

When building a model what we are trying to do is use the inferential power of mathematics to discover relationships between quantities; these could be observable quantities in the market, on a company's balance sheet, macroeconomic variables, or unobservable such as the fair price of assets. In order to do this, we need to express some of our beliefs and knowledge about these quantities using mathematical assertions. This is very difficult to do because we need to make intuitive or fuzzy notions sufficiently precise to be able to use mathematics. We therefore begin by making some simplifying or even idealizing assumptions.

The pros and cons of theoretical models

The advantage of doing this is that we can then use the power of mathematics to draw new inferences and learn new things about what we're studying. The cost is that there are some idealizations, some simplifications and some known falsehoods that go into this process. A model is useful if it allows you to use mathematics to discover something about your assumptions or your data that you did not already know.

The Black-Scholes model will be used as a running illustrative example

As an example we will consider the Black-Scholes model. It begins with some assumptions (or claims) about how the prices of underlying assets and options evolve over time. These are used to derive a new, previously unknown, formula which relates the fair price of the option to various other parameters, such as the strike price or time to expiration.

How badly wrong assumptions are varies with time and market conditions

The conclusions you draw from the model are only as good as the assumptions with which you begin. These are never going to be perfectly accurate, but how badly wrong they are can vary with time and market conditions. Models generally don't fail because the mathematics is wrong, but because the assumptions with which they begin, the way in which the mathematics is linked up to the asset, the market or the world in general, end up being inaccurate.

"The Holes in Black-Scholes": the assumptions in the Black-Scholes model

This, of course, is not an original point. Fisher Black himself made it very compellingly in an article called "The Holes in Black-Scholes", published shortly after the 1987 market crash. Black argues the Black-Scholes model has so many simplifications and assumptions that go into it that it is a miracle it ever works. He gives a list of what he takes to be the unrealistic assumptions behind the Black-Scholes model:

"In the original derivation of the formula, Myron Scholes and I made the following unrealistic assumptions:

- A stock's volatility is known and never changes.
- The short term interest rate never changes.
- Anyone can borrow or lend as much as he wants at single interest rate as long as he provides a portfolio of collateral with a value that exceeds any borrowing he may do.
- An investor who sells a security short, will have the use all of the proceeds.
- There are no transaction costs.
- Investors' trades do not affect the taxes he pays.
- Stocks pay no dividends.
- There are no takeovers, or other events that end the life of an option early."

There are some other assumptions that aren't listed here, which we should emphasize: trading is continuous, prices change continuously, there are no jumps in the prices of the underlying assets or the options, liquidity is infinite (so trades can always be executed) and transactions occur instantaneously. It is clear that none of these assumptions are valid, each and every one of them fails, but they're good enough for most purposes.

Black Monday and Portfolio Insurance

Portfolio insurance relied on the Black-Scholes model to construct a put option on the market

When are they not good enough? Let us use the example of Black Monday: the 1987 crash. In 1976, Cain Leland and Mark Rubinstein introduced a product known as portfolio insurance – an insurance policy to protect against drawdowns. The basic idea was to buy a put option on the market as a whole. The way to do this was to use the Black-Scholes model to construct such an option by taking certain short positions in market or index futures.

What this means is that the basic reasoning that underlies portfolio insurance (or underlied portfolio insurance as it was sold in the 1980s), was one that relied on the Black-Scholes model including the assumptions behind it: for instance, continuous trading and infinite liquidity.

Why blame portfolio insurance?

In October 1987, we saw the largest single day drop in the Dow-Jones Industrial average by percentage, a record that holds to today. Many people blamed portfolio insurance for the fall, and there are a few reasons to do so. Firstly, the insurance trade was automated, meaning that many people were unwinding identical positions as the market was crashing, which amplified the crash. Secondly, portfolio insurance created unrealistic expectations of risk. People thought that they had insured their portfolios and were relatively safe meaning that there was less risk in buying as the market went up. Finally and perhaps most importantly, it just didn't work: portfolio insurance didn't protect people. If anything on the whole, market participants lost more as a result of it.

Assumptions of infinite liquidity, continuous prices, instantaneous execution fail badly during market crashes

Why did this happen? The answer is that portfolio insurance is supposed to be used in circumstances where the assumptions of the underlying model fail most badly. During a market crash, infinite liquidity and instantaneous execution simply do not hold; there are big price drops – the assumption of continuous price changes also fails. These assumptions are good enough for practical purposes under ordinary circumstances, but in this case, under precisely the circumstances when you needed to use the model, the model failed.

These sorts of model failures can be identified in advance. We could consider the list of holes in Black-Scholes and ask under what circumstances are, for instance, transaction costs or taxes or failures of liquidity going to be most important?

Before we move on to big data, I want to suggest that there are some simple morals about some best practices for how to use models. When using models, be sure to ask:

- What does this model assume about market conditions?
- Are these assumptions compatible with my overall trading strategy?
- What features in markets does this model simplify and how?
- If the model's assumptions fail, how will the model fail?
- If all market participants use this model, would the model still be effective?

Big data

As we have discussed, the traditional models (such as Black-Scholes) are driven by some theoretical assumptions and simplifications – such as infinite liquidity and the availability of a risk free asset. Recently there has been an explosion in new models that are not driven by theory at all; where one doesn't make theoretical assertions in constructing the model.

Machine learning methods rely on huge amounts of data

What you do instead is begin with data. These new models use machine learning algorithms to extract predictive relationships from enormous data sets. They take advantage of the fact that over the last 30 years, the rise in digital technologies has produced a massive amount of data that we simply didn't have access to before, and in this data one can find relationships that are predictive of the future.

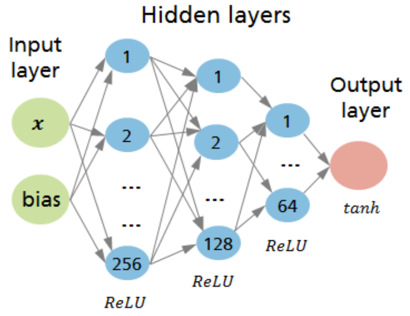
There are many different data sets that you might use in the context of understanding financial markets. For example, you might consider data subsets that contain market data, such as bids and asks, and last executed trades, but also you might include macroeconomic data such as GDP. Many people consider what is sometimes called alternative data: data that is not directly related to financial markets, to find signal that could (consistently) predict prices.

Many different types of machine learning algorithms exist: decision trees, Bayesian networks, generic algorithms and artificial neural networks to name a few, which are well-suited to different tasks. They may require different kind of inputs and they succeed and fail under different circumstances.

The following discussion will be focused on artificial neural networks (ANNs). However, it will be sufficiently general so that we don't need to distinguish between different machine learning models.

Let's begin by reflecting on how deep learning works. Deep learning uses *neural networks* that have a distinctive hierarchical character. I'm not going to go into any kind of detail[3], but you can think of the neural networks that one uses in deep learning as consisting of multiple layers (see Figure 2). There are two "outer layers": an input layer (for the input data) and an output layer (for the predictions) and a number of intermediate (hidden) layers. Each of the layers takes the output from its predecessor and transforms it in a meaningful way (using linear and non-linear maps).

Figure 2: Feed-forward ANN



Source: UBS Quant.

The hidden layers have a benefit and a disadvantage. On the one hand they allow the system to potentially produce much more effective results; on the other hand they obscure how the system does so. It becomes very difficult to reconstruct the "reasoning" of the system, and so you can come up with remarkably accurate predictions without being able to retrace how those came about.

Deep learning algorithms have achieved super-human Go playing skills

The big example here that is often celebrated is the success of AlphaGo developed by Google DeepMind. AlphaGo has learned to play Go - a board game that for a long time defied artificial intelligence. Only recently has AlphaGo managed to become good enough at the game to beat human grand masters. In 2016 AlphaGo defeated the 18-time world champion Lee Sedol, which was a major milestone in artificial intelligence research. One of the most striking things about this example is that the top human players who play AlphaGo report that the machine seems to be thinking differently from any human player. This looks like computational creativity of a sort that is very startling, perhaps even disturbing.

The computer programme "thinks" in a very different way

The end of theory?

Some people have argued that big data is "the end of theory". We can look at examples in which machine learning manages to identify patterns in data sets that unassisted humans could never find.

Machine learning allows us to come up with predictive patterns without making theoretical assumptions …

Machine learning does this without humans explicitly deriving anything, without theories or simplifications being used in the model building process, such as existence of a risk-free asset, infinite liquidity or any of the sorts of assumptions that go into the traditional models. Hence if your view is that those traditional models are dangerous because they make these unrealistic simplifying assumptions it looks like big data provides a solution to this. You can come up with predictive patterns without having to make any assumptions. Big data models can be considered as pure empiricism: an induction from actual data in the real world.

… but assumptions are still necessary

I'm going to push back against this idea. I completely agree and concede that machine learning does not rely on explicit theoretical or idealizing assumptions about the world. And it doesn't fail because the economic theory that underlies the model fails (because there isn't an economic theory that underlies the model). But, I want to argue, this doesn't mean that no assumptions are necessary, or that machine-learning cannot fail.

[3] See the write up of the expert call Introduction to Deep Learning with Matthew Dixon

What assumptions lie behind machine learning?

The assumptions behind machine learning have a somewhat different character. These are assumptions that concern the relationship between the data that you're using and the world. Machine-learning models therefore fail when the data itself misbehaves, when the wrong data is being used, or when the relationship between the data and the world is wrong.

A machine-learning algorithm is a computer program that learns how to construct a certain mapping, an association of input data to a desired output.

To give a few examples could be:

- **Task 1.** Input: the history of moves in a game of Go; Output: the ideal next move so as to maximize the probability of winning.
- **Task 2.** Input: an image; Output: Identify what is in that image.
- **Task 3.** Input: water temperature across the Pacific measured by surface temperature sensors; Output: future weather patterns.
- **Task 4.** Input: recent bid, ask and volume traded; Output: future prices.

For each of these tasks, the computer is trained to produce the correct output given some inputs. For example, suppose we have developed a model to perform Task 3; if we now feed in the current water temperature across the Pacific as an output we are going to get a reliable predictor of the future weather patterns.

Predictive models are not automatic

It is important to emphasise that the process by which this happens, although it involves artificial intelligence and algorithms, is not automatic. There is an art that goes into constructing these systems. First you need to identify the problem that you're trying to solve. You need to choose an algorithm (of which there are many), which is well-suited to the problem at hand, otherwise you're not going to get very good results. Resolving data-related issues is another big part of developing machine learning systems: data has to be collected, cleaned, labelled, we need to choose what variables to use as inputs, make sure the data is sufficiently informative for the task at hand, consider how to treat outliers, and so on.

Resolving data-related issues is a time-consuming, manual task

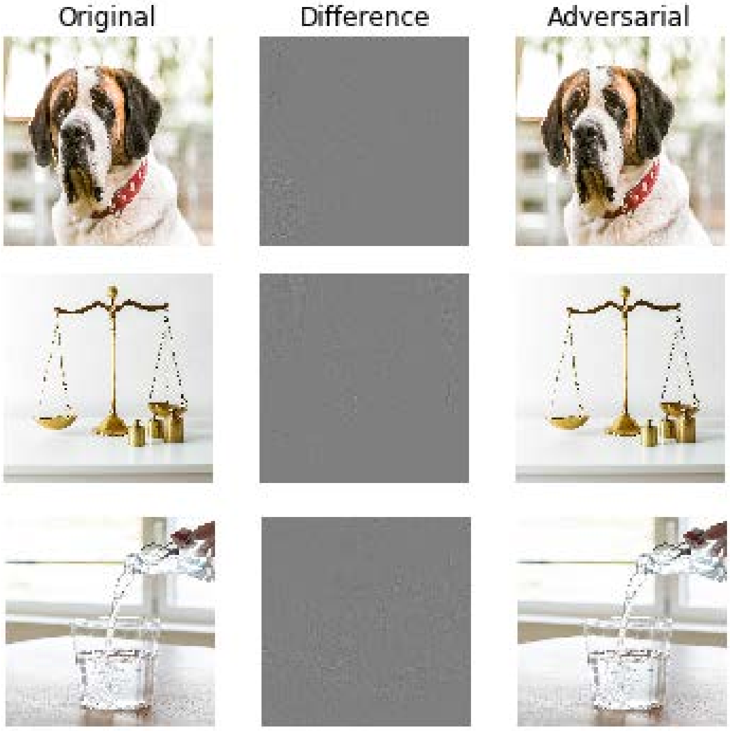
For example, if you want to do facial recognition, and you're using as your training data trillions of photographs of kittens, you're not going to end up with an algorithm that knows how to identify human faces. In this case it might seem obvious but the same thing is true of any machine learning task. If you are building a predictive model for markets using various bits of market data, and you train it on data from 1947 to 1970 in the US, then it is going to be an utter failure if you try to get it to make predictions during the late 1970s. The market had simply changed and the data on which you've trained the algorithm isn't relevant to the particular task.

Dealing with extreme data points

There are difficulties arising when dealing with rare and extreme cases. Consider market crashes: relatively unusual, infrequent, but also very big and significant events. Algorithms often have difficulty figuring out how "seriously" to take them. Should these be treated as outliers and get removed? This may not be a very good idea. On the other hand, should the behaviour of these extreme events dictate what the algorithm does under all circumstances? Again, this may be a bad idea.

How else can these algorithms fail? Some machine-learning algorithms, in particular neural networks, can fail when presented with data that really looks like they ought to be able to work on. You can construct what are known as adversarial input data for algorithms that have learned how to identify images, for example. Figure 3 shows three images, the leftmost of which a particular neural network (ResNet50) was able to successfully identify.

Figure 3: Adversarial examples generated for ResNet50



Source: UBS Quantitative Research.

Overlaying these images with particular non-random noise (the central image of each triplet) gives a new image (the right-most image), which to the human eye is indistinguishable from the original. The neural network, however, identifies all three images as a "coffee mug".

Small changes in the input lead to large changes in the output

This should be troubling to you because it means that in some cases what you intuitively want to think of as very small changes to your input data can lead to very large changes in your output. The algorithm produces *confidence estimate*, which tells you how confident the algorithm is that it has successfully identified the image. Another striking thing about these examples is that the confidence estimates go up once the noise is added, i.e. the algorithm is more confident that these are pictures of a coffee mug.

Confidently predicting noise as something meaningful

Another type of failure mode of similar character would be to confidently predict noise as something meaningful. We would like the machine learning algorithm to be able to tell when the new input data is too different from the data it was trained on, but as Nguyen et al (2015) demonstrate, "deep neural networks are easily fooled" (see for example Figure 1 in Nguyen et al, 2015) .

Implications to markets

This a problem if you have machine-learning algorithms that have been trained on a particular data set, but are operating under conditions where markets could be evolving or changing. So, new sorts of data can be presented that are very different from what they've seen before during training, but the model will not be able to tell this difference.

The assumptions behind machine learning

From this we can extract a number of assumptions that are operating when we use machine-learning. I don't claim this as a complete list.

- **The data has to reflect persistent relationships**. The world can't change. In some sense, this is just the problem of induction, classically understood in philosophy. The fact that the world has been a certain way for a very long time doesn't mean that it will continue to be that way. You simply can't infer that. So, you need to assume that the sorts of relationships that are reflected in the training data are going to persist.

- **Stable data generating process**. You have to assume that the processes by which the training data came to be generated are stable, continue to operate and that the relationships are being identified are relationships that occur because of these stable causal processes. It is only in the presence of this assumption that you can expect future data to continue to exhibit the same sorts of correlations and dependencies that you see in the training set data.

- **Input variables are sufficiently rich**. There's enough information in the dataset to distinguish between importantly different cases (training samples). If a particular variable takes identical values but the output is different, then there needs to be another variable that is able to explain that difference and distinguish between the two cases.

- **Training data is sufficiently rich**. It needs to be the case that the data on which you train your algorithm contains enough information about all relevant configurations. This is particularly a big problem if you're thinking about market crashes or other unusual events. You might think these could happen in many different ways. Probably, we haven't seen all of the ways in which markets can crash yet, but that means that whatever data you have, probably doesn't contain configurations that correspond to all of the possible market crashes. And that means that there just isn't enough information for the algorithms to figure out how to predict the sorts of things that haven't yet happened.

- **Correct learning algorithm**. You need to make sure that you've chosen an algorithm that's well-suited to the task at hand.

- **Endogenous factors are not dominant**. People like Nassim Taleb go around talking about the importance of black swans, these unpredictable, extreme events that end up dominating everything else in the long run. They are presented as a big problem for traditional models, because you don't know the ways in which the assumptions you're making can fail if they've never failed in those ways before. But this is no less a problem for machine-learning. If anything, it's more of a problem for machine learning.

"Black swan" events are more of a problem for machine learning than traditional models

- **Underlying processes are not too chaotic**. It has to be the case of a finite number of data points in your input set are sufficient to capture all of the ways in which the input data can vary. If very small changes to input data produce very large changes to your desired output data, it can be very difficult for the machine-learning algorithm to sort out those relationships.

- **There are no adversarial inputs**. Adversarial inputs might be constructed by other agents in the market, or they could just happen endogenously. They could happen accidentally because market conditions are changing in particular ways.

Do models change markets?

Models can provide insight into current and future market behaviour. One way of thinking about what models are doing which they give us a snapshot: they act as a camera to tell us more about how markets **are**. However, there is an argument due to a Scottish sociologist, Donald MacKenzie, which I find very persuasive. This is that models can actually change markets. One of the examples he looks at in his book, "An Engine, Not a Camera" (2006), is that options markets changed pretty dramatically from before to after the widespread adoption of the Black-Scholes model.

How Black-Scholes model changed the options market

In the 1970s, when options-trading, in the US at least, first became widespread, there was no particular relationship between Black-Scholes prices based on historical volatility and the market prices for options. By the 1980s this had completely changed and market prices were very closely aligned with a theoretically correct Black-Scholes price based on historical volatility. So closely aligned, in fact, that it was no longer profitable to try to use the Black-Scholes model to look for arbitrage opportunities. This is how we got to a place where the Black-Scholes model is used primarily to work backwards to figure out implied volatilities from market data. This was a change in how options markets work. After the 1987 crash, you start seeing the volatility smile; people still argue about whether or not it was there before the crash, but certainly it wasn't widely recognized prior to 1987. So once again, it seems the markets changed as a result of how models were used.

Volatility smile appeared after 1987

There are more subtle ways in which models structure markets: they can change how we think about markets. As an example, options traders often consider the so-called Greeks, such as delta, vega[4], etc. These correspond to outputs derived from the Black-Scholes equation – first and second-order derivatives of options prices with respect to underlying prices, volatility, time, etc. People would not have ever used these quantities to understand markets in an intuitive way before the Black-Scholes model came along. This is the way in which the Black-Scholes model structures our thinking about options, even when we aren't actually using the model to calculate prices.

The ways in which models can change and structure markets are often obscure to market participants. An example of this is the way in which CDO valuation in the early 2000s, before the 2008 crisis, relied on particular assumptions about correlations between mortgage default rates across geographical regions. These assumptions were perfectly good when housing prices are generally going up (as they did in the US for the whole history of the country until 2006 or so), but it becomes a very bad assumption when housing prices start softening across the board.

Assumptions underlying models can become opaque to the people who are using them

One thing that happened in the lead of the 2008 crisis is that CDOs came to play a role in financial practice as assets that were low-information. It was difficult to speculate on them because it was hard to get information about the individual loans that went into any particular tranche of the CDO; they were used as short-term collateral by traders and organizations that did not think of them as assets that needed to be valued, using a model that made a particularly strong, and as it happened by the late 2000s, a very bad assumption. This demonstrates how

[4] which of course is not actually a Greek letter

assumptions underlying models can become opaque to the people who are using them.

On the other hand, the same ways in which models can become hidden and assumptions can come to structure market participants' thinking, can also create opportunities. Someone who has control over the assumptions that go into the models used in various aspects of financial practice can have an insight into how other market participants are thinking, how they're going to behave, and when their reasoning is going to fail. We have the great example of Michael Burry, as described in "The Big Short".

There are people in 2008 that managed to exit the market way ahead of the collapse in CDO prices, for example Renaissance Technologies. This was, at least in part, because they were able to identify the ways in which the CDOs pricing models were going to fail under precisely the conditions that were emerging in the market.

Machine learning isn't any different in this regard. It relies on background assumptions about data, which means that as machine learning becomes more prevalent, those assumptions are going to structure how people think about markets. Although implicit, these will be the assumptions that are being by market participants. Hence if you can identify how and when those assumptions are going to fail, that's going to allow you to use predictive analytics based on these algorithms more effectively safely.

Theory returns

On the other hand, it can also lead to new trading opportunities, particularly if you can identify widely-used data sets whose predictive qualities rely on some of the assumptions that I've discussed above, but which will be known to fail under particular conditions. And there's an irony here because those who are going around saying that what machine learning augers is the end of theory, apparently aren't noticing the fact that in order to understand when machine-learning will fail and how you could exploit possible failures of machine-learning, are going to need to use theory to do it. And so, theory ends up creeping back in here in an interesting and, to my mind, important way.

Conclusion

To conclude there are three points I've made.

- Every model makes assumptions. The reliability of the models depends on that.
- Machine-learning models also make assumptions. These assumptions are different. They don't involve explicit theory or explicit fiction, but they can fail. And just like with traditional models, we need to identify and understand what these failure modes are, and what we're assuming if we want to use these models effectively.
- And finally, it's not all doom-and-gloom. I think that understanding these assumptions, understanding the ways in which models do and don't fail is not only essential to using them reliably, but can also create trading opportunities.

References

Black Fischer (1989). How to use the holes in Black-Scholes. *Journal of Applied Corporate Finance*,1(4), p67-73.

MacKenzie Donald (2006). An Engine, Not a Camera. How Financial Models Shape Markets. The MIT Press.

Nguyen Anh, Yosinski J. and Clune J. (2015).Deep Neural Networks are Easily Fooled: High Confidence Predictions for Unrecognizable Images. *In Computer Vision and Pattern Recognition* (CVPR '15), IEEE. Available on arXiv.

Rauber Jonas, W. Brendel and M. Bethge (2017) Foolbox: A Python toolbox to benchmark the robustness of machine learning models. Available on arXiv.

Szegedy Christian, Zaremba W., Sutskever I., Bruna J., Erhan D, Goodfellow I. and Fergus R. Intriguing properties of neural networks (2014). Available on arXiv.

Valuation Method and Risk Statement

Our quantitative models rely on reported financial statement information, consensus earnings forecasts and stock prices. Errors in these numbers are sometimes impossible to prevent (as when an item is misstated by a company). Also, the models employ historical data to estimate the efficacy of stock selection strategies and the relationships among strategies, which may change in the future. Additionally, unusual company-specific events could overwhelm the systematic influence of the strategies used to rank and score stocks.

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Neutral	FSR is between -6% and 6% of the MRA.	39%	23%
Sell	FSR is > 6% below the MRA.	15%	12%
Short-Term Rating	**Definition**	**Coverage**[3]	**IB Services**[4]
Buy	Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%

Source: UBS. Rating allocations are as of 31 March 2018.
1:Percentage of companies under coverage globally within the 12-month rating category.
2:Percentage of companies within the 12-month rating category for which investment banking (IB) services were provided within the past 12 months.
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