Science Behind Finance: Revisiting the Foundation: Black Swan, Randomness, Predictability, Causality, Convexity, Conventional Statistical Tools, Factor Investing , Tail Risk.

Author : Pankaj Mani

(manipankaj9@gmail.com)

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Affiliations : CQFI(Fitch Learning),GARP FRM, AIFI@NYU Tandon, RWRI, RealWorldRisk

Note :This is Randomly written Collection of Deterministic Thoughts in Randomized English Syntax !!

Abstract :

Conventional Financial Investing has been studied from an economic perspective logic and application of Conventional flawed Popular Statistical Tools, Factor Investing (Often Misunderstood by the Modelers) affecting trillions of dollars investment globally but it lacks a proper Scientific base. This paper aims to check and forward the conceptual, Scientific background of Financial Investment, Risk Management, the Duality of Randomness and Determinism, Black Swan, Tail Risk, Conventional Statistical Tools e.g. Linear Regression, and Popular Risk measurement metrics e.g. Sharpe Ratio, Max Drawdown etc.

It further explores the scientific foundation of Convexity, Causal Based Randomized Factor Investing for Portfolio Management and how Financial Investment & Risk Management should be studied and practised in Scientific way in Real World rather based on many Economic theories without proper Scientific validation. This is a Conceptual Paper because it looks at the foundational issues with the Conventional Statistical /Mathematical /AI/ML tools applied in Real World Finance.

It explores how financial investment and risk management/taking should be done scientifically in forward direction of time rather backward direction of time.

Note : Everything can't be made public here as that could affect the causality dynamics for this paper being the part of the system studied by traders and investors as well . It's Self-Referential issue. as Godel's Self-Referential Statements in Mathematics and Logic !

The topics covered :

- **Background of Modern Science**
- **Scientific Philosophy background of Randomness & Determinism in Universe/Nature, Markets, Life, Human Behaviour**
- **Philosophy of Predictability Vs Uncertainty**
- **Scientific Origin of Black Swan**
- **Foundational Issues with Conventional Statistical Tools : Linear Regression, Correlation, Beta, Simpson's Paradox, Error Dynamics**
- **Fundamental Issues with Conventional Factor Investing**

- **Scientific Causal Mechanism Dynamics of Market**
- **Causal Dynamics Example of Bubbles and Crash**
- **Scientific Origin of Convexity & Randomized Approach e.g. RCT, AlgoWheel etc..**
- **Causal Adjusted Randomized Factor Investing**
- **Understanding Risk Scientifically in Real World**
- **Fundamental Scientific Concerns about Popular Tools e.g. Backtesting, Scenario Analysis**
- **Causal Adjusted Monte Carlo Simulations, Probabilistic Expectations**
- **Foundational Issues of Classical Mathematical/Statistical Tools in Finance**
- **Foundational issues in AI/ML models: Scientific Origin of non-Stationarity**

1.Background of Modern Science :

Modern Science has evolved from Newton's Classical Laws to Quantum Mechanics over the time. Einstein's Theory of Relativity to Schrodinger's wave Equation to Heisenberg Uncertainty Principle to Paul Dirac's Principle of Least Action to Feynman Path Integral Approach have been developed in

the study of science over the time. Science is still trying to unify the two extremes of Classical & Quantum world laws. On one hand, things appear Deterministic in day to day Classical world, things appear highly Uncertain/Random/Probabilistic in Quantum world. Modern Science is trying to understand the Quantum world of Uncertainty and Unifying it to the Classical world.

Albert Einstein throughout his life couldn't digest the belief that God is playing dice with us. He believed in Deterministic world inherently which has been refuted over the time. On contrary, Principle of Complementarity emphasizes the role of Observer(Human Brain) through which the External world is experienced. Even Stephen Hawking talked in context of theory of Everything in Science about the same regarding the role of human brain in the ultimate theory of universe.

Max Planck ask talked on the similar line. This is in fact true that Science can't find the ultimate theory of Everything without knowing about Human Brains, Consciousness etc. There is also Paradox of Self Consciousness and I wish I could take this here to show how Modern Science needs radical approach and try to unify the ultimate reality of the Universe-Brain mutually. How a peculiar super geometry could unify the Copenhagen/Quantum and Classical Interpretation of the universe where the external world exists independent or dependent on the observer. But that's extremely deep and require outstanding imagination but as this is beyond the scope of this paper, I would leave it here for now for some science paper/book.

This is beyond the scope of this paper here. Hence, I would like to confine here.

Feynman's Path Integral approach has been arguably the most powerful scientific result in Science which originated from Paul Dirac's Principle of Least Action. I would state based on my own scientific research that even Classical world theories like Newton's Laws of Motion etc. originate from the Quantum Energy Laws fundamentally. In context of deeper aspects of Zeno's paradox, I would say that Classical world laws are just the superficially an illusion created by Quantum Realities. But that's deep subject for some other paper.

Those who have studied Physics know that one can derive Newton's Laws of Motion from Principal of Least Action which is also supposed to be the core of Quantum world Laws. It states that any system tries to trace the path of Least Action (Action is basically a function of Kinetic & Potential energy), loosely speaking, least energy in least time.

So, Feynman's Path Integral approach which also the principle behind Feynman; Kac approach for solving Differential Equation having use in Quantitative Finance originated when Richard Feynman tries to show that Schrodinger Wave Equation in Quantum Physics can be derived from Feynman's Path Integral approach.

Feynman's Path Integral tries to sum all the possibilities of trajectory to find out the resultant path and this came up when he tried to explain wave particle duality in context of the famous Double Slit Interference experiment.

Though this approach by Feynman needs further improvement and clarifications in my own ongoing research especially in Human Quantum Behavioural context , that's beyond the scope of this paper now but that's the foundational guide to how financial market tools must be redeveloped scientifically in the real world future applications replacing the ineffective old ones.

Infact Especially the Quantum Human Behavioural world, as Feynman calculates the Causal Probability of different Possible Paths and then sum all of them, In Reality the Paul Dirac's Path of Least Action may not be the Sum of All Paths rather the Path of Maximum Stability & Likelihood. This is where the fundamental revision requires in Quantum Human aspects driving the financial markets based on my research .

Quantum Human Version of Feynman's Path Integral /Paul Dirac's Principle of Least Action.

Maximum Stability Path may not be the Sum/Average of All Probabilistic Paths rather always in especially Quantum Human Behavioural Driven world which drives the market. This is also linked to how Conventional Probability & Statistical Expectation Value need to be revised in Market Context Causally driven by Quantum Human World.I'll talk about it later and show how the powerful tools like MC Simulations, Statistical Expectations & Statistical Tools have to be made Causally Scientific in Real World Fiannce!

Feynman's path integrals formula is so far possibly the most powerful theory in physics to describe the laws of Nature. Starting from the Paul Dirac's theory that a body traces the path of least action(roughly speaking least energy and time), Richard Feynman derived Path Integral approach to discover the path of an object. It basically extends Principle of Least Action to Quantum world from Classical world.

Below are the equations of Feynman's Path Integral theory to Principle of Least Action which tries to minimize the Energy Function of a system from which are linked to the Laws of Motions

$$\langle x_t | e^{-i\hat{H}t/\hbar} | x_0 \rangle =$$

x_0

x_t
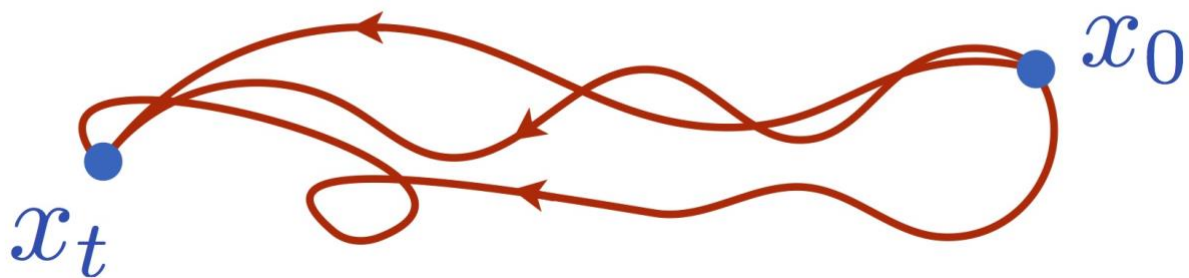
$$U(x_f, t_f; x_i, t_i) = \lim_{N \to \infty} \int \left(\frac{m}{2\pi i \Delta t}\right)^{N/2} \prod_{k=1}^{N-1} dx_k e^{i\Delta t \left[\sum_{l=1}^{N} \frac{m}{2} \left(\frac{x_l - x_{l-1}}{\Delta t}\right)^2 - V(x_{l-1})\right]}$$

$$\equiv \int_{x_i, t_i}^{x_f, t_f} \mathcal{D}x e^{i \int_{t_i}^{t_f} dt \left[\frac{1}{2} m (\partial_t x)^2 - V(x)\right]}$$

$$\equiv \int \mathcal{D}x e^{iS[x(t)]}$$

$$S = \int_{t_i}^{t_f} dt \; L[x(t)] = \int_{t_i}^{t_f} dt \; \left(\frac{m}{2}(\partial_t x)^2 - V(x)\right)$$

Principle of Least action :

$$\delta \int_{t_0}^{t_f} \mathcal{L} dt = 0$$

$$S = \int (E_k - E_p)dt$$

E_k is Kinetic Energy while
E_p *is Potential Energy of the system.*

Still Science has lot to deeply look into like Locality-at-distance by John Bell(Bell's theorem ,Quantum Entanglement, Superposition, Interconnectedness, EPR Paradox (this year Nobel was awarded on the same Bell's theorem related work in Physics) for some wonderful experiments.

I could humbly try to take Science to much deeper level to explain my own findings here but that I would deal with separately the mystery of Locality-at-distance which Modern Science has not probably imagined so far and also Modern Science needs to push it's boundary beyond and obviously the Crucial role of Human Consciousness comes into play. Infact it's the super geometry at play behind the Quantum Entanglement & Universal Interconnectedness unifying the Consciousness of the Observer and the External Physical Realities. Will talk about in some other paper. Sorry I get drifted to talk more deeply about science here! But that guides how serious finance should be done in real world in causal scientific approach.

But controlling myself here, what is relevant in Finance context that Market and hence the dual game play of Uncertainty & Predictability would keep on going endlessly until investors. Market is essentially the sum of Quantum Human Behaviours of Buyers and Sellers in the Market and Stakeholders etc. Even Feynman's Path Integral approach/ Paul Dirac's Principle of Least action follows for Human Quantum Behaviour in Markets but yes slightly different variable form rather constant as in non-living world physics.

Hence, while Market/Finance has to be studied Scientifically in Causal way, one has to acknowledge that Science won't do magic by being able to Predict the Fundamental Uncertainty inherent Everywhere in Nature including Human Behavior. But there is good news to deal with Uncertainty which I would cover in different section here on Randomness.

Infact the whole philosophy of Prediction using Deterministic Mathematical /Statistical Tools seems to be misguided scientifically. Prediction tries to believe in disrespecting Quantum Uncertainty in Nature, Human Life etc. That's doesn't mean I am advocating against Prediction rather acknowledge the scientific Fundamental role of randomness, Uncertainty in Nature in Complementary way. And scientifically, the best way of Prediction is not to Predict beyond a point and respect Uncertainty in Nature that exists as Wave Particle Duality type. I'll explain that in detail in my book.

Infact, Conventional Mathematics itself is Deterministic say Conventional Probability Theory, Statistical Tools are themselves Deterministic!!

Beyond that as traditionally, statistical tools e.g. Backtesting etc. are applied in finance are mostly backward static looking but by looking it into science like dynamical motion of stock in Quantum Human Behavior Space-Time, trajectories would be forward looking like hard science Physics applied to Human Context. It would help understand and manage Black Swan type events scientifically and better be prepared to manage portfolio for people at large which affects common innocent people's hard earned money at large including through pension, Sovereign Funds, Mutual funds, hedge funds etc.

Quantum Zeno Paradox /Turing's paradox in Financial Markets.

One of the most important quantum phenomena is Quantum Zeno Paradox also known as Turing's paradox. Classical Zeno' Paradox pointed out that motion is impossible. Quantum Zeno paradox is that more frequently an observer observes, it arrests the change in the time evolution of the quantum system . I'm not going deeply into that here but the contextual point is that the market is fundamentally a quantum system, there is a Quantum observer's influence as well. The more frequently a trader/ investor tries to observe at market, there would be more arrest of time change of the

evolution of the system. This frequent time-to-time observance by traders /investors could delay its time evolution in some way affecting the growth over time, consequently the risk-return. Hence to make money in the quantum market, a trader has to allow the optimal time frame without influencing the quantum evolution of the portfolio. This is a very deep topic and requires proprietary strategies! Hence, I'll stop as it would likely affect the Causality of the Markets. Yes, that's true. Causality can be affected to some extent by writing about Causality publicly!! Self-referential issue!!

2.Randomness (Unpredictability, Uncertainty)Vs Determinism(Predictability): Duality in Nature.

For Long there has been serious conflict going on in Science/Philosophy/Social/Financial domains whether the world is Random or Deterministic. Science is still far from solving this. But let me state that there exists Fundamental duality in the Universe in terms of Randomness & Determinism just like Light behaves as Wave or Particle, which is a fundamental duality inherent in the Universe. Similarly, there exists a Fundamental duality of Uncertainty & Determinism in Nature and that's well reflected everywhere

including in Financial Markets. The market essentially also has this duality. And this exists Relative to the Observer. **Same thing can be Random or Deterministic to different Observer relatively. Information availability is also one of the causes. Also, same thing can be Random and Deterministic both to the same observer in different perspectives. This is Paradox of Randomness.**

In fact, Randomness & Determinism are NOT absolute phenomena. They can both co-exist with the same observer from two different perspectives and also relatively for different observers. It just depends on perspectives and also the level of information. Paradox of Randomness can be resolved by understanding this Fundamental duality in Nature, hence markets, life that Both co-exist together perspective wise.

It is generally treated that there is Absolute Randomness existing, that perspective needs to be fundamentally changed ! It's Relative not just for different Observers but also for the same Observer!!

One to understand this Duality inherent in Nature and everywhere in Life, markets. And I must say it is fundamentally linked to Wave-Particle Duality in Nature! That's deep and beyond the scope of this paper.

At the same time, I must categorically mention that Causation & Random are not two opposites rather even Randomness has the Cause. But knowing that something is Causal doesn't mean it's completely deterministic. It all depends on the level of information. As we know the Causal Law of Motion of a

Car but that doesn't mean one can completely predict an accident!! Randomness would also be deterministic in itself. Reference frame matters.

So, Randomness is NOT Randomly Random but "Deterministically" Random. ! Things are Locally Random but Globally Deterministic in Nature, Universe, and even Markets. One can relate this to Quantum Physics where a particle behaves randomly at the individual level but is highly deterministic at the collective level. But again, Deterministic doesn't mean Completely Predictive!

Hence, contrary to the understanding that Randomness is opposite or different from Causality and Causality is overestimated by Humans, I would rather say Randomness does have Causality and even Randomness has inherent Determinism that need to be discovered but that doesn't mean they would be completely predictable. It's like Quantum world as explained earlier, Fundamental duality exists. Things could be random and predictable relatively. As in Quantum world, a wave could behave Random/ Uncertain at some level but Predictable as well at some other level.

So, Randomness has to be studied deeply as the part of Causality but one has to acknowledge its existence and uncertainty inherent in Nature Relatively and Things can't be completely Deterministic or Completely Random. Randomness doesn't mean anything can happen, it would always be driven by Causal forces, but that we may not

completely know. One an relate this to Complexity, Non-Linearity etc.

Hence, Randomness is Deterministically Random not Truly Random in Nature/Market/Life hence in Financial Markets as well.

==As usually understood , Randomness is not absolute phenomenon, same thing can be random and deterministic from different perspectives and availability of information relatively for the same observer and different observers too. It's like Duality==.

==Non-Stationarity in Financial Data comes out of this Randomness originally. It's problem for financial models because most of them are backward looking . It should be managed scientifically opportunistically in forward direction of time==

<u>Randomness does converge to its Equilibrium State ! This is governed by the Law of Energy and Nature.This is Deterministic Law of Randomness/Uncertainty!! Yes Looks Paradoxical but true in Nature !</u>

So, things – On needs to understand the Causality /Determinism behind the Randomness. Randomness does follow some Deterministic aspects but that doesn't mean it would be completely predictable. That's the key to success in real world It's linked to attaining more and more Convexity. Will be dealt in the later section.

I would categorically state that Randomness is Deterministically Random not Randomly Random. What I mean here is that Even Randomness has Causality and they follow some Deterministic Laws of Nature.. Things appear Random Locally but they are highly Deterministic Globally in Nature. One can even visualize this in Mathematics as well. Riemann Hypothesis is termed as one of the most important problem in Mathematics which is linked to the Prime Number Distribution. The existence of Prime Number appears Random Locally like Riemann Zeta function's Non-Trivial Zeros but they are highly Deterministic that Non-Trivial Zeros linked to Prime Number lie on Critical Line. This has been experimentally verified as well which I think it's true.

Riemann Zeta Function : Hypothesis Pictures
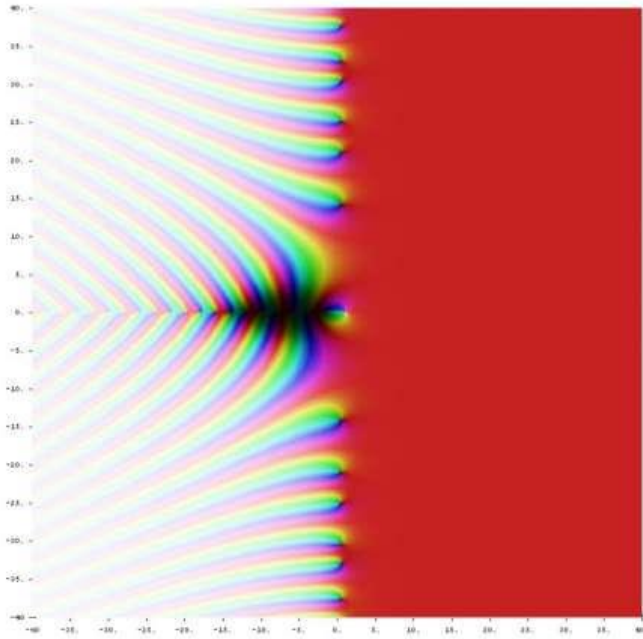
$$\zeta(z) = \sum_{k=1}^{\infty} \frac{1}{k^z} = \frac{1}{\Gamma(z)} \int_0^{\infty} dt \, \frac{t^{z-1}}{e^t - 1}$$

$$\hat{H} = \frac{1}{1 - e^{-i\hat{p}}} \, (\hat{x}\,\hat{p} + \hat{p}\,\hat{x})(1 - e^{-i\hat{p}})$$

Similarly one can see at many places in Mathematics as well. **One has to fundamentally understand that Nature is work in progress. Randomness is the part of evolution of Nature locally like wave but they are highly Deterministic Globally like Particle**..

Infact, Brownian Motion is also fundamentally/mathematically linked to Riemann Zeta function. Hence I had written a paper earlier to show that based on the Riemann Zeta Link /Riemann Hypothesis, even Brownian motion could be fundamentally globally Deterministic even if Random Process locally ! I had also devised an approach many years ago to show Riemann Hypothesis would be True by imagining the whole mathematics as a physical system but that's an open problem as of now officially). Based on that If they truly describe markets, Markets are also globally Deterministic, despite

looking Random. This could also raise Fundamental question on the Brownian Motion/Stochastic Equations as the infrastructure to describe Randomness in Markets which was first done by Louis Bachelier, if market is really random!!

Collective dynamics like Quantum world is that Summation of Randomness Leads to Deterministic patterns. That's how Nature Fundamentally evolves. That's also the reason why Monte Carlo Simulations type algorithms might work . Also, RCT, Algo Wheel type Randomized approaches.

There exist Global Causality of Local Randomness ! Randomness does follow the Law of Nature & Energy Deterministically in the Universe hence Human Behavior, Markets…

That doesn't mean things would be completely predictable. It's like we know the Laws of motion of a Car but can't exactly predict an accident!

The dynamics of Randomness comes from the Origin of Principle of Least Action by Paul Dirac to Feynman Path Integral…Things follow this path to reach the most equilibrium stage…And Randomness too essentially follows that Law ! That's why even Portfolio Construction should be based on Randomized approaches like Algo wheel where Factors can be Randomized and the Best Path of Least Action could be selected……This is what essentially leads to Convexity approach scientifically.

Hence , Black Swan ,Randomness do exist but essentially they would follow the Law of Causality where they would revert to

their equilibrium state. The key to Risk Management is to survive the whole cycle before the convergence !!

Randomness in Nature is not Randomly Random but they are Deterministically Random ! Randomness does follow Deterministic Laws of Convergence to the Stability being the form of Energy.

Deterministically Randomness has well defined Causal Mechanism but that doesn't mean we can completely predict them !

It means they have duality . They are basically Random but even inside **Randomness things have certain causes and are governed by the causal laws ! Random is Relative term depending upon the level of information/Perspective of the Observer.** So, we may not know what exactly would happen but that doesn't mean anything can happen anytime.

What ever would happen is governed by the causal laws but yes even then we can't predict them completely due to Incomplete information availability.

"We have to technically understand that Randomness in Nature hence Market & Human Behavior is NOT "Randomly" Random rather they are "Deterministically" Random in Nature and Markets ! Means Randomness doesn't mean anything could happen randomly. Whatever happens (we might not predict completely due to lack of complete

information available at any time)as the fundamental principles inherent in Nature inherited to Markets but it has certain causal determinism Fundamentally!" – Randomness has Hidden Synchronicity!

3)The Philosophy Behind Prediction : Trying to make the world Deterministic and Banishing Fundamental Uncertainty

from Nature, Life & Markets. Non-Stationarity as the Quantum Phenomenton in Finance

Almost all the financial models try to predict the market based on various statistical and mathematical tools. Even in Life, we want to predict and also in various other social and other domains. Everyone talks about Prediction more or less. But have we ever thought deeply that what we inherently do when we try to predict ? So, what does Prediction mean scientifically? Prediction means the observer is trying to make the world deterministic by knowing the state of the world at Time t at present (Time =0). Even Nature doesn't know what it could be at Time T =t because it's itself a work-in- progress driven by Causal forces. And the State of the world at Time T=0 and the Time T=T both could be different and even Nature doesn't know what could be. So, by trying to predict, the observer might influence the system by influencing itself. These all are Scientific in context of Quantum Reality in Physics.

Hence, it's scientific based on quantum uncertainty effect that the best way to predict is not to predict it beyond a point. It's better to focus on the local process in a convex way, automatically, the outcome would get accomplished. The more certain and predictable observer/trader/investor would try to make the outcome by predicting more and more beyond a point , the more it could be unpredictable . This is Quantum World Effect in Market ,

Non-Stationarity in Finance as the Quantum Reflection of Human Behavior :An Opportunity rather Constraint !!

Non-Stationarity of Financial Data in Real World, a fundamental issue with almost all the Financial Models is basically the reflection of Quantum Human Behavioural world that is being mapped onto classical mathematical/statistical models to predict etc..

What needs to be conceptually understood that no matter how sophisticated models based on stationary mathematical tools(e.g. classical tools) are developed,the prediction will be constrained by Non-Stationarity being a Quantum Reflection of the Reality ! The Conventional Classical Mathematical Tools are fundamentally Stationary

But practically here, Non-Stationarity can't be resolved by developing advanced models as long as their mathematical foundation is itself stationary !! Even the Fundamental Philosophy of Prediction will also always be constrained by Non-Stationarity. So, the key is not to develop complicated stationary models rather understand the causality dynamics of quantum human behavioural randomness from where non-stationarity enters in the financial time series data. As discussed in the Scientific aspect of Randomness in this paper, it can be possibly resolved. In this way, Non-Stationarity should be like an opportunity rather a fundamental constraint here !

4.Application of Statistical Tools in Finance : Misunderstandings : Role of Time in Mathematics/Statistics in Real World. Statistics Needs to be Scientific: They are always Backward in Time: Causal Science can make them look forward in Time. Fundamental issues in Conventional Mathematical Tools in Finance : Classical to Quantum Mathematics

Statistics is abundantly applied in the world of finance. Almost all the financial models so far uses statistics whether for risk management or prediction etc. But the fundamental issue with almost all the conventional statistical models is they all are backward looking in the direction of time. This ignorance of understanding the role of Time dimension has possibly made the Financial models like a scam in itself may be. Mathematics has always been studied independently of Time assuming absolute for all the observers. This Platonist view is also one of the causes of misunderstanding and

misapplication of Statistical tools in Finance which suffers from Hindsight Bias.

THE FUNDAMENTAL PROBLEM WITH STATISTICS IS THAT IT'S ALWAYS BACKWARD IN DIRECTION OF TIME !! STATISTICS NEEDS TO BE REPLACED BY CAUSAL SCIENTIFIC MECHANISM IN FORWARD DIRECTION OF TIME DRIVEN BY FORCES !

The Problem with History is that observer sees only one history out of many possible unobserved histories that could have occurred like in many world theories. This biasness risk could be dangerous in real world for back ward looking financial models and tools.

Financial Statistical Models are always built in Past data in the direction of Time. At Time T=0, a modeller does curve fitting for Data over T< 0.

But the Modeller doesn't understand ignorantly or by inertia that T> 0 & T<0 are not the same in the world of Statistics/Finance.

By looking Backward in the direction of Time, Modeller rules out the Randomness component which is present while looking in future way back then. Future Direction of Time has many possible paths randomly but Backward Direction of time has just One Deterministic path which actually occurred and on which Data fitting is done. This foundational blunder

of ignoring the Randomness in Backward Direction of Time is the core of all the issues in Financial Modeling based on Statistical Tools. The entire estimation of Risk, Prediction etc based on such Statistical Tools ignore the vital role of Randomness which a trader actually undergoes while taking decisions in real world. Unfortunately, Out of many possible unobserved paths in future, the statistical modellers only takes the observed path in the backward direction of time.

The fundamental issue with Statistics is that it is always done in the backward direction of time based on historical data. That's where the role of Causality & Science comes in. Causality tries to look forward using scientific mechanism . Let's imagine in physics, we are using statistical analysis of past trajectories to trace out the future trajectory. Does it sound awkward? So, then how do we do that in Finance? Finance has to be studied like Scientific Physics and that Principle in the forward direction of time. This ingrained psychology of statistical analysis in finance should be replaced by scientific Causal analysis of the future where we could study Randomness, Determinism, Human Behaviour, etc.. And yes, some investment and risk strategies are causal based on scientific principles. We will talk about it later.

Hence Psychologically engrained Backward Time Looking Statistical Analysis must be discarded and Forward-Looking Scientific Causal Analysis as we do in Physics etc. must be adopted. This would also be the key to Scientific Risk Taking & Management and dealing Scientifically with Black Swan-type events in Real World.

The fundamental issue with the financial models is that these statistics tools, methods are all backward looking in time. They are not forward. It's a paradox/Contradiction in itself that Backward Looking analysis tools are applied for Future analysis in the dimension of time.

The tools like Back testing etc are the subset of that unscientific understanding of Role of Arrow of Time in Statistics in Real World.

That's the reason why Finance has to be developed in the forward direction of time as we do in Physics. Do we Backtest in Physics to predict the Trajectory of a vehicle /Car or we study the equations of causal forces? This fundamental psychological change has to be brought in the world of finance where the trajectory of a stock price is studied scientifically by analyzing Causal forces, rather than Backtesting.

Even for those who simulate Randomly in future like MC Simulations etc must understand that There could always be more future possible Scenarios in Real World than one can simulate using Computers or otherwise. This could be fundamentally related to Godel's results.

The point is Finance has to be studied in scientific way in forward direction of time like physics/science. That's the way, one can have better understanding of risk-return in real world

finance. For that ,one will have to understand the Causal concept of Uncertainty/ Randomness in Life/Nature/Markets. This is because by understanding this concept, one can take Scientific decisions to build the portfolio or otherwise.. Otherwise all those Statistical based tools like Sharpe Ratio, Drawdown, Correlation etc. out of historical data or observed data is just the tiny subset of all the possibilities and hence hugely misleading for understanding risk in future real world.

Like in Feynman Path Integral approach of Quantum Mechanics /Paul Dirac Principle of Least Action, Explore all the paths not just the observed ones and each path is based on certain causality like action of that path ! I'll explain later in detail.

Now let's look at the Fundamental Compatibility of Mathematical/Statistical Tools in Finance.

Traditionally the tools that are often applied are Probability Theory, Statistical Expectations Operators, Euclidean Calculus(Stochastic), Linear Algebra etc. Let's look at their origins. These tools were originated by contemporary mathematicians when there were classical world developments in physics by Newton, Leibniz, Gauss, etc.. over time Physics evolved from the Classical Newtonian world to Einstein's Relativity theories to Quantum Mechanics, etc..but the mathematical tools that originated to support physics or

otherwise remained trapped in the Platonist philosophy of view which would remain constant and independent in Classical forms. But as long as they are applied to Classical worlds, they are fine but when they are forcibly applied to Quantum world say Quantum Human Behavioural aspects like Markets, Finance, Life, etc. These fundamental issues start raising up that how compatible those classical world deterministic Euclidean space mathematical/statistical tools are with the Quantum worlds particularly Human behavior which drives the markets.

Let's take an example: First with Statistical Operations like Expectation E[] which are used to calculate moments, and the Probability Theorems.

Are in Real World Quantum Human Behavioural Space-Time Expectation Operator Formula is the same as for the Motion of Non-Living Natural Celestial Objects? To remind that LS based Regression was first formulated to apply to celestial mechanics.   In Real Life, does this traditional deterministic probability theory or Statistical Operators hold true always? No! If we look into the Logic behind this, it comes from the understanding of logic & Physics of those Legendary mathematicians. At that time Quantum Mechanics, Relativity, Principle of Least Action etc were not known.

So, to make the mathematical/ statistical tools compatible enough for Quantum Human Behaviour these Probability theories, Euclidean Calculus etc. Not likely true. There has to be developed Quantum Mathematics, Quantum Operators, Quantum Expectations etc. as they work in Human Quantum

world. Say for example to explain the difference, in classical world, if observer conducts an experiment 10 times, it would get the same outcome, But in Quantum world/Quantum Human Behavior, one can't expect the same Deterministic Outcome of Expected Results in 10 Quantum Trials. One can relate it to Markets which is also a Quantum System fundamentally. There would be Uncertainty in the Expectation / Expected Result. So, the foundational point is Quantum Human Mathematical Tools have to be developed like Riemannian Geometry was developed for Einstein's General Theory Of Relativity. We see mostly financial people using the classical conventional deterministic tools to prove and disprove n number of results in finance and real world without understanding the fundamental discrepancy and incompatibility somehow. Then they complain about Non-Stationarity without understanding the hidden concepts in depth. Blindly applying those statistical/mathematical operators, tools etc. and blindly applying to make investment decisions.

So, the fundamental requirement is to develop new mathematical & statistical tools operators for quantum human behavior and hence financial markets . This is because Classical Euclidean type mathematical/statistical tools might not be fundamentally compatible with quantum human behavior. Hence, it doesn't make true sense to model financial markets, risk etc. In real world.

This is the prime reason I've not used Mathematical/Statistical tools here in the paper much as I don't find them much fundamentally compatible (beyond a point) in real world markets driven by quantum human behavior. One can't explain the fundamental issues with these Conventional Conventional/Statistical tools using these tools themselves. The problem of Self-reference.

5.Regression Analysis, & Paradoxes

$$Y = \alpha + \beta * X + \epsilon$$

$$E[\epsilon/X] = 0$$
$$E[\beta/X] = \beta$$

$do[X = x]$ Let's assume the Linear Regression Equation

$$Y = \alpha + \beta * X + \epsilon$$

$$X = \alpha_1 + \beta_1 * Y + \epsilon_1$$

$$Y := X\beta + Z\lambda + u \ where \ \lambda$$
$$\neq 0 \ and \ u \ is \ the \ white \ noise$$

$$X \ causes \ Y \ iff \quad P\big[Y\big|do[X]\big] > P[Y]$$

Where Y is the Dependent Variable , X is the Independent variable and α is the Error Term of the Linear Regression.

$$X = \alpha_1 + \beta_1 * Y + \epsilon_1$$

So, we can see that Association ignores the Fundamental Role of Direction of Time here. . It could be both way but Causation has direction like Cause and Effect at different Times subsequently.. ! To determine Causality, one will have to block all other paths/factors and test the direct effect ..for example…Stocks in different economic scenarios…or other company specific factors to test the causality …

For example: The Sun rises in the morning and the bird sings in the morning .They are obviously correlated but to test if Bird singing causes the Sun to Rise one can test if the bird sings when the Sun doesn't rise on cloudy days or if the Bird doesn't sing, does the Sun rise or not… One would find that this is not the case. That means it's association ! Like two cars running on road would be associational not causal and they could suddenly change the direction after sometime if roads diverge suddenly…So, misunderstanding those two cars relationship is causal could mislead suddenly! Similar is like Factor Investing. If certain factors work doesn't mean they are causal. They could be misleading and could be by chance unless Causality is established !

If this is causality the absence of one would definitely affect the occurrence of the other event. If A causes B then if A doesn't occur, B should be affected every time. That need to be tested.

But one does have to accept that there could be many more unknown causal factors that one might not know which could be in the form of randomness errors…!! So, that's why Randomized type algorithms (e.g. RCT, Algo wheel etc.) type approaches would be required at later stage to deal with them !!

Linear Regression: Single Variable

$$\widehat{y} = \beta_0 + \beta_1 x + \epsilon$$

Predicted output · Coefficients · Input · Error

Linear Regression: Multiple Variables

$$\widehat{y} = \beta_0 + \beta_1 x_1 + \dots + \beta_p x_p + \epsilon$$

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon$$

Point 1) In the first one variable Linear Regression Model (LRM), what is the most important term is the Error term(residual). This represents the Randomness ,Uncertainty component . **The error term is the TRUE Origin of the Black Swan events & hence Disastrous Tail Risk.**

What is to be noted that in the above Regression formula, X1,X2 etc. are independent variables usually ignored in Factor based Investment Models.

For example, while doing Linear Regression analysis in Factors and hence to calculate So-called Alpha, why is it assumed that different factors like Value (HML), Momentum, Size (SMB) etc. are independent ? Are they really

independent in Real World ? No , they are not necessarily Fundamentally Independent ! so how far this Regression Analysis application to calculate Alpha is accurate ? The entire calculation of Alpha itself violates the fundamental assumptions/requirements of Linear Regression . The assumption of Independence in Statistics is the fundamental blunder in Real World Finance affecting huge amount of money management in the finance industry.

As I usually say Assumptions & Approximations could be more dangerous than Nuclear Bomb !!

1)Reverse regression Y on X and X on Y are different !

2)Relativity of Beta when many independent variables X 1 ,X2 etc are included. Beta changes . Beta becomes different when new independent variables are included in the Linear Regression Analysis. Hence the value of Beta is NOT absolute rather relative !

Statistics is NOT wrong but Statistician needs to understand the statistical terms well in real world applications and their assumptions ! This error term which is often ignored is the most vital component in the real-world financial applications. This is where the Mystery lies !!
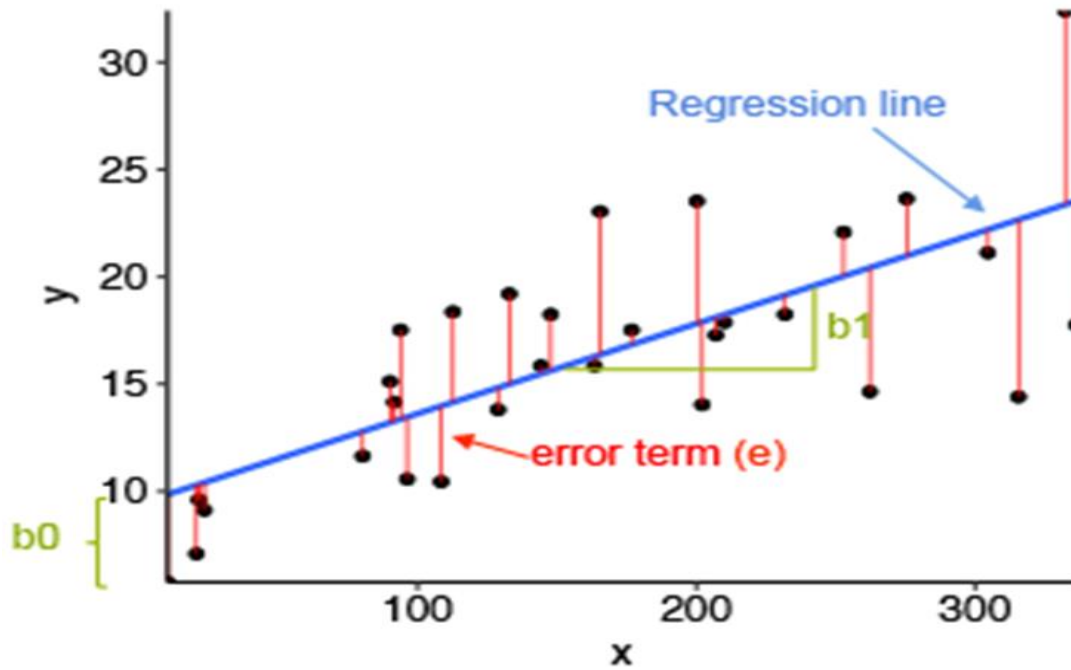
The General Structure of Machine Learning Models Like the Regression and other ones is the following

$$Y = f(X) + \alpha$$

It's all about finding the suitable functions $f(\ )$. Here also once can see that though $f(\ )$ could be many but the error term still exists which is the source of Black Swan Tail Risk.

The key issue is while most approaches on finding f() based on historical data fitting, what should be the focus is on

managing future error terms (randomness uncertain components). Little effort is made to focus on Randomness (Error), most effort is focused on Modeling Deterministic aspects and assuming Error/Random term would be expectedly zero or like that. This is what the core blunder is in real world applications. AI/ML models also need to change its focus on that .

That's where the generic fundamental issue of Non Stationarity in Financial Real World Data is! No matter how sophisticated functions based on these deterministic classical Euclidean-type mathematical and statistical tools are developed, the problem of Non-Stationarity would remain because of Fundamental Quantum Randomness. Hence, The Real Focus should be on the Error term of the Regression /ML Models which reflect that quantum reflection ! That's the true source of Black Swan, Tail Risk, Fat-Tailed, etc.

That's where real-world model development is needed…Managing the Unknowns and Random Components in the form of Error is equally rather more important from risk /black swan type events..

Market is essentially the resultant of all Human Behaviors ! Need not forget.

In context of Black Swan ,it is said that Real World is more Random than usually understood Indeed that's right ! But then Randomness is also not Truly Random..It   follows Deterministic Laws of Nature. It's basically paradoxical in the form of Duality in Nature, Life and Markets.

One more fundamentally important point is that Stock Prices don't move on Euclidean Space of Paper in reality . This is virtual mapping of trajectory because Conventional (Classical)Mathematics itself has assumption about its own space . In Real World, the Stock Price moves in different Non-Euclidean /Riemannian/Some other Quantum Economic Space-Time which captures Human Quantum Minds etc.. Then we are trying to superficially/virtually draw the trajectory on the two dimensional paper .

 So, while doing Linear Regression Analysis , it must be independent of the intrinsic characteristics of the underlying space. Hence, whether Regression Analysis is done on Euclidean or different Geometric Space (as in Machine Learning etc.) the true physical relationship must be invariant ! We also often see AI/ML tools relying on Euclidean metric spaces only! That could be misleading inreal world finance.

Hence, these parameters like Beta, Alpha, etc depending on the slope of the line in Euclidean Space could be fundamentally misleading !! Because in different Spaces, Beta (calculating using Euclidean Metric Least Square Distance)could be possibly different but it has to be independent of the underlying characteristics of Spac**e. This is an extremely fundamental issue while doing conventional Linear Regression analysis/AI/ML models etc.. In a nutshell, this Beta relationship couldn't be in the Real Economic Space Time but the characteristics of the space of the paper on which we have superficially assumed to draw the trajectory of the stocks by mapping. This is also because these conventional mathematical tools deriving out of Euclidean**

type metric spaces are fundamentally Incompatible to the Realities in other Quantum Spaces including Huma Behaviour and hence Markets.

6.REGRESSION PART2

A)Causation is in the dimension of time which LS Linear Regression doesn't take into account….Time dimension…it treats them statically in timeless dimension only space !

We have to understand in real-world perspective that Causation is established in the Space-Time dimension not just Space. As in the Physical world, cause occurs at say for example T=0 and effect occurs at sometime in future T= t. If we ignore the dimension of Time and take only Spatial locations into consideration, it becomes just association not causation. For Causation we have to test the Cause and Effect in Space-Time not just Space. Unfortunately, LS Regression is being conducted particularly in Factor Based Investing and otherwise in Finance ignoring the Time Dimension. This omission of time makes the entire relationship like associational of patterns that could be just co-incidence but not scientifically causal.

By running the following LS Regression

$$Y_t = \alpha + \beta X_t + \epsilon$$

We often inherently assume that X and Y both are able to transmit information causally "simultaneously" at time T=t at more than the speed of light, but how this is possible ? If they are really causal, then first X should occur at Time T=t and this should cause effect to Y at some time in future T = t+n where n >0. **But in the conventional LS regression it is inherently assumed that X and Y both are cause and event at the same time which is contradiction in real world**

scientifically in Nature unless it's the case of Quantum Entanglement like events !!

It otherwise proves that X and Y relationship is Associational based on Superficial Patterns either caused by Coincidence(Like two independent Cars moving on the road in the same direction misleading an external observer to be causal to each other) or they are caused by some hidden causal mechanism of some other variable known as Confounder. **The above LS based regression can take place at the same time "Simultaneously" iff there is hidden Confounder(if it's not coincidence!) as information can't travel at more than the Speed of the Light ! (Of course it's not Locality-at-distance logically here**!)

So, for Causational Proof, the Equation has to be in the form of do calculus. This is causal intervention that if X is causally set to value x at time T=0 for example how the effect on Y behaves in future value of Time =t and that time t can have different values on case to case basis.

$$do[X = x] \; represents \; intervention \; where \; X \; set \; to \; x$$

$$X \; causes \; Y \; iff \quad P\big[Y\big|do[X]\big] > P[Y]$$

I have been advocating for long that Time Dimension is often ignored in the Statistical and Mathematical world(Timeless Platonic world) unlike Physical world(Space-Time) at the foundational level. The role of time appears non-sensical often but at deeper level it makes huge difference! Many of

the long Paradoxes in Mathematics originate also due to this omission of Time as well fundamentally. Say for example, Theory of Relativity considers "Simultaneity" as Relative while Conventional Set Theory in Mathematics rests on the Principle of Simultaneity as an Absolute Phenomenon. This is beyond the scope of this paper. But I mentioned to show how this foundational misunderstanding percolates down to statistics and Association in LS based Regression is often misunderstood as Causation !

B) Let's go back to the history if LS Regression method. It was first formulated by Mathematicians like Gauss, Legendre in 1722 to around 1800 for the estimation of Trajectories of the Celestial Physical Bodies like our Earth in the Euclidean Space.

That's mathematically good estimation as that physical space-time behaves like Euclidean Space-Time. But the foundational issue arises when that Tool from Physical Space Bodies is being applied to the Financial & Economic Space-Time. **The financial and economic space-time driven by quantum human minds is not essentially an Euclidean Space-Time rather they have at least Non-Euclidean/Riemannian or some other Quantum Metric in Real World.** Statisticians import the observations from that Space to Euclidean Space of Computer Screen or Paper to draw and apply LS Regression ! But this raises fundamental question that the Euclidean Space of Paper and Metric calculation doesn't bias the Estimation of Financial & Economic Variables from a different Non-Euclidean space-time ? I am stating this because the way Least Square method is developed, is it Not inherently dependent on the Euclidean metric relationship ? What if these data are drawn on some other Non-Euclidean Space ? I mean this Relationship should

be independent of the Underlying Geometry of Space where these are drawn. The Real -World Economic & Financial Space-Time is not Euclidean !! This a point of exploration as even in ML methods, often Euclidean metric tools are applied. But it could be Non-Euclidean and other Riemannian Metric Spaces as well to better discover the relationship. But in reality Financial time series data originate in Quantum Human Behavioral space-time.

But anyway let's confine to the Euclidean one that is generally taken to derive the Least Square based Regression Method for a while ….

Least Square based Regression Tool is due to the algebraic structure of Least Square Formula where it minimizes the Sum of Squared Differences(we can say them Euclidean Errors!). If we change this objective of Minimizing the Squares to something different, the entire Calculation of Beta would be different and the value of Beta would change! Beta is actually dependent on that Euclidean method. But why we minimize the Sum of Errors is itself under question! How far is this process effective to take into account the Outlier in Real World ? Let's say we don't minimize the Sum rather we minimize some other functions that could be more suited to Outliers for example from Tail Risk Perspective. There could be different values of Beta on the same set of Data the way we define the minimization function of errors. It's not Absolute ! It's Relative ! The important concern is that in Factors Investing and Finance & Risk Management LS Beta is blindly applied for Allocation, Risk estimation that has proven to be disastrous in Real World in case of extraordinary(outlier) scenarios.

Further, one more important aspect of LS based Regression is the Exogenous Condition that

E[error] = 0

And if this exogenous condition of error is not satisfied, the whole estimation of Beta is unreliable and biased ! This is the fundamental reason why in Real World Finance, Beta is often biased and variable in Financial Time Series data.

Exogenous condition means the independence of Error terms E[error/X] If Exogenous conditions are not satisfied, that means the Error itself is the function of some hidden relationship . It could be that Error is dependent on Y or X or some other hidden variables which govern the dynamics of the error and which in turn make Beta unbiased and unreliable as both are mathematically related ! Hence the internal dynamics of Error has to be established otherwise it would affect the other aspects of the LS Regression. Even there can be different dynamics of Error say if Error itself is some other variables regression

$$Y = \alpha + \beta X + \epsilon \text{ where } \epsilon = \alpha_0 + \lambda Z(orXorY) + \epsilon_0$$

If such is the case β value would be highly misestimated ! This actually happens in the Real World Finance & Economics Time Series data !

It's like in algebraic equation

$$y = m\,x + c$$

where constant c is itself a function of variables x or y or z …

In this case the m would be highly misleading ,biased and incorrect mathematically.!

Infact such conceptual mistakes highly mislead in the real world finance and economics where beta(technically slope) becomes too variable dependent on the data time frame etc…and exposed to Black Swan Tail Risk affecting Billions/ Trillions of Dollars of Investment globally affecting common people and Investors' lives.

Error basically means Random Component ..all the deterministic components of Y dependent on Independent variables like X have to be removed from the Error term.

So, In Financial /Economic world, unless Error satisfies the Exogenous condition $E[\epsilon/X_t] = 0$, the LS estimate value of β will not be unbiased.

If the expected value of the Error term above is not 0(the violation of Exogenous condition), it means that there is still some hidden deterministic variables relationship to be discovered inside error terms. The error term like constant as in the equation $y = mx + c$ is not a constant but a function of some hidden variables or even $x \, or \, y \, itself$.

The correct meaning of $\epsilon \; error \; term$ is that uncertain Portion   of
$Y \; which \; is \; not \; explained \; deterministically \; by \; X.$ In Real World example the error term represents that Unpredictable component when we try to explain Y in terms of X causally.

It's like we intervene by the cause $do[X = x]$ at say Time T= 0 and measure its effect on Y at Time T= t. Infact in true causal sense these two occur at different points in time not at the same time(simultaneously) because information traveling takes some time. Then we try to understand what uncertain random component of Y is not explained by the deterministic components of the equation. We call this as the error ϵ causally. But this omission of Time dimension makes the entire thing superficial associational relationship and just an artifact of Euclidean metric space !! **The way error is defined as Y − E[Y/X], it shows that the error term is not independently defined.**

This is like B1 Spurious case as explained.

"This is most likely valid in the field for which LS Regression was formulated in Celestial calculation but not often in the Financial and Economic Space. The Real World Data hardly show the Exogenous condition Satisfied."

Econometricians can't define error deriving from algebraic equation like Y- beta*X rather error terms should independently satisfy exogenous conditions E[error] = 0

Error should be independent of X

Exogenous conditions means Regression assumes deterministic set up.

Expectations of error or randomness to be 0

Correct meaning is if we do[X] at time t= 0 then at time t >0, Y should equal to X*beta.

Error means Unexplained part in Causal relationship of Y due to X.

Most Machine Learning Tools focuses on the deterministic part but there is need to focus on the Randomness(error) part and its underlying mechanism and how to manage those unexplained, uncertain components.

Present regression method at same time means it assumes the role of hidden confounder.

What is important to observe that in LS regression, the order of variable is also very important.

The two regression lines below are not derived from each other with respective coefficients.

$$Y_t = \beta_0 + \beta_1 X_t + \epsilon_t$$

$$X_t = \lambda_0 + \lambda_1 Y_t + \mu_t$$

That means in general LS regression method

$$-\lambda_0 \neq \beta_0/\beta_1$$

$$\mu_t \neq -\epsilon_t/\beta_1$$

$$\lambda_1 \neq 1/\beta_1$$

This reveals the internal dynamics of LS Regression that the Minimizing the Sum of Squared Errors method is not symmetric in this sense. The Order matters and at the same time the values of the Slope and the Error terms depend on the error and are not inter-linked. This implies that in real world financial and economic applications, before applying

this associational LS regression, one has to make sure about the Order otherwise the derived slopes and randomness error would change leading to different estimations of risk affecting allocations etc. This also shows that Error itself is relative and order of variable dependent on LS based system . **But in the Real World, the Random Components should be linked to each other if the Variables are the same just order changes.**

Coming back to the Commentary : the entire system is getting misled superficially by the Associational relationship based on LS type Regression affecting Trillions of Dollars Globally.

The way sum of squared error minimization has been defined in LS system, it's dependent on the Euclidean type system.

Econometricians assume they are doing Causal but the mathematical tools used are associational.

If LS system is changed, Beta will also be changed..

Question why LS system ?

Rather than minimizing the sum of the squares, there can be other better approaches as well from tail risk perspectives. (This is the other detailed research topic in itself !).

There is no fixed Beta . The value of Beta would depend upon how the Error terms are dealt with like LS equation. This is because Beta is derived by minimizing the Sum of Squared Error Terms.

Lets say there are different points $(x_1, y1), (x_2, y_2), \ldots (x_n, y_n)$

We are trying to find the regression equation

$$f(\alpha,\beta) = \sum_{n=1}^{n} \epsilon_i$$

where $\epsilon_i = y_i - (\alpha + \beta x_i)$

Here the values of α, β are those which minimizes the function

$$f(\alpha,\beta)$$

It shows here that at time T=0 the error(randomness) terms are figured out, then at time T= t >0 they are minimized mathematically to derive beta (deterministic)term ! This is also like In-sample derivation of Beta term(Deterministic Term) from the mathematical minimization of function of Random Terms!

Please imagine the role of Time dimension here. How Time dimension is often ignored. This is the fundamental cause of biasness. The LS Regression is basically like In-Sample Testing !!

Lets say the Regression equation

$$\frac{\partial S}{\partial \beta_j} = 2 \sum_i r_i \frac{\partial r_i}{\partial \beta_j} = 0, \; j = 1, \ldots, m,$$

$$r_i = y_i - f(x_i, \beta)$$

Here it shows that Randomness Term is the Function of Deterministic Term and that's why we take the derivatives to find out the minimum.

That mean at Time T =0, we try to estimate the Error first and then calculate Suitable Beta at Time T= t >0 , Please note the role of Time Direction as well. This is because for Causation, role of Time Dimension is the fundamental requirement in Real World. **By the way, This is like In-Sample Estimation where Beta is searched by deriving from the Error terms.**

Ideally what happens in the Real World… We should pre-estimate Beta(Deterministic Expected Term) at T=0 and then measure Error Terms "INDEPENDENTLY" at T = t > 0 and study the Exogenous Condition E[error/X] =0 if that is satisfied or not ! In the existing previous approach, "INDEPENDENCE" is completely compromised as Beta is derived from the Error itself !!

This is in principle foundationally incorrect leading to Biased estimation of Beta in In-Sample way.

So, the entire traditional Beta Estimation in LS approach is like In-Sample. It doesn't tell about Out-Sample Beta in Real World in Forward Direction of Time! Especially for the Financial Data which is often unstable, this could lead to huge misestimation in real world out sample result.

As we have seen earlier, the LS approach was formulated for Celestial Physical Bodies which is Classical World Stable Data unlike Financial Data driven by Quantum Human(Trader & Investor) Minds

7. Exogenous Condition :

LS Sum of the error minimum when Expected (error)= 0 . LS approach relies on the Expected (Average) figure where Average is hugely misleading Statistical Tool in Financial world with fat-tailed data.

The issue is even Exogenous Condition is not sufficient in Real World Finance because even if Expected i.e. Average is 0 satisfied but there is large negative movement and then subsequently large positive movement but the system could get exposed to Tail Risk Bankruptcy in the large Negative Error term and can't even wait for the next Positive Upside Error Movement. **So, from that Perspective of Tail Risk, even Exogenous Condition is not sufficient. It's another detailed discussion of its own how these conditions should be re-framed !**

We will talk later that Non-Stationarity is basically reflected in that Random error terms.

8. Beta is not Absolute but Relative.

Beta depends upon how the error is dealt with and also with respect to what other variables are .

The Exogenous condition of error is extremely important.

So, probably one test is Take Beta to that level until Exogenous condition on Error Randomness is satisfied independently !!Then only Beta would be unbiased. Otherwise, it means that the Beta is biased as Error Term itself is some function rather independent ! As long as the error doesn't satisfy exogenous conditions independently, it shows there are some more factors(contributing to different betas … deterministic components) to be discovered….

Moreover Beta value depends on how Error Term formula is tweaked like in LS form, There can be other forms as well. Beta would be different in various cases. It's all dependent on the method followed.

Beta should be such that it should maintain a balance between tail outliers and normal depending upon the requirements.

If Error has intrinsic hidden further pattern ..it would make the existing beta biased and different types of structure within error would affect the dynamics of beta and further may be causality or not.

9. Hidden Dynamics of Error Terms :

Now Further, There are different possible scenarios….Error terms have some hidden Deterministic components which affects X or Y or X affects the error term or even Y affects the error term …in all different cases the validity of Beta would be different

Say for example

$$Y_t = \alpha + \beta X_t + \epsilon$$

But if Error term is biased and Not Random say for example

$$\epsilon = \beta_1 Z_t + \epsilon_1$$

And further

Z_t is function of Y_t or X_t or some other hidden variables.

In that case, the entire estimation of β would be highly biased as this is derived from ϵ which itself is the function of different variables implicitly rather than independently.

Biasness of Beta

It's like three variables algebraic equation in x and y and z..one is assuming z as constant and make quadratic in x and y…it

could be technically wrong !! Similarly until error term is exogenous and independent…..it would lead to wrong beta estimation !! That's why in Regression.. independence is of huge importance.

If Error is function of some hidden variables then Beta won't be correct…how do you make error is independent ?

Simply doing regression without independence of error is technically wrong and could lead to biasness and misestimation.

Like in Quadratic or Functional algebraic equations if you treat a variable as constant ..it would give wrong solution

$Y = m X + c$ ….here c needs to be strictly constant ….can't be a variable related to X and Y or else m would be incorrect…

One can't treat function as a constant and do functional algebra ..it is technically wrong

So when doing such statistical regressions, make sure error terms is not a function of some related variables or else beta would be biased and unstable over the time…and as beta would depend on error

That's the reason Beta becomes unstable in real world finance. It can be tested in real world where we see that the measured value of beta keeps on changing rather than fixed constant ! One can experimentally verify this on many financial time series data and check how beta has its own inherent dynamics. Beta keeps on changing dynamically over the time dimension or otherwise relatively if new variables are included!

Error would change over the time if it's function ..not exogenous conditions satisfied…

If Error is itself a function not satisfying exogenous conditions ..it could be the source of Black swan and disastrous tail risk

10. Error Terms & Simpson's Paradox : Simpson paradox reveals a lot about the Reality !

A) It reveals that the DETERMINISTIC parameters like Alpha, Beta themselves have Randomness over the time !

B) Further, the existence of these parameters and error terms are RELATIVE !! THE LINE OF BEST-FIT itself behaves geometrically RANDOM over the time ! What was the Direction of Error Terms eventually becomes the LINE OF Best Fit and what was Line of Best-Fit becomes the Error ! This reveals the Fundamental aspect of Relativity and Randomness over the time for an observer.

It reveals the Fundamental Duality of Randomness & Determinism existing in the Universe,Life and hence Markets.

The Universe and hence its subset ,the Markets have both the components: Fundamental & Deterministic. One can't differentiate between the two. They exist Relatively and Simultaneously. Deterministic(Line of Best Fit) becomes Random(Error term) and Randomness(Error terms) becomes Deterministic (Line of Best Fit)

One has to be very careful while making decisions based on the Regression analysis particularly ignoring the Error terms ! Blindly following the Fixed Line of Best Fit to make investment decisions could be highly misleading and disastrous in real world !!

So, this points towards extremely fundamental points while doing the Linear Regression analysis : That parameters like Beta, Alpha etc. could keep on changing depending on the data set and there are no fixed values.

First, Two things tracing the same trajectory might not be correlated in true sense. Say for example two cars moving on the road would appear to be correlated to an external observer from sky. But that's not so, may be later the road diverges after a long time and both the Cars could change the directions and befool the external observer from the sky who was assuming them to be correlated by observing their past trajectory for a long time !!. Similarly in markets !!

The Point is to establish the Scientific Causation first and then one can rely scientifically Regression to some extent as long as error is managed well.

For that causation, one has to block non-causal paths by observing the Y & X while blocking other variables or checking how Y behave if X is there and NOT there. If X causes Y then if X stops, Y must be affected or stopped !

###

We have to understand that Regression is fine it could help in prediction at times but given the large unexpected error terms at times could be highly misleading at times and disastrous. So, what one should do optimally is to expect along the Regression Line of Best Fit but still be prepared to manage Random Error term which could be huge in the world full of Complexity

11. LS Regression, Beta, Error, Simpson's Paradox, P-Hacking, Reproducibility Crisis – Part 3

I think Black Swan Theory itself could be exposed to Black Swan without some Causality –Self -Referential Problem !! Causality is to be mixed up to diversify the Black Swan concepts

In this Physical Universe where there is ongoing duality between Predictability and Randomness and consequently inherited to Markets. Human Traders/Investors are like Energy Particles driving the markets. There has to be a balance between Causality and Randomness approach.

LS ..Square of Error is like Variance minimization…It could be Skew minimization or Kurtosis minimization or some other approaches ..for Tail risk. There can be different more robust approaches that can be explored in detail but beyond this paper as of now.

$$Y_t = \alpha + \beta X_t + \epsilon$$

$$X_t = \alpha_1 + \beta_1 Y_t + \epsilon_1$$

In LS method having two equations above …Randomness term would be quite different for the order of X and Y because the method to minimize Sum of Squares and Sum of Reciprocal of Squares would be different !

The reason why the coefficients in the above two equations are not interrelated is because Randomness(Error) term varies for the two equations affecting the Beta of the two equations.

If the randomness (error) term is really constant like $y = mx + c$ these two have been reversible into $x = m_1 y + c_1$ where the coefficients could have been inter-related but that's not the case. The fundamental reason is the way LS approach is done by Square of Error Minimizations and also the Error Term is not Constant rather some hidden function of variables, they are not inter-related in terms of their coefficients !

If really the LS regression is in the form y = mx + c where c is constant then the order of y and x would not change m and c i.e. beta and error terms.

But in LS case error is not constant but itself a function. That makes it irreversible and beta and error both change on order reversal of Y on X and X on Y. It is because the LS equation is not Deterministic .It has randomness components as well and error determines beta by minimizing the square of error terms. So both are functionally related ..in LS frame work Randomness (error) derives Deterministic(beta) components!

This indicates very fundamental issue while applying in the real world. One has to be careful why applying LS regression as to which if X has to be Regressed on Y or Y on X as the Beta and Error terms would be different and not inter-convertible respectively !

" In the LS system , Deterministic Term(Beta) is derived from Random Term(Error Term) mathematically !"

This also shows that Error is not independent of Beta and Beta is not independent of error.

Deterministic term beta is the function of Randomness (error) term in LS which is found by the Sum of Square Minimization mathematically. This inherently means that Deterministic Term Beta is also derived from Randomness(Error term) ! And as in Real World especially Financial Data, the LS -Error terms keep changing being the hidden function of variables, the consequently Beta(Deterministic) term also keeps on changing affected by Error. I have explained this mathematically in the previous section.

The foundation issue is Direction of Time …In LS regression analysis. Based on historical data backward time direction, we already know error(residuals as the difference calculated between y- beta x) ..making error as the dependent function on beta using the formula for residual..so error is no longer truly independent.

But in Real World Forward time we don't know the error first…we   estimate y based on x and then uncertain component of y on x would be termed as error. so in physical

==**causal terms ..we don't know error in advance and then its expected value should be 0 (exogenous condition) independent of X and y..**==

Need to minutely understand the role of arrow of time and independence of error from the deterministic term. It requires the higher level of imagination by learned expert traditional brains how the time dimension is ingrained in the mathematical and statistical developments that is often ignored and causes fundamental conflicts.

So in real-world forward direction , these expectations (beta) and error(Random) occur at different order…first deterministic term expected and then independent error term…

But here in backward time , LS …we know error (random component)already and then we derive beta(deterministic) part from that using sum of square minimization.

True unbiased beta would be when   independently calculated error term in forward direction of time satisfies the exogenous conditions.

Not that we define the system backward in such a way using LS that exogenous conditions is forcefully satisfied and modify beta accordingly

 This is the crucial difference between causal structure and associational structure. Like in Physical World, Causation is in the dimension of Time and when we ignore Time dimension, it becomes Associational !

This is like we randomly assign $do[\quad]calculus$

$do[X = x]$ as in RCT and then what Causal component of y is not explained by x ..that is error and should satisfy the exogenous condition in the forward direction of time

This Randomness in forward direction of time is often wiped out while doing LS regression in backward direction of time

So, in true sense Beta is not Slope in forward direction…Beta is made slope in backward analysis where error is already known…but in correct causal structure Beta is related to

$$E[Y/do[X = x]] = \beta X$$

In LS calculation Error(Random) term is made function of Beta(deterministic) term…

Or Beta (deterministic) term is derived from the Error(random) term minimization…

Infact this is generic issue with Statistical models, they are often in backward direction of time and static , there has to be dynamic and forward looking as the market is like an physical energy system, of course driven by human behavior which is also an energy system !!

Statistics has to be made Causal forward looking by looking at it scientifically and dynamically. there the role of

managing errors term is related to Convexity approach and Randomized Algorithms. Will talk about it later. Statistics has to be transformed into Dynamistics ! Will talk about that in detail in my book.

12. Paradox in LS- Regression Methodology :

It assumes that Beta(Deterministic term) originates from Error (Randomness term) ! Hence Deterministic term is also Random if Error is Random…or else if it claims Beta to be really deterministic then Error term (Random) is also Deterministic !

It's paradox in itself !

This paradox is indicating towards the fundamental loopholes in the LS method of Regression how Beta is derived mathematically ignoring the time dimension in the biased way and if error terms are truly independent.

In Real World Forward Direction, Causation world Randomness and Determinism are independently existing and not derived from each other Deterministically !

In Causal real world forward direction of time first expectations (Deterministic component is fixed) then error(random component is calculated and then it must satisfy exogenous conditions independently if LS regression is correct and unbiased.

In Associational backward time .. LS error term is figured out first and that using minimization of the sum function, the expected term beta (assumed earlier) is discovered by trial in backward direction of time and then changed to !

This traditional LS Regression is fundamentally like in-sample testing.

Infact correct beta should be figured out by out-sample testing and checking which method should be taken compared to LS approach and how error terms satisfy the exogenous condition.

Both the approaches are technically and fundamentally different.

The Role of Time dimension is Extremely Important leading to this difference!!

In backward LS regression, you derive beta(D term) based on Error(Random term)! ..In forward real Causal world, you fix Beta(expected deterministic term) and then derive the error (random) term independently..

I am repeating this time and again to bring to the conscious state of readers' mind what they have been doing over last 50 years around.

To use regressions for prediction or to infer causal relationships, respectively, a researcher must carefully justify why existing relationships have predictive power for a new context or why a relationship between two variables has a causal interpretation. The latter is especially important when researchers hope to estimate causal relationships using observational data

The result of this In-Sample Testing is clearly visible when testing on the financial data how the measured values of Beta keeps on changing over the time unstably in real-world influenced by the error terms in the forward directions. Beta also behaves Randomly over the time ,which is supposed to be deterministic !

Beta change over the time and data shows that the Things are more Random actually not as much Deterministic as LS regression is expected to be.

How can Physical things in 3 -4dimension be explained clearly in 2 dimension?

How can Time dimension in Real Physical Causal world be explained in 2 dimensional Timeless Space (Mathematical) ? Big Incompatibility...visible in LS Regression ... Time (Causal) becomes Timeless(Associational) because of this reason !

That's why Beta keeps on changing over the time, showing randomness not Deterministic aspect...Ref (Simpson's paradox)

This means LS Regression inherently assumes Randomness and Determinism are derived from each other algebraically using fixed deterministic rules...using LS method . ?? .but in Real Causal World is that the case..? No ! These things are extremely fundamental not be overlooked for this is the reason in real world linear regression misleads dangerously at times.. This misconception affects the investment allocations and all in the portfolio management and miscalculating the risk factor(beta) could lead to disaster !

In Real   Causal World Randomness and Deterministic components come from different origin of information !

Key Point :

That's why if one uses LS Regression type in Real Causal World, one should simultaneously apply the RCT (Algo Wheel type) method to handle Random (error term) along with Causal Deterministic terms. This model error and biasness in beta estimation using LS Regression has to be hedged by Strategizing the Randomness Error Term.

Without Proper Strategy to Manage Randomness Error Term, it's highly dangerous to trust Beta which is often ignored in day to day life financial investment decisions. That's the important role of Causal adjusted Convexity to manage random error terms along with the Deterministic ones to manage disastrous tail risks and black swan events.

Skill Vs Luck Or Managing Luck also a Skill ?

It's often said Skill Vs Luck to measure Alpha but I state that Managing Luck (by Strategizing Randomness) is itself an exceptional Skill !!

Infact in real world finance Managing Error is the Exceptional Key Skill !!

That's where the role of Randomized tools   tools like RCT,AlgoWheel etc.

So, either assume Randomness and Deterministic are linked deterministically using mathematical formula or then LS regression is technically incorrect !! It violates and rules out the mechanism of Randomness and Deterministic only

This means LS Regression shows the world has both Random or Deterministic components.

But in Real World Random component has its own intrinsic determinism also but that's not derived from the external deterministic components like in LS Regression

13.Simpson's paradox :

Error and Beta in LS are Relative...Errors become Beta and Beta becomes Error direction wise in different reference frames. This also points that LS regression tries to determine the two dimensional system of points by one dimensional Beta measure while ignoring the direction of Error which is complementary to Beta. Or need to introduce two dimensional beta in place of one dimensional beta.

Infact this shows that LS regression approach is not suitable for deriving absolute relationship. There is fundamental instability in Beta derived deterministically using mathematical formula from Errors.

This also questions the validity of such regression in the real world. **In another perspective, most fundamentally Simpson's paradox shows the fundamental duality between Randomness & Deterministic terms interchangeably**.

To figure out the relationship between the variables.

The measurement of beta in LS-Regression is Data dependent. & Time dependent and unstable especially in financial data.

There is no fixed absolute relationship and the Beta (deterministic term) behave more randomly influenced by the error terms.

In LS method…Beta derived from Error so in real world…need to manage error as well along with beta. It's often taken beta and not the error terms,

But the origin is error only in this flawed LS approach in real world

Simpson's Paradox reveals the importance for Causal relationship where one should reject non-causal betas and accept causal betas like extraneous values in algebra.

It's extremely careful thing to apply in social decision making as well where we get misled….by beta type relationships

Rather than making Beta one dimensional…may be you can make it two dimensional. Along x and y coordinate axes….

Two dimensional concept of Beta and Resultant rather than One dimensional

There would be dynamic equation for Beta and Error components as well

Two dimensional pictures of LS Regression. Simpson's paradox

One direction analysis doesn't fit for two dimensional movement of data ?

Beta and Error are Relative..Time and Data frame dependent…not absolute

So, it should be like Beta of the stock over last one month is 0.6….Beta of the stock over last 6 months is 1.2…like this…

14. Beta as the Time-Dependent Figure.

Beta   should be talked in the dimension of time like

$\beta_{t,t+n}$ denoting the value for the time t,t+n for the financial time series data.

Like Beta of Stock over 1 month, 6 months, 1 year ,10 years like that. This is because the values of Beta behave more randomly than expected influenced by the dynamics of the errors in LS regression especially for the financial time series data. Beta keeps on changing over the time unstably over the period of time. Hence simply representing Beta as the constant term independent of time dimension is highly misleading in real-world causal financial world !

This traditional definition and representation of say Beta of a fund is 1.2 for example is fundamentally misleading and incorrect in the real world the way LS Regression is derived.

The Fundamental Role of Time Dimension is Extremely Important which is ignored Traditionally in the Investment Industry.

Since, the Physical World is Causal in the dimension of Time, Statistical & Mathematical tools used in the finance have to be essentially incorporate the dimension of time. LS Regression parameters ignoring the time dimension is ruling out the Causational and making it Associational by ignoring the Time Dimension. And, it should be mandatorily be

followed the way financial investment and risk industry has been traditionally.

Beta not Static as usually treated…. Simpson's paradox --- Ignoring Time dimension of data frame…even beta has time dependent function….not constant as in LS….not to be treated as constant static as usually done….dynamic

So, as it's two dimensional thing, one has to study both the dimensions…(error and beta) ..error as well..

Need to study dynamics over the time…not just static

The most fundamental reason is Ignoring Time dimension in mathematics and statistics in Real World Physical applications where Time is crucial for an event to occur.

Psychology and Social application of Simpson's paradox

Error is also a direction….

Errors and Beta are like X and Y axis… Should be Independent

Dynamics of Statistics over Time dimension can't get captured by the Static Capture of Statistics*

Beta & Error are functions of time ..ignoring that is leading to many paradoxes and conflicts

Simpson Paradox also shows the fundamental issues with LS regression method

Taking investment and risk decisions in real world based on static view could be highly misleading

15. Simpson's Correlation Paradox(Misleading Correlation)

Say for example : X & Y show positive correlation over 1 year statically ..but they are infact negative on daily basis dynamics

Or they show negative correlation on 1 year but they are positive on daily basis dynamics

Simpson's Contradictory statement --- Role of Causal Time Dimension

& Correlations can take many different values over different time and data

Real-World Judgement can have huge variation

No value of Beta without Error terms

Simply taking out Beta(Deterministic component) (direction) hugely misleading* *Hence handling (Random Components)Error is crucial and complementary*

It's two dimensional thing so taking one and ignoring the other could be dangerous*

P-Value Hacking : P-Value itself has statistical distribution as a stochastic/random variable. Most often the favorable P-value of the distribution is selected in a biased way. Which P-Value is being selected out of its own distribution is a big concern !

Exogenous condition: $E()$. = 0 but in real world if Errors are too large positive and Negative then also $E( ) = 0$ but that doesn't mean it would work in the Real World as any Large Error can bankrupt the system even if average is 0*

Least Square Method is basically Minimum Variance Principle but Variance may not be the true statistical representation always especially in real world finance.

Hence just Exogenous Condition wouldn't be helpful in the Real World!!

Even if E( ) = 0 but it could bankrupt in the Real World. What matters is not the Expected Value rather the dynamics of error term. Later on we will also see that this definition of Expectation Operator could itself be fundamentally flawed in real world.

Beta is meaningless unless Error is managed well !!

Deriving Beta from Error (Residual) and then Calculating R^2 by involving them ..it's totally Insample thing ..even high R^2 can't be relied as Beta is derived from Residual only…

P-value Hacking : Backtesting Randomness Best Cases selection based on Random Parameters testing….

Misleading P-Value, R^2, Correlation as Random Variables in Real World.

P-Value , R^2, Correlations all are themselves like Stochastic/Random variables having their own statistical distributions, hence their values are not fixed rather variable. Hence their conventional applications in real world could be highly misleading treating them often as constants.

One can select the favorable mean P-value out of its distribution to false claim one's result statistically. But what if tail values of P-value distribution gets realized ?

This is similar to Correlation which also has its own statistical distribution and that's the reason Correlation could be highly misleading in Real World especially Finance.

These days while performing backtesting or simulation using computer based algorithms, so many trials are conducted and the best is selected to false claim the great performance of the strategy. This is basically Reproducibility Crisis in Finance.

But what is often forgotten that every Random Trail must come with some Cost in Real World to remove Selection Biasness. Will explain that in Convexity Section later that how Causality can minimize that Cost !

In context of **Reproducibility Crisis** That's not Independence .It should be like you take random trials and then see how do you perform...not that try 1000 trials and select the best....Best varies over that time....Best at Time T =0 might not be equal to Best at Time T = 1

Even the "Best" could be having Randomness and Time Dependent.

It's like in sample result to select the best and leave the rest.

Will explain later in this article on Convexity that how each Random Trial should have some cost involved and how it's related to Reproducibility Crisis
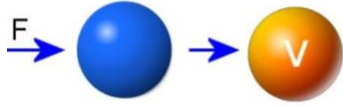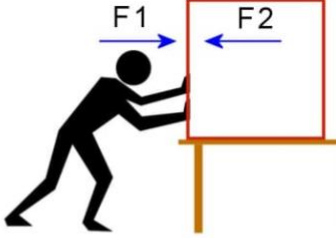
16.Newton's Laws of Motion in Markets & Quantum Law for Markets

Newton's Laws of Motion for Markets : Principle of Least Action by Paul Dirac : Feynman's Path Intergal approach in Quantum & Classical World

Laws of Motion of Stock Prices in Quantum World:

Net Resultant Valuation(Energy) generates Forces(Demand * Supply i.e. Buy and Sell Orders i.e. OrderFlow which finally leads to the Motion i.e. Change in Momentum

Newton's Laws of Motion

1st Law	2nd Law	3rd Law
v forever	F = ma	F1 = F2

Newton's Laws of Motion in Microscopic world :

Consider a system of N classical particles. The particles a confined to a particular region of space by a "container" of volume V. The particles have a finite kinetic energy and are therefore in constant motion, driven by the forces they exert on each other (and any external forces which may be present). At a given instant in time t, the Cartesian positions of the particles are $r1(t), \cdots, rN(t)$. The time evolution of the positions of the particles is then given by Newton's second law of motion:

$$m_i \ddot{r}_i = F_i(r_1, \cdots, r_N)$$

where $F_1,\cdots,F_N$ are the forces on each of the N particles due to all the other particles in the system. The notation $\ddot{r}_i = d^2 (r_i/dt^2)$ i.e. second derivative.

N Newton's equations of motion constitute a set of $3N3$ coupled second order differential equations. In order to solve these, it is necessary to specify a set of appropriate initial conditions on the coordinates and their first time derivatives, $\{r_1(0),\cdots,r_N(0),\dot{r}_1(0),\cdots,\dot{r}_N(0)\}$ Then, the solution of Newton's equations gives the complete set of coordinates and velocities for all time t.

For an Investor , based on the valuation, the causal force of demand is created for a stock by the trader/investor. The Valuation is like Total Potential (in Physics) that generates the force in the stock.

Valuation is relative depending upon the investors' perspectives. Valuation (Potential) generates the market forces. Yes it's as per the Physical Laws of the Nature.

So, there would be different valuations for different investors/traders (who are like human brain quantum particles!) causing different forces.

Let $V_1 t$ denotes that equivalent force caused by the respective potential (Valuation)

$$V_1 t, \qquad V_2 t, \qquad \ldots \ldots V_n t$$

$$V_{(resultant\ at\ time\ t)} = V_1 t + V_2 t + \cdots .. V_n t$$

So, the causal process : market is the system of different investors

Each investor i has the relative valuation V_i. Every Non-Zero Valuation would apply either upward or downward forces.

$$V_{(resultant\ at\ t)} = V_{(upward/buyer\ at\ t)} +$$

$$V_{(downward\ /seller\ at\ t)}$$

Causal Process due to Forces in the Markets.

Different Valuation-generated forces V_i attracts and causes different investors/traders to put Buy/Sell Orders O_i.

$$O_i := V_i$$

(i.e. demand and supply forces) .This is scientifically like the gravitational force on energy or law of attraction! **Higher Value tends to attracts small values towards itself..**

The Resultant Order Flow Imbalance is caused by the Sum of all these Buying and Selling Orders (Caused due to the Value generatedDemand-Supply Forces).

$O_{(resultant)}$ **is like Electric Flux i.e. Number of Order Lines passing through due to Valuation Caused Field.**

(Note : I refer here only to the genuine orders intended to be executed not the false orders ,for that there will be more causal analysis)

$$O_{(resultant)} = \sum_{1}^{n} O_i$$

$$O_{(resultant)} := V_{(resultant)}$$

The Resultant Order Flow(due to Valuation Generated Forces) causes the Momentum change for the next time duration [Newton's Laws of Motion]

$$MOM_{t_+} := O_{(resultant)}$$

$$Set\ of\ O_i\ determines\ the\ \ Liquidity$$

$$Liquidity$$
$$\propto Number of\ Opposite\ Orders(OI_i)\ \&\ Quantity\ (Q_i)$$

$$V_{(resultant)} \propto Liquidity$$

Now As the Stock Price gains Momentum due to forces, Price changes using F = m *a (Newton's Laws of Motion type mechanism), The Price changes subsequently.

Price at time t+ would be caused by Momentum generated at time t and then updated Valuation for different investors would change relatively due to change in Price and Momentum in the dimension of time. Price and Momentum

being two of many factors affecting the Real- World Valuation at anytime. (This has been explained in detail)

$$Price\left(P_{t_+}\right) := MOM_t$$

$$V_{i_{(t++)}} := P_{t_+} \,\&\, MOM\_t$$

Explanation :

Valuation at any time V_i is the function of many multiples and factors and their dynamics over the time for every investor. There is a resultant of all the Valuation. Open-ended process.

We have explained earlier

$$V_i \quad at \quad time \quad t_+ = f(MOM_t, Price_t \ldots \ldots)$$

So, to be specific related to Momentum and Value Relationship

a) Valuation at time t is also dependent on Momentum at time t-1 i.e. previous momentum. The mechanism for Valuation is mentioned below..

$$V_t := MOM_{t-}$$

a)Valuation at time t drives the momentum (velocity) at time t for t+1 through the force it generates.

$$MOM_{t+1} := V_t$$

a)As the Stock price goes into the motion(momentum), it adds values for different investors leading to change in the Order Flow Imbalance. $O_{(resultant)}$ is caused by more and more

forces in the markets caused by the Valuation changing over the time.

$$O(resultant) \coloneqq V_{(resultant\ at\ t)}$$

OI_t is like Electric Flux i.e. Number of Orders Flowing

Number of Field Lines crossing is akin to Number of Trading Orders of Traders/Investors caused due to Valuation changes as the Potential.

Which depends upon the Current Strength caused by the Potential/Force/Valuation changing over the time.

Order Flow is essentially and scientifically the Market Quantum Force. One needs to study the Order Flow (Force) to be able to understand the motion of the resultant Stock Price. Like we study Newton's Laws of Motion in Physics to figure out the trajectory of a body. One can apply ML to study Order Flow Dynamics to study the Quantum Forces driving the Market. It can be quite useful to study dynamics of tail events in fat-tailed events . This is Proprietary here further !

So, Based on the Laws of Quantum Motion affecting The Human Traders' Behavior and hence the Stock Price can be studied in the ORDER FLOW dynamics how Forces evolve. This is where ML could be useful. I state and claim based on my experiments that it's similar to Energy system of Particles. This is linked with Century Old Problem and essentially Financial Brownian Motion would be similar to Geometrical Brownian motion but in different sense ! This is linked to what I've explained in other parts that Human Brain follows the Laws of Quantum Motion and that's the advanced version of Classical World Laws of Motion. So, microscopic Newtonian dynamics, the Boltzmann and

Langevin equations are derived for the macroscopic dynamics.

Hence I state and claim that one can experimentally verify that Financial Brownian Motion (Quantum Living version) is possibly more advanced form of Physical Brownian Motion (Quantum Non-Living Version) although their foundations being the Energy system only fundamentally but in different forms. This fundamentally originates from the fact that Human Brain Quantum Behavior is the advanced version of Classical Laws of Motion where the former is variable while the later is constant. But yes all these Classical Laws of Motions are valid and originate from the Quantum world only. That too, Living Beings Quantum Laws have more variable components than Non-Living Quantum Laws but all of them are highly Causal. This is beyond the scope of this paper.

But for this paper, that can be well studied and verified in the behavior of Order Flow dynamics ! It's fundamentally the energy dynamics.

More the Valuations for different investors, it would attract more OI assuming there is availability of fund with the investors.

To note : Momentum is just one of the factors among many. What matters is the resultant of all like in physical forces. These are similar physical forces attracting investors through their quantum force on their brains(neurons).

Step2 :At any moment in time The V(upward/buy orders)tries to push the price up and V(downward/sell orders) tries to push the price downward.

This is tussle between the two driving the market ,eventually converging to the equilibrium state as happens in physics.

Step 3. The Momentum drives the prices further up due to the net upward force. Gradually based on the combined effects, the price moves. The distance travelled by the stock price can be calculated on the change in momentum caused by the forces.

Step 4: As the price moves up and the momentum increases, it affects the Valuation dynamically. Valuation (upward) and Valuation(downward) keeps on changing time to time. Upward force and downward force keeps on changing. .Gradually as the price goes up significantly , the Upward Force weakens gradually due to weaker upward Valuation and downward force becomes strong due to stronger downward valuation. Upward That leads to price coming down again. This cycle goes on to reach the state of equilibrium and fair value over the time.

$$F = m * a$$

[Newton's Laws of Motion] This is universal law in Nature not just for Physics of Non-Living Objects ! But yes in different forms because nature of motions differ in classical and

Quantum worlds ! But this is also applicable in quantum brain world ..

$$MOM_{(stock)} \; i.e. \, Momentum(stock)$$
$$= Mass(stock) * Velocity(stock)$$

$$V_{(resultantforce)} = Mass_{(Stock)} * acceleration_{(stock)}$$

$$V_{(resultant)} = \Delta MOM_{(stock)}$$

Here Mass of Stock can be taken as Market Capitalization which typically means Small Cap Stock will have less mass than Mid Cap than Large Cap. So, why Small caps could be more volatile than large cap in general is also because of their lower mass and hence requirements of forces. But this would depend on the resultant forces on case to case basis. But yes it's indeed caused by scientific equations of forces !

Like in Classical world, Quantum world also has gravity ! Larger stocks are having more mass and hence gravity than smaller caps in general comparatively. Yes it's like Physics . So, there is more amount of force required to move its price to similar distance (i.e. same return) compared to small cap (low mass) stocks in general given all other things are constant. Hence they also show lower risk as more amount of force would be required to pull their prices down. And there this forces come

from demand supply forces which are actually quantum forces in the brains of buyers and sellers (traders) or computer codes...

"Factors have to be discovered scientifically how they contribute to the Quantum Laws of Motion of Stock Prices not associational regression based approaches traditionally followed.   One has to discover how a factor is affecting the acceleration/motion of the stock through Force and Mass ..For that one has to study the Law of Quantum Motion of a Stock Price originating from Human (Investors) Forces of Demand Supply & Order Flow. So, one has to study how Momentum , Size, Quality,   etc. are contributing to the Scientific Laws of Equation .

Not that they should be compensated for their risk due to a factor and hence the return! Hence, Linear Regression based CAPM result that Higher Risk means Higher Return etc may not be valid always in Causal Scientific Dynamics of Risk-Return.

This Economic Rationale that an investor should be compensated just because he/she has taken some specific type of risks has to be scientifically validated   and determined how they are contributing to the Laws of Motion of a Stock Price, otherwise it's just a superficial and non-scientific and not true ! Infact explained later that Economic /Financial Space- Time itself exists scientifically having their Laws of Motion as we have in Physics!!

17.The Issue with Conventional Value Method in Finance

Connection with Regression Analysis Price to Book Value wrt. ROE (Ref. Aswath Damodaran papers).

This Linear Regression Analysis is again applied with misleading results about Undervalued and Overvalued. **Also, something becomes undervalued using one multiple while overvalued using another multiple. This also reveals the fundamental flaw and incompleteness of single multiple approach to Valuation. If one uses(despite flaws),one should possibly take into account different multiples to figure out the same**.

Infact there exist proprietary model based on AI/ML or based on the dynamics of various factors to decide the true Valuation in Relative Valuation approach which is so widely applied in Valuation for Investment industry.

Traditionally we have seen factors e.g. Value, Size, Quality, Momentum etc. based investing being very popular and at the same it has also shown the dismal performance over the last few years.

Two important aspects :

a)Value as the term has been defined incorrectly in this context that Low price to Book Value mean Undervalued and High mean Overvalued or similar other analysis. Infact this

decision on Low or High is based on the LS -based Regression Line as well .

Given the fundamental issue with the Regression Line, the basic definition of Low and High could be mis-estimated.

Moreover, even if one takes LS based Regression approach, Valuing something based on just one specific ratio could be misleading as different Ratios reflect different components of the Valuation(Relative Valuation Approach).

Low Price to Book Value Vs ROE Regression(Reference Aswath Damodaran).Misuse of LSS based Regression to figure out Low to High Book Value. The determination of Low and High based on the Line of the Best-fit is itself faulty ! Again same typical Regression issue. Line of Best-fit itself could itself misleading in Real-World applications. So, what one figures out Low could be High if Line of Best Fit is changed !

There could be indeed better methodologies to incorporate different ratios dimensions of Valuation but that's not the discussion of this paper here.

    a) Value in Real World is not the same as such Academic Theoretical Definition as conventionally calculated in the Finance & Investment Literatures. The Definition of Value needs to be Redefined and Recalculated even in the Literature. This is the fundamental reason why Value has started underperforming over the time recently. So, we shall discuss on this in detail below.

This Theoretical Definition of Value is itself flawed and incomplete when we look at how Value works out in Real-World Markets for Investors.

How Investors figure out value in a stock traditionally is itself flawed based on conventional approaches.

There will always be some patterns in this world enough to mislead us and that could be due to chance.

b) **As assumed in Linear Regression based approach to judge the Value , in Reality, all these factors don't independently exist rather have interdependence which creates Value in totality. We shall see this as we go further here. .The basic statistical method to apply and judge Alpha or decide the performance of Factor based approaches like Fema-Fench models is itself flawed leading to false calculation of Real World Alpha.**

18. VALUE IN REAL SCIENTIFIC WORLD :REDEFINITION

So, How this Valuation formulates in Real World. There is the difference between Academic Old Definition of Value and Real-World Scientific Value. Infact Academic definition of Value should be redefined.

Here is the brief formulation: Now taking the idea of Relative Valuations Multiple here…Valuation of a stock for an observer(investor) could be the different (Relative Valuation). Every Relative Multiple shows different component of Valuation. Selecting any particular multiple might be biased at times in real world finance.

The key drawback is that a firm can be overvalued and undervalued at the same time using different relative multiples. **This reveals the key drawback of the process**! How something is concluded to be Overvalued or Undervalued traditionally using any particular multiple e.g. Price to Book Value etc. in Valued based Investment is both conceptually and statistically flawed !

Infact , Value depends on the optimal combination of different multiples with right weightage and randomness component. Not just Static perspective of Cheapness means Value(which could be flawed in real world) that rather higher order dynamics of how those Value ratios, their trajectories etc. The different ratios have their own dynamics over the time

==Higher Order Analysis not just First Order Analysis also affect the Value. There needs to be developed Proprietary models (AI/ML can also help) to Calculate True Value.==

That's why I categorically repeat that the way Value has been traditionally and academically defined as Low Price to Book Value etc. is both foundationally as well as statistically flawed in Real World.

Value is also relative on observer to observer. It's NOT absolute !

$$V = \epsilon + k * f(EarningMultiple * ProfiabilityMultiple * GrowthMultiple * MomentumMultiple * SentimentMultiple * MacroEconomicMultiple * RelativeUtilityMultiple\ of\ the\ Investor) / (PBVMultiple * RiskMultiple * CostMultiple)$$

Note : This is just a basic mathematical simple framework to show a framework but actually this is proprietary function to decide the Value and would depend investor to investor relatively. There could be more advanced Proprietary version in practical approach.

Further, it's not just first order thing but also how these multiples behave over the time also determine the Value over the time.

So, What Value depends upon the combined approach for an investor. Conventional Academic Value itself needs Redefinition in the Real World. Momentum, Quality etc. are the components of the True Consolidated Value not different entities from them in Real World. All these aspects/components determine the Value not just Cheapness on just low Price to Book Value multiple. It's an Open -ended rather than a closed ended formula in every scenario.

Value is scientifically determined by the Causal forces affecting human (investors') Relative perceptions in real life and Cheapness of Price is just one of the many causal factors.

Contrary to conventional perceived notion that Cheapness means Value could be fundamentally misleading, Only Cheapness doesn't mean Value to buy. There could be Cheapness but not Valuable overall. Moreover, Cheapness canine figured based on one Static Ratio. It's has to be dynamically seen in Higher Order Perspective. These are proprietary aspects further.

What is also alarming that Conventional flawed LS Regression type tools are applied to decide Cheapness not ! With slight shift of so called Line of Best fit due to error, something will be declared Cheap or not Cheap !! This itself is concern that how one calculates cheapness in real world based on such flawed statistical tools !

Key Result : Cheapness doesn't mean Value always in Real World as widely believed !!

Many factor dynamics below decide True Value in Real World

       a) Price to Book Value Multiple.
       b) Earning Multiples
       c) Debt Multiples
       d) Cash Flow Multiple
       e) Macro Economic Multiple
       f) Profitability & Growth Multiple
       g) Risk Multiple
       h) Cost Multiple
       i) Utility Multiple
       j) Momentum Multiple
       k) Sentimental Multiple
       l) Randomness
       m)   Others factors

This can be written as the statistical framework which remains proprietary here!

Further, I repeat - it's not just the first order rather how they have behaved dynamically over the time i. e. higher order would give better insight.

So, Value in Real World depends upon many Causal Multiples which actually affects the Business of a firm and Human(Investor behavior) scientifically in a causal way as well as Randomness.

It's not just Book to value Multiple. Infact, this traditional academic definition of Value is incomplete and needs to be redefined. Also, by this traditional definition, if something is cheap doesn't mean all the investors would buy it. Cheapness is just one of the factors to buy. **The IMPORTANT Point is We need to Understand How Value should be defined and how it works actually in the Real World.**

One thing to Note that Momentum is also one of the Cause of Value . The reason being Momentum reflects the strength of Demand Supply forces being caused through Order Flow Imbalance. This force of demand supply also determines the value of something! Hence, contrary to traditional static absolute understanding of Value as different to Momentum, we have to understand it from the dynamic relative perspective tha**t Momentum is itself one of the Causes of Value and Vice versa！ Infact, it's two ways : Value causes Momentum and Momentum causes Value. It's essentially like Laws of Nature/Physics where Value is like Total Energy(including Potential) and Momentum is like Kinetic form.**

So, all the other causal factors including momentum and randomness resultantly decide the Value.

Infact, Value is the function of many different causal factors including Momentum as well as unknown randomness ! This has its origin in the Human behaviors driving the Investors' behavior at large coming from the science and laws of Nature & Human Behavior.

By the way, Scientifically using Laws of Stability Equilibrium in Nature , there also exists Proprietary approach to calculate

the fair Valuation Relatively using Geometrical Methods! We shall possibly discuss this later as much we can(due to proprietary nature) after talking about how Markets are linked to the Laws of Nature and Physics !

Note : there are scientific approaches to calculate True Value based on force dynamics. This is Proprietary here now.

20.Causal Equation of Market

Let's understand this in simple Newton's Laws of motion like relationship in detail later but before that I write the Causal mechanism in the form of **Ornstein Uhlenbeck(OU) mean reversion Process where Stock price tends to revert to their true mean value over the time which is the state of equilibrium.**

This is Pure Scientific.

So in this equation, Net Effective Valuation at time t-

V_{t_-} cause the momentum at time t, MOM_t to move.

$$MOM_t := V_{t_-}$$

Valuation at time t V_t is caused by the historical Momentum MOM_{t_-} as well.

$$V_t := MOM_{t_-}$$

But unlike interest rate dynamics here the mean reversion level keeps on changing over the time for a stock or market depending upon various valuation constituents.

$$dS_t = v_t(V_t - S_t)\,dt + \sigma\,dW_t$$

v_t is the velocity at time t causing the momentum $MOM_t = m_t * v_t$

NOTE : What is extremely important to understand is that Even the Causal Equations have Error & Randomness Components which is the origin of Black Swan type events/ risks!

$$dx_t = \theta(\mu - x_t)\, dt + \sigma\, dW_t$$

$$dr_t = a(b - r_t)\, dt + \sigma\, dW_t$$

The typical parameters   and   , together with the initial condition   , completely characterize the dynamics, and can be quickly characterized as follows, assuming   to be non-negative:

- b   : "long term mean level". All future trajectories of   will evolve around a mean level b in the long run;

- a : "speed of reversion". characterizes the velocity at which such trajectories will regroup around in time;

- σ : "instantaneous volatility", measures instant by instant the amplitude of randomness entering the system. Higher implies more randomness

The following derived quantity is also of interest,

- $\sigma^2 / 2a$: "long term variance". All future trajectories of will regroup around the long term mean with such variance after a long time.

21.Scientific Background of Convexity & Randomized Approach in finance : Quantum Energy Dynamics Connection

Convexity :
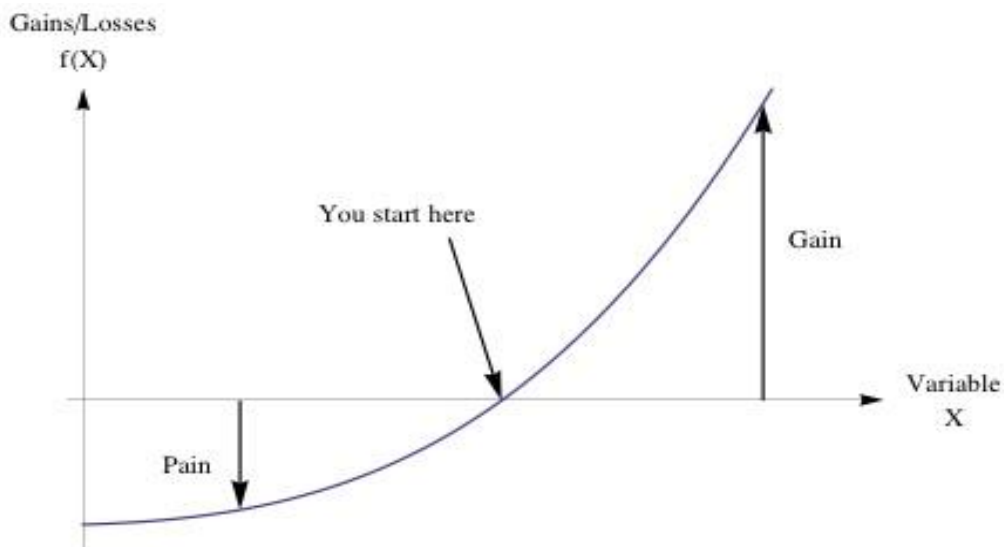
More Gain than Pain from a Random Event. The performance curves outward, hence looks "convex". Anywhere where such asymmetry prevails, we can call it convex, otherwise we are in a concave position. The implication is that you are harmed much less by an error (or a variation) than you can benefit from it, you would welcome uncertainty in the long run.
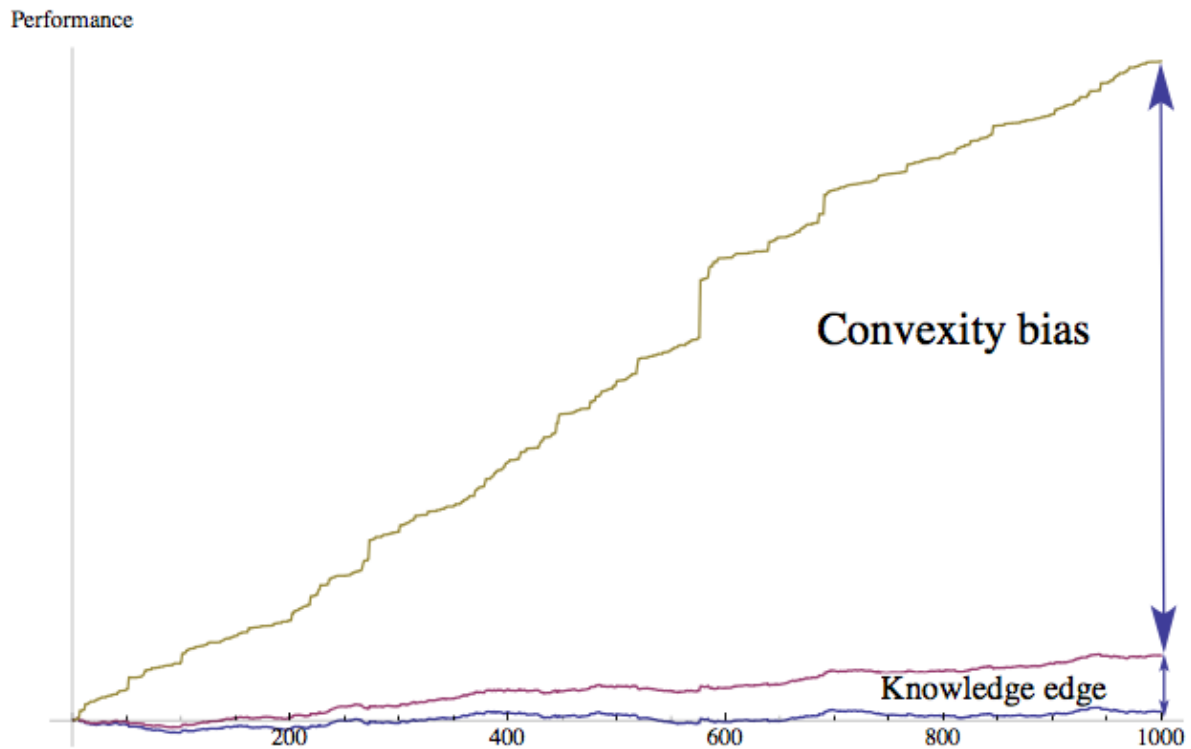
The Picture taken from Internet : Source Nassim Taleb Papers

Let's look at how Convexity, Randomized Tools like RCT, Algo wheel etc. are Scientifically placed for Finance, Life etc..

As we know Feynman's Path Integral approach has been the most important and powerful scientific result in Science which originated from Paul Dirac's Principle of Least Action. So, as we know that Market is fundamentally a Quantum wave driven by Human Brains' Behaviour, it would follow the Laws of Quantum world. Market would have uncertainty, randomness which could make it Unpredictable in some perspectives while they would follow some deterministic approach in other perspectives. These two aspects would co-exist simultaneously. One will have to discover that Determinism inside Randomness/Uncertainty at some scale.

So, rather than directly trying to predict the Uncertainty, one has to look at Uncertainty from indirect perspectives. One has to find out the hidden Causal Mechanism inside Randomness. These all are being done while acknowledging the existence of Uncertainty at some scale. So, one may not directly predict Uncertainty at local scale or in individual perspective but one can definitely do that in global and collective context relatively. This is directly how Quantum world works. One might not predict the Behavior of a Quantum entity like electron individually due to Uncertainty but definitely as the collective system. That's where the role of Randomized based approach fundamentally comes in. The most Predictive approach tries to predict at individual level but that's not how the Quantum world works. They don't acknowledge Uncertainty inherent in Nature. So, Scientifically one should find out global Certainty in Uncertainty/Randomness rather than trying to predict the Local Uncertainty!

That's what I had stated earlier that Randomness is NOT Randomly Random rather Deterministically Random .Randomenss also has cause. The discovery of that Determinism inside Randomness is the key to success in markets or real world or life.

Hence, One should conduct Random Trials in Causal way and discover the Determinism inside. It's like Path of Least Action as in Feynman's Path Integral or Paul Dirac's Principle of Least Action . That Path inside Randomness is the key. And random

trials should be based on some Causal aspects not Randomly Random Trials always because for every Random Trial there would be some cost involved. One has to minimize that cost too. This can also be looked at from Reproducibility Crisis Perspective where one generates large number of computer random trials to select the best to produce the backtested results in a biased way !! The point is every random trial comes with some cost involved not free in real world !

So, by following the Causal adjusted Random Trials, own can maximize Convexity. This is also linked to the law of energy. If the cost is not minimized, due to herd behavior of energy in markets like interconnectedness in the complex system , it could worsen leading to huge disastrous Tail risk like Black Swan . Hence , the clue is to take the small loss before the energy dynamics leads to escalation and lead to huge tail risk. So, Convexity as the process of taking small loss by cutting the tail and keeping the upside open is fundamentally based on the Energy dynamics in the Quantum System driven by Humans. . As earlier explained that this complexity dynamics leads to instability and system crash.

This is also related to Reproducibility Crisis in someway where one tries so many computer simulations and random trials to select the best ignoring that best is not always the best ,best could also be random !!

.

So, in my humble views, it's not basically Knowledge Vs Convexity rather Knowledge+ Convexity . Through Causal knowledge one can increase the Convexity by minimizing the cost of random trials. And this is also linked to Reproducibility Crisis where just taking random trials and selecting the best blindly could be biased as done in Backtesting etc.. ! This is because even the Best could behave randomly over the time.

That's the clue to success : Discover the Determinism inside Randomness and follow the Path for Least Action . That's based on Scientific Quantum Laws..

So, the concept of Convexity is scientifically linked to Laws of Science/Nature but at the same time by understanding the Causality Dynamics of Quantum Human Forces in the Market would help in the minimization of cost of Randomized Trials which would in turn improve the degree of Convexity !! So, Causality Dynamics should be seen as the Complementary to the Convexity rather than Competitor !

22.Complexity (Causality):Black Swan : Convexity : Scientific Causal Dynamics of Crash

The real world we live in including markets, life ,Nature is basically a complex system . One should imagine essentially this as the energy system. In such system, inter connectedness among the human leading to herd behavior leads to fat- tailed type events like Black Swan.   When there is sudden panic in the energy system through external or internal or both combined, there is formed a sudden cluster due to mutual energy attraction leading to instability in the system. This intrinsic instability leads to crash. It's technically force and energy dynamics.

This has to be causally understood in terms of energy dynamics. But that doesn't means one can predict such with certainty but yes understanding them can help to detect the cluster energy formation as early as possible and in turn minimize tail risk.

The key idea is that in Complex systems, one needs to understand the energy dynamics internally and hence to cut the Tail risk, early action would be quite useful. This is quite Causal dynamics like in Quantum Physics.

But despite the Causal understanding, one can't Completely make it Deterministic/Predictable. That's where the role of Convexity comes into play. One has to remain convex to the Unpredictability . But by knowing the Causality and the scientific Internal energy dynamics of these Complex systems like Markets, Nature, Life, the cost of of attaining Convexity can be minimized. The cost of multiple trials can be minimized by selecting the Causal Adjusted Random Trials.

Let me also explain the theory by Didier Sornette where there exists causality that super exponential growth can have downside burst risk. This is supported by the Laws of Energy & Nature. As explained earlier, like the Law of Gravity in Classical world, similar Law of Gravity exists in Human Behavior Dynamics as well in Quantum Economic space-time. Hence, as an example where some Physicist turned Economists have claimed about Super Exponential Growth leading to Crash. This has scientific base. But it must NOT be misunderstood. It doesn't mean one can Deterministically predict the Bubble Crash always. In my view, The term Super Exponential Growth is not Absolute rather Relative here contextually !!

It is scientifically based on Law of Energy but indeed Uncertainty exists as to when it would crash !! There might notbe Time Certainty over this in Real World always. This is also against the Law of Nature where there would be

completely deterministic & Predictability of Crash over time from Quantum science perspective!!

23. Causal -Adjusted Randomized Factor Approach

Now having understood the scientific concepts now deduce the approach for Causal Factor Investing. We see that Market participants keep on finding new and new Deterministic factors and try to predict it using LS Regression type tools. They try to predict individual factors and try to find out the Ultimate complete set of Deterministic factors to predict the markets. That holy grail of such factors is utopian and scientifically could not possibly exist due to Quantum Nature of Market. The effort to make the Real World Deterministic which is fundamentally Quantum and having Uncertainty is against the Laws of Nature scientifically. Hence , that utopian dream of discovering the ultimate set of Deterministic Factors is against the Laws of Nature. It's analogous to the ground breaking Godel Results in Mathematics and Logicwhere the effort to make market Deterministic by Complete set of Deterministic Factors is like making Arithmetic a Complete Axiomatic system while being Consistent!

In other words, discovering the ultimate Holy Grail of Such Deterministic Factors is like trying to assume the world as Deterministic, which is scientifically not possible and against the Law of Quantum world.

The **key is to follow Forward Looking Causal Based Randomized Factor Approach unlike Backward Looking Conventional Approaches.** So,In this approach like Feynman's Path Integral & Paul Dirac

Principle of Least Action, we try to apply the same in Human Quantum World. This is where we try to discover the hidden Determinism inside Random Causal Factors. This way we explore Certainty inside inherent Uncertainty. That's the key and analogous to the Law of Quantum world (Physics being just a subset of that). RCT, Algo wheel are based on that principles but there are many other tools using which we try to study the Determinism inside Random Factors. So, like an electron, we may not predict exactly about every single factor deterministically rather obviously in collective sense. It's like Quantum world Interference, where one may not predict the trajectory of each electron individually , but definitely as a whole we can find some determinism that they would like around.

Hence, unlike traditional approach of selecting factors on one by one basis, the scientific approach should be to Randomize the Factors based on some Causal understanding and create a Convex System.

For that,

On can follow the new approach **Causal Based Randomized Learning Algorithm i in the forward looking approach in the combined way rather than conventional backward looking approaches as usually followed in the AI/ML/RL techniques**. This is for general demonstration purpose only here. Proprietary version would be more specialized for real world applications.

For this new AI/ML Learning algorithm needs to be trained

a) Random Selection of the Set of stocks based on the Causal based Deterministic and Random Factors according to their Real-World Valuations as discussed above $S_1, S_2, S_3 \ldots \ldots . S_n$.

b) Allocation of weights to them have to be dynamically set in a well diversified manner, putting various constraints on the weight, while also looking at Tail Risk perspective idiosyncratically.

c) The key is to discover the Causal determinism in forward direction of time out of Randomized approach over the time follow the path of least action as a group as the scientific principle works. Causal adjusted Random Paths. Each Random Path will be allocated weightage allocation in the portfolio based on the degree of Causality. Like in Feynman's Path Integral approach action over the path is taken into consideration to allocate probability.

So, Allocate causal adjusted random weights to them at start to these selected Causal stocks $w_1, w_2, w_3 \ldots \ldots w_n$.

d) Some Predictive views based on Causality Factor Analysis could add up to weightages. Say for example if the S_1 has better risk-return profile expectation Causally in future than S_2, then even though randomly assigned weight $w_1 > w_2$.

e) Put Constraints on the Weights to make it well diversified for example $w_1 + w_2 + w_3 \leq a$

risk management point of view.

f) Based on the discovered determinism inside their random trajectories over the time, keep on adjusting weights dynamically to each of them over the time $w_{t+1} = w_t + f(\alpha) * r_t$. (for example just for demonstrative purpose here)

There will be more sophisticated equations to update the weightage for practical applications. Randomized Trials would be done based on Causal perspectives as well in forward direction of time.

g) The weights keep on adjusting dynamically based on discovering causal determinism inside their randomness in real world . Proprietary here.

g) Effectively, the Portfolio becomes relatively Convex to handle Black Swan Risk Effectively and revert to their equilibrium true state over the time….

The exact equations and functions to update weight would be changing in real world scenarios depending on the scenarios and one's own risk-return objectives. Here it is just for demonstration perspective. The key aspect of Causal Adjusted Randomized Factor Approach is to Randomize the Factors selection in causal way and then discover the Determinism hidden inside over the time. This is unlike traditional approach where selected traditional associational factors are bet in deterministic way. But to acknowledge that the Holy grail of Completely Deterministic Factors won't ever be found due to Quantum behavior of Markets. The key is to discover Causal Determinism inside Uncertainty/Randomness !

This above new Randomized Approach is basically Causal Adjusted Randomized Trials like in Feynman' s Path Integral

and Paul Dirac's Principle of Least Action in Science. This is Quantum Human Version of that here.

RCT/Algo wheel are some basic tools based on this approaches. The more advanced proprietary scientific tools based on this approach could be applied. It's also based on the Convexity Principle to build the Portfolio dynamically over the time.

So, here True Risk is Black Swan Tail Risk, Normal Volatility should not be blindly taken as Risk rather they could be the essential scientific natural mechanism of the Markets ! As long as one is Convex and Prudent to Black Swan/Tail Risks, Intermediary Volatility should not be of much concern as according to the Laws of Nature and hence Markets, it would revert to the true Equilibrium Value state over the time.

Beyond that it would it would influence the causal behavior hence the that would remain proprietary and private

As explained in the beginning of the paper that there is Self-referential issue in the paper where publicly disclosing everything could influence the causal mechanism in someway …Even the information in this paper could be discounted by traders/investors in markets directly or indirectly.

24. Understanding Risk Mechanism in Real World:

Issues with Conventional Risk Management Tools e.g. Max Drawdown, Sharpe Ratio etc….. How Risk might often be miscalculated in Real World!

It's often found that managers use conventional tools like Max Drawdown, Sharpe Ratio, using Backtesting etc. but let's ask do they really measure the true risk in Real World ? In the fat-tailed financial world , true aspects of risk are in the tail side which come unpredictably.

The fundamental problem with all these traditional tools is that they are often calculated on historical data in back ward direction of time based on observed data set. As explained above in various other contexts, direction of time is crucial in real world applications. These tools like Max Drawdown,Sharpe Ratio all are measured based on the data which have actually occurred in past. Say for example a stock had max drawdown of 25% in past.

How this drawdown is calculated ? At time T = t, looking at the previous actual data (one that has actually happened!) one calculates the Max Drawdown. Or someone backtests a strategy at Time T= t based on the actual trading data for T <t .

But let's imagine that these actual data reflect the true risk in forward direction of time in the real world ? The key difference is that the trader / investor/observer is at T=0 and looking forward to T=t in forward direction of time live. In that case, there are multiple possible risky paths stock prices could take as per the reader's estimates which could have been actualized ,realized with full of uncertainty but that didn't actually happen ! **This is also related in context of historical equity risk premium puzzle. Infact Risk is often calculated wrongly in real world leading to such puzzle being one of the prime reasons along with fundamental issues with statistical regression framework and fat tailed data.**

Actual Data Path is just the Subset of Many possible Risky Paths that could have been traced in many worlds like scientific theories but didn't actually !

Hence in forward direction of time, the actual risk that traders took and the stock prices could have been were far more possible risky paths than the actual path travelled. But in historical analysis in backward direction of time like Backtesting or max drawdown or Sharpe ratio calculation etc. those real world live possible risks taken over many possible paths in forward direction of time at T= 0 for the trader were not considered that could have been ! Hence , the analysis in the backward direction of time , could grossly misunderstands possible risks !

These fundamental issues arise because of the omission of Time Direction ! In forward direction of time there could have

been many possible paths for the traders)as per this expectations or unexpectedly) which could have different possible max drawdown ,Sharpe, Skew ,Tail Risks etc. But

That actually didn't occur and hence missed out in the backward direction of time.

Hence, these Conventional tools like Max Drawdown ,Volatility occurred or Sharpe ratio, of even Tail measures on Historical trading data observed in backward direction of time might not truly reflect the risk by looking Backward direction of Time on actual data ! True measure of risks would be in the forward direction of time over many possible paths which could have been but didn't happen and those might not get reflected in actual trading data !

At the same time, if one does Scenario analysis in forward direction of time , there would always remain more possible scenarios than the human minds or computer algorithms could imagine/simulate ! This follows philosophically and practically from the Legendary Godel's Results in Mathematics & Logic, indirectly that there would always remain more unimaginable scenarios than simulated in forward direction of time !   Hence the key is how to measure or be prudent to those Uncertain scenarios which one can't imagine at that point in time in forward direction of time.

So, the best way of measuring Risk Prudently is to figure out how the Strategy could have performed(in forward direction

of time way back then) or perform in forward direction of time assuming things could behaving randomly ! This is technically fragility especially to tail events. If the strategy is prudent convex enough to sail through Randomness inherent in Markets/Nature, then one can say that the Strategy is Risk Prudent in Real Forward Direction of Time .And, if one can sail through Randomness, one can be prudent to Black Swan risks as well for the originate out of Randomness, Incompleteness!

Hence, to understand risk truly , one should measure in forward direction of time not backward analysis like Backtesting, max drawdown ,Sharpe ratio on Historical data ! Also, not just future scenario analysis but the underlying principle should be as much convex to take advantage of Randomness due to relative lack of information at any moment in time for an observer (investor).

But yes that has to be Causal adjusted as Causality would minimize the cost of achieving Convexity for Randomness management. In a nutshell, there has to be balance between the two.

As explained earlier, it's scientific that things revert to their equilibrium stage value over the time. Hence, one needs not worry about intermediary on prediction of Black Swan(which is in principle Unpredictable) . But what is extremely important to understand that we must be able to bear the

downside phase during Black Swan events. And that comes from Prudent Risk Management. Often the institutions blow up because they can't handle downside and before the market reverts to stable equilibrium level, they become bankrupt.

This is mostly because of fragile strategies like Leverage etc.. It's quite Scientific.

Nature does have many ups and downs ,catastrophes, but what matters Is to able to survive downside effectively to garner upside when it reverts scientifically as per the laws of Nature.

Hence, The True measurement of Risk is how concave the system is to possible Randomness and unimaginable scenarios in forward direction of time despite being Causal !

Risk is not what actually happened rather what could/might have happened but didn't happen ! But this aspect is often missed while analyzing a fund performance on max drawdown, Sharpe, beta etc. as traditionally reported.

The Traditional measures like Drawdown ,Sharpe Ratio would be complementary to the tail risk measure otherwise they don't make sense if exposed to tail risk !

It's not risk prudent to sail on a boat in a powerful tide sea wave even when it didn't sink by chance with low ups and

==downs somehow if it could have sunk possibly which actually didn't take place due to luck !==

True Management of Risk in Real-World is Degree of Causal Adjusted Convexity in forward direction of time ! True Risk is reflected in fragility to tail events.   Then Sharpe Ratio ,Sortino, Max Drawdown, skewness etc based on the historical performance in backward direction of time or even forward scenario, stress testing etc. analyses measuring normal dimensions of   risk would be complementary useful and informative but without the former ones, these traditional tools are simply superficial as these don't   talk anything about how prudent the strategy is in unforeseen unpredictable random scenarios like Black Swan etc… that's the reason many funds with excellent traditional risk metrics have blown up in real world unpredictably !

25.Causal Theory Dynamics Example of Bubble & Crash

Here I relate the causal mechanism with Prof. Didier Sornette's model of bubble and Crash in Economy

Money Supply and Credit Growth! As Didier Sornette explains.

Didier Sornette's Set of Equations for flow of money in the Economy

The following models are for the Liquidity and Asset Prices :

A reduced form model for the financial accelerator by Didier Sornette.

Money channeled to the financial markets and financial prices.

$$dM_{F\,t} = \alpha P_t M_{F,t} dt + \sigma_{M_F} dW_t M_F$$

$$dP_t = \beta P_t M_F, t dt + \sigma_{M_F} dW_t M_F$$

$M_{F\,t}$ is the Money channeled to Financial Investment Markets and P_t is the Price of the Stock Price.

These two self-reinforcing interactions equations between the the money flow in the investment cycle and stock price lead to

bubble and burst cycle .There are Finite Time singularities in the economy and markets as well leading to phase transition and crash of bubble as fundamental process to attain stable equilibrium. This was explained earlier by me as the OU type process to attain the stable equilibrium valuation. This is fundamentally nothing but according to the Law of Energy Equilibrium of Collective Human Behavior.

The reason I am citing this here to show the causal perspective of Bubble and Burst Cycle due to Money Supply, Credit etc.

These are fundamentally linked to what I had talked about that this entire cycle is linked to physics of human behavior affecting demand and supply cycle.

Super Exponential Growth (as explained by Didier Sornette) linked to Geometrical Stability Equilibrium Theory mentioned above by me in Causal Equation of Motion in Markets : Newton's Laws & Energy system.

Further As I have explained earlier, Super Exponential is Relative. Based on the OU Process using Stability Valuation Causal Equation, Bubble and Crash are like Internal dynamic forces of quantum Supply and Demand reverting to stability leading to bubble and crash. Infact, this is the Energy dynamics in Quantum Human Behavioral Collective Space-Time (which is also dealt in Complexity Dynamics). Fundamentally they follow the law of energy inherent in Nature. Behind Sornette's Equation lies the Fundamental Dynamics of Causal Energy Laws.

One must understand the dynamics of market scientifically in terms of energy mechanism. This is complementary to the Convexity approach .

Note : Despite the fact that there definitely exists scientific causal dynamics behind bubble and crash in markets driven by law of energy, that doesn't mean one can completely predict the timing etc. There would always remain Uncertainty despite being Causal but knowing the Causality to some extent can help increase degree of Convexity by Cost Minimizing during Causal adjusted Random Trials. Hence again Causality & Convexity as Complementary to each other !

26.Feynman Path Integral, Paul Dirac Principle of Least Action in Science: Scientific Commentary on Back testing, Causal Adjusted Probability, Expectations, Causal-Adjusted Monte Carlo Simulations

One thing to note the deep scientific implications for finance. Just like Feynman Path Integral to Paul Dirac's Principle of Least Action, the Stock Trajectory is also caused in the same way. Like in Feynman's theory in sciwnce, one explores the possible paths randomly (in causal way) and selects the best one with least action (Principle of Least Action); similarly, for a stock portfolio, one should explore Randomized paths in causal way and select the best one with most stable least action. But in Human Quantum Behavioral world the definition of "least" keeps on changing. This is the hidden scientific principle behind Randomized Approaches like Algo Wheel Type approach in Randomized Control Trials etc

The entire science and origin of Randomized Algorithm like RCT based on that principle of Nature. Explore Random paths and choose the best one based on the resultant causal force ..This is also the origin of Convexity ! But yes, the selection of Randomized Path Trials is crucial for the maximum Convexity results by minimizing the cost !! This is the Scientific Origin of Randomized Based Algorithms. This Randomized approach of Nature's Experiment to select the Path of Least Action is itself the Causality of Nature's way of working ! Hence it has to be Causal Adjusted Randomized approach to minimize and maximize Convexity !

Hence, drawing from the Principle of Nature's way of Functioning, Finance also works on that principle being the part of Nature.

That's the scientific reason against relying blindly on Backtesting in backward direction of time, the Path of Least Action could be curved and the dynamics of Resultant force in forward direction of time not just Historical ones !! Relying on the Backtesting in Finance is like Relying on the Past trajectory of a moving Car to predict it's future trajectory ! Finance is like a dynamical motion like in Physics. Does one try to predict future motion trajectory based on Backtesting ? Then how can that be in Finance ? Finance also being the scientific motion of stock prices in Quantum Human Behavioral Space-Time. Analogy with Physical systems could help one imagine how scientific blind the Backtesting really is !!

Similarly, like simulation in Monte Carlo Simulations where one tries to simulate random paths and takes the average. This is akin to Feynman's Path Integral theory. But this approach of MC Simulations has fundamental issues in context of Financial Data and Human Behavior.

Monte Carlo Simulations need to be revamped in Causal way. Causal Adjusted Randomized Monte Carlo Simulations.

As explained earlier, Feynman's Path Integral approach might not be valid as per the Paul Dirac's Path of Least Action in Quantum Human Behavioral world like in Physics of Non-Living world ! The Path of Least action i.e. the Path of Most Stability.

So, Monte Carlo Simulation for Quantum Human Behavioral world might not be possibly the same as MC Simulation for Physical world of Non-Living ! This is extremely important because the financial markets are driven by quantum collective human behavior and hence physical non-living world tools might not be suitable!!

Monte Carlo Simulation has been frequently being used in Physics like Phase Transition etc. where analytical solutions are not achievable. It's so actively applied for Monte Carlo Simulation for Quantum Human Behavioral Dynamical Systems like Markets could be different ! Here as explained above conventional average of all the paths might not be the true expected value in Real World.

As explained earlier, The Point is that Expected Value in Real World is based on Causal and either of the many possible outcomes. That Expected Value is One and Only one among many paths i.e. the Path of Most Stability/ Least Action etc. not necessarily Conventional Statistical Probability Weighted Average ! This is where fundamental difference how Expectation should be calculated in Real World rather than based on Conventional Theoretical Statistical approach commonly used, which could be vastly misleading in day to day example decision making in real world finance.

Hence in Real World Monte Carlo Simulation especially Finance driven by Human Behavior, the Expected Outcome would be the path of least action/most stable under the dynamics of causal forces rather than conventional statistical average as usually done. That's the reason why in Real World Investment Scenarios, Monte Carlo Simulation often gets misleading and the Real Path/Outcome is different from the

conventional Expectation. The Randomized Trials and taking just Average could vastly misleading in financial world at times.

<mark>The Figure below in the section shows the Counterfactual illusion of Probability and Human World. The Actual Path Occurred is quite different from the Simulated Paths. The Actual Path is one of those many paths rather than average of all the paths especially in Human Behavioral world. That specific path is the path of most stability, least action under the casual dynamics of forces in the market</mark>.

The Picture below taken from Prof. Emanuel Derman's handle correctly explains that.

.
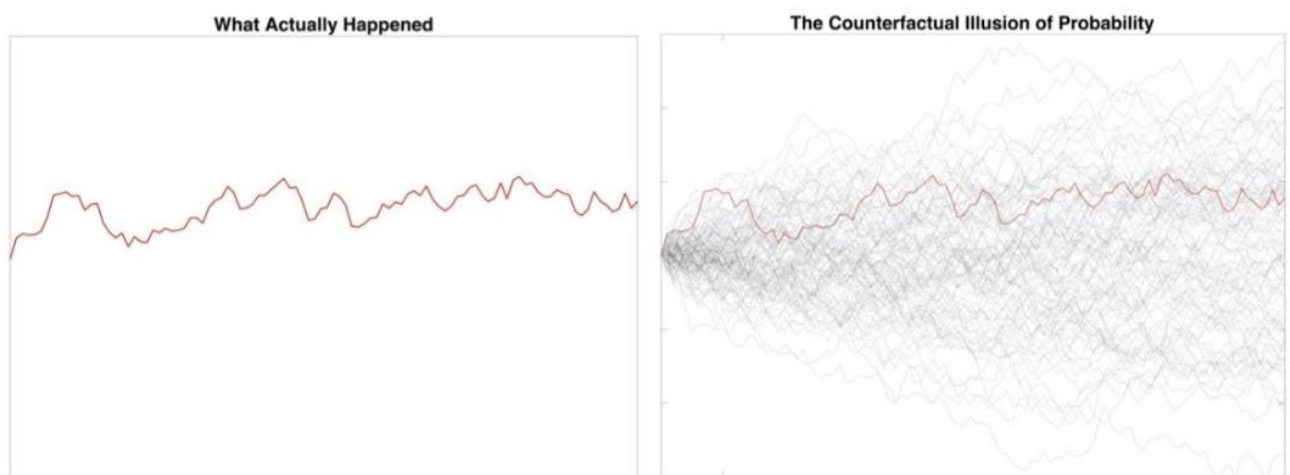
The Expected Probabilistic Value of an event has to be Causally Calculated as the Path of Maximum Likelihood/Stability/Path of Most Stability/Least Action rather Conventional Statistical approaches like

$$E[X] = x_1 p_1 + x_2 p_2 + \cdots + x_k p_k.$$ or $$E[X] = \int_{-\infty}^{\infty} x f(x)\, dx.$$ which tries to average overall the paths.

For example: in Real World, the Expected Value of a Coining of toss by a Game Captain is either Heads or Tails causally not Half of Both Heads and Tails as calculated in Conventional Statistics. Expectation $E[\blacksquare]$ is the Path of Least Action/Max Stability not the Average of all as usually done.

In fact Conventional Statistical Theory of Probability/Mathematical tools like Euclidean Type Calculus, (that too Classical approach) have to be redeveloped Causally in Real World rather than as usually done. Probability theory could be highly misleading especially in real world finance driven by quantum human behavior.

Hence, here is required the fundamental change in the conventional Statistical Based Probability Theory, Monte Carlo Approach for Human Behavioral Driven Markets. That is Rather than Conventional Statistical Based Monte Carlo to Causal Based Monte Carlo approach ! In Causal Adjusted MC Simulations like earlier discussed for Expectations in Probability, one has to find out the Causal Adjusted Path of Maximum Stability & Likelihood rather than conventional Sum& Average of all the paths usually done. This is Proprietary further !!

Drawing from the Scientific Origin , rather than taking the average of different paths, the path travelled is the one being the most stable(least action) due to Quantum human forces. Taking the average path doesn't work always in the Real Human Quantum Mathematical Space ! This is linked to the Principle of Least Action theory from the Laws of Nature where the Path having the least action, most stable equilibrium is followed not the average or sum.

Infact Feynman's Path Integral needs some improvement which is beyond the scope here.

Hence, based on the Scientific Origin while doing the Monte Carlo Simulations in Finance in Human Space- Time, One has to find out the most stable simulated path having least action rather than just taking average or summation, which is scientifically not justified like Non-Living Physical world. That's the fundamental reason often in the Real World Finance in Human Quantum Mathematical Space- Time to improve MC Simulation type process scientifically. It has to be Causal Based Monte Carlo Simulations to find out the Path of Least Action,given the fact Randomness is also Deterministically caused rather than taking the average of all. As explained earlier, the Expectation Operator E [ ] formula needs Fundamental change which also basically like Average of all paths. For Human Quantum Behavioral Space, the Expectation may not be the average always rather the least action/ most stable path as in Principle fo Least Action.

Hence, just doing the simulation like Monte Carlo exploring all the paths and Sum all of them might be different from Reality based on Human affairs. The Quantum Space traces the Best Most Stable one with the Least Action not just the Sum of All Possible ones. That's the mechanism behind Human Scientific Behavior Laws of Nature from where the Market originates. Hence, in Real World, Monte Carlo Algorithm needs improvement and need to align with the Principle of Least Action as the Law of Nature.

28.Backtesting & Simulations In Causal World

Let's take the world of causality as in science/physics. Is Backtesting done to calculate the Trajectory of a Ball or the Newton's Laws of Motion or similar tools are applied ? Then why for markets ! This is deeply psychological problem !! There needs deep psychological change in the finance to see the system like causal physics type system where backtesting is not done rather causal force equations are written.

Backtesting Based on Historical Data is often biased towards Observed events ! One often forgets that even there could have been many possible unobserved Histories like in many world interpretations in quantum physics or similar concepts. Hence, relying only on the observed historical data could be highly misleading if those unobserved historical trajectories come up in future !

Market is essentially a causal system driven by collective quantum Human forces, so similarly one has to trace the trajectory by causal equations of motion not backtesting !! Backtesting is not necessarily Causal Scientific !!

Financial world which blindly seem to rely superficial on Statistical Backtesting doesn't seem to understand the Scientific Causality of the market driven by Quantum Human Behavioral Forces !! Future Trajectory would depend on the Net Resultant Causal Forces not the Historical Paths covered . It's like the Trajectory of a Ball would depend on the resultant causal forces not necessarily the past trajectory of the ball ! There has to be fundamental change in the psychology in the financial world to be able to the market as the Causal Physics type system where motion depends upon the force and energy dynamics not past like backtesting !!

Similar case is with Random Simulations. There could always be more Real-world Paths than the Simulated ones no matter how many. If one simulates infinite number of paths, there could be more real world paths of higher orders of infinity just like mathematician George Cantor's orders of Infinities !) .There will always remain the issue.

Hence, relying on Random Simulations could also be misleading at times especially in the financial world ! Here comes the Role of Causal Adjusted Convexity explained earlier.

29.Financial/Economic Space-Time like General Theory of Relativity in Physics as Causal Dynamics.

It's seen that Financial/AI/ML models use Euclidean space metric Mathematical tools but does Financial Space-Time really Euclidean ? Infact Conventional Euclidean Mathematical tools are mapped to model the Quantum Human Behavior driven world. Infact a different mathematics needs to be evolved for those spaces.

But for the time being, talking about Classical framework, there exists Economic Space-Time (/ Non Euclidean/Riemannian metric)where financial variable traces a geodesic Equation like in General Relativity by Einstein in Physics. . The Trajectory of a Stock Value or Economic Variable traces Geodesics in that Economic Space-Time Curvature. So, the traditional equations of SDE Brownian motion needs to be expanded in N-dimensional Riemannian Economic Space-Time. This approach can also be used to prepare the Bankruptcy model of a firm etc. like Singularity e.g. Black Hole in Physical Space-Time. But this is not the focus of this paper. The analogy is similar to the Einstein's General Theory of Relativity in Riemannian metric space. Similarly, there exists Financial / Economic Space-Time. One of the key fundamental issues is that Economic Space-Time is not the Euclidean Space of the Paper on which these trajectories are virtually drawn. The actual Trajectory occurs in Non-Euclidean Euclidean /Financial Space-Time, Hence, the SDE Brownian Motion in

Non-Euclidean (Riemann Metric Space-Time would have been more meaningful) .

Infact the below equation is the Causal Extension of standard SDE Brownian equation below which is also associational in nature fundamentally

$$dS_t = \mu S dt + \sigma S_t dW_t$$

The fundamental issue is Stock Price doesn't travel on the Deterministic Euclidean Paper or Computer Screen rather they are just the shadow of their Trajectory in the Quantum Human Behavioral Economic /Financial Space-Time. But for now let's not go into that depth otherwise the classical mathematical tools might   be ruled out practically and develop new Quantum world Mathematical Tools rather than Classical ones.

But for practical purpose if one wants to work in classical world then, the Euclidean type metric needs to be taken to Non-Euclidean Riemannian metric Space-time or even Quantum metric space-time

So, in reality, there is need to expand this SDE generic equations to the N-dimensional Space-time in Causal perspective. SDE above is more of associational in nature where we just try to find out the relationship between Stock Price with Time on the Euclidean Paper. This omits the actual causal dynamics happening in the Real Economic Space-Time. This is also the foundation of Quantitative Finance where SDE

is the foundational Structure! That is often used needs to be expanded in that space- time like Schwarzschild metric etc...This is Classical Economic /Financial Space-Time Metric where a financial /economic variable traces geodesic . This is N-Dimensional Causal Economic/Financial Manifold where the trajectory of a financial variable here stock price travels a Geodesic like Einstein's General Theory of Relativity in the Riemannian manifold. Indeed, like Physical Space-time there exists Economic Manifold more complex than the physical one. This metric space is Non-Euclidean. Infact, this has also quite significance for Machine Learning where distance metric formula could be Non-Euclidean/Riemannian rather than traditional Euclidean metric.

Financial Economic Riemannian Manifold :

$$dS_t^2 = \mu S_t dt^2 + f_1(\ )dA_t^2 + g(\ )dB_t^2 + h(\ )dC_t^2 + \cdots.. \sigma S_t^2 dW_t$$

This should also be made Quantum further like Quantum Gravity but let's remain classical here.

Where these the causal n-dimensional space with randomness dimension as well ?

Equation of Geodesic is calculated using the set of following equations as in General Theory of Relativity. Similarly the Financial/Economic Trajectory of an economic entity traces Geodesic in N-Dimensional Riemannian(Non-Euclidean) Causal Metric Space.

$$\frac{d^2 x^\mu}{ds^2} + \Gamma^\mu{}_{\alpha\beta} \frac{dx^\alpha}{ds} \frac{dx^\beta}{ds} = 0$$

where *s* is a scalar parameter of motion and coefficients

 are Christoffel symbols symmetric in the two lower indices. Greek indices may take the values: 0, 1, 2, 3 and the summation convention   is   used   for   repeated

indices   and   . The quantity on the left-hand-side of this equation is the acceleration of a particle, so this equation is analogous to Newton's Laws of Motion which likewise provide formulae for the acceleration of a particle. The Christoffel symbols are functions of the four spacetime coordinates and so are independent of the velocity or acceleration or other characteristics of a test particle whose motion is described by the geodesic equation.

Infact, this approach can also be used to predict the bankruptcy of a firm where Bankruptcy is analogous to the Black-Hole Singularity in the Economic/Financial Riemannian Manifold like General Relativity in Physics ! I had talked about it in a paper around a decade ago, which I had not publicly. This is not the discussion of this paper as of now but I mentioned it to show that how deep scientific causality exists in finance and economics as well.

But again, this is advanced   classical version only for conventional modeling purpose. The reality is always in Quantum Space-time of Human Behavior where different mathematical tools need to be discovered ! That is beyond this paper as of now.

29.Current State of AI /Machine Learning in Finance : Fundamental issues .

Machine Learning is undoubtedly quite useful in many scenarios but while applying on non-stationary financial time series data, finding on the best fit on historical training of data in backward direction of time could be Fundamentally misleading at times ! The fundamental process of Training on Historical data in backward direction of time could itself suffering from hindsight bias especially for non-stationary financial data in real world !

The general form of most ML based Models is like below

$$y = f(x, \ldots) + \epsilon$$

The Fundamental issue is these conventional classical mathematical tools are fundamentally stationary in nature ! So, there is need to evolve Non-Stationary mathematics or understand the causal dynamics of non-Stationarity coming from randomness.

"Most ML techniques are basically advanced forms of Regression Techniques tries to find the function $f(x, \ldots)$

trained on historical data training in backward direction of time. But it doesn't often talk about Random Error (ϵ)

components and how to handle them. Reinforced Learning tries do that in forward direction of time but there also lot of issues are there fundamentally as it's also in away backward looking historical best performance exploitation and random forward exploration ." That's why even Reinforcement Learning has to be redeveloped into Causal Based Reinforcement Learning to make it truly forward looking in real world.

Similarly other ML models have to be based on Causal Dynamics of Randomness to deal with Non-Stationarity issues in Real World Finance !

True aspect of Non-Stationarity as the Quantum reflection of Human Behavior in Financial Data is reflected in the Error term, and key to effective real world application taking risk including tail risks into consideration lies in understanding the causal dynamics of error terms i.e. randomness terms. For that one will have to understand the causal dynamics of randomness along with science of convexity.

So, the focus of ML must be on Handling of Randomness and Error terms in forward direction of time effectively rather than backward curve fitting to find out f ()…But yes it should also work out to find out the Causal structure as explained above.

The point of focus for ML should be on how to make the System discover Causality along with Future Randomness management by maximizing Convex through minimum cost ! ML needs to be evolved to look forward by incorporating Causality dynamics of Randomness as explained in this paper to deal with Non-Stationarity in Real World Finance as the opportunity rather than fundamental constraint !

Evolution of Mathematics/Statistics in Real World Finance

Also, Most of the AI/ML models fundamentally rely on Euclidean Type Classical Stationary Mathematical /Statistical Tools, which itself is a fundamental issue in Real World Finance driven by Quantum Behavior of Human Brains. Infact, Mathematics and Statistics themselves have to be evolved as the existing tools are fundamentally incompatible in the Real World finance. For example, fundamental assumptions of Calculus, Probability Theory, Statistics don't always hold true in Real World Finance driven by Quantum Dynamics of Human Brains in Quantum Space-Time. That's also one of the fundamental reason why Mathematical /Statistical/AI/ML models don't perform quite well in Real World Finance. They have to be made forward looking in a causal and convex way dealing with randomness !

29.Non Stationarity

<u>Non-Stationarity in Finance as the Quantum Reflection of Human Behavior :An Opportunity rather Constraints !</u>

Non-Stationarity of Financial Data in Real World, a fundamental issue with almost all the Financial AI/ML Models is basically the reflection of Quantum Human Behavioural world that is being mapped onto classical mathematical/statistical models to predict etc..

What needs to be conceptually understood that no matter how sophisticated models based on stationary mathematical tools(e.g. classical tools) are developed, the prediction will be constrained by Non-Stationarity being a Quantum Reflection of the Reality ! The Conventional Classical Mathematical Tools are fundamentally Stationary

But practically here, Non-Stationarity can't be resolved by developing advanced models as long as their mathematical foundation is itself stationary !! Even the Fundamental Philosophy of Prediction will also always be constrained by Non-Stationarity. So, the key is not to develop complicated stationary models rather understand the causality dynamics of quantum human behavioural randomness from where non-stationarity enters in the financial time series data. As discussed in the Scientific aspect of Randomness in this paper, it can be possibly resolved.

The fundamental issue is – as long as models in finance exist in backward looing direction of time ,non-stionarity would remain the deeper concern , the moment, they are made forward looking , non-stationarity would become the opportunity to leverage in convex way. In this way, Non-Stationarity should be like an opportunity rather a fundamental constraint here, but for that there is required a fundamental change in how financial models are built in the direction of time!

Conclusion:

Financial Factor Based Investment and Risk Models based on Conventional Tools like Linear Regression Models have to be evolved in forward direction of time based on Causality and Uncertainty/ Randomness Convexity Principles and not just blindly backward looking training and testing and struggling with non-stationarity as in Back testing and all !

For that there have to be made fundamental changes, they have to made scientific discipline rather based on economic logic and assumptions without scientific principle. Statistics has to be Causally Dynamistic in Real World Finance! One has to understand the science of causality, randomness, convexity, uncertainty in real world.

For that one has to be Causally adjusted Convex / to deal with Non-Stationarity/Randomness in forward direction of time rather than Blindly applying Back testing and Scenario analysis. These also apply to AI/ML models that are developed on Euclidean type Classical Mathematical/Statistical Tools. In fact, new mathematics/statistical tools have to be developed for real world finance.

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Note : For different topics there would be required proprieray models . The reason everything can't be publicly disclosed here is it could affect the causal dynamics significantly itself for readers likely to be traders,investors etc. Godel's Self-Referential Issue here.

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P.S. Author(I) have engaged in discussions/interactions/collaboration along with many world-renowned top experts in finance quant, investment and risk over the years. I have written this paper based on my investment and risk experience over the years in market and research which has done quite well. It has been my perspective, if someone finds it different, no worries, there could exist many worlds!!

Happy to discuss further if you find interesting.