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The Benefits of Belief in God in Mathematics

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Abstract:

In this paper, we revisit Blaise Pascal's famous wager and explore its implications for belief in God, particularly through the lens of probability theory. While Pascal's Wager has been widely discussed in philosophical and theological circles, we approach this challenge from a distinctly different perspective. Our backgrounds are in mathematical economics, finance, and computer science, with extensive experience applying mathematics—particularly probability theory—to real-world problems in financial markets, specifically in the domain of statistical arbitrage on Wall Street. Over the past 30 years, we have developed a deep understanding of probability not as an abstract mathematical tool, but as a concrete and practical method for managing uncertainty in financial systems. In this paper, we apply similar probabilistic reasoning to the question of belief in God. Our conclusion can be summarized by an adaptation of the logical principle: "When you have eliminated the impossible, whatever remains, however improbable, must be the truth." — Arthur Conan Doyle, The Sign of the Four

Keywords: belief, God, mathematics

Introduction

This paper originates from an unexpected discovery made during our research aimed at improving cryptocurrency payment processing systems. While the central focus of our research was on optimizing financial operations, particularly in the use value of money, we encountered findings that appear to touch upon deeper questions in theoretical physics, and potentially in mathematics as well. These findings, although speculative at this stage, suggest possible connections between financial modeling and certain principles in physics.

We acknowledge that this connection remains tenuous, and further research is necessary to fully explore its implications. An excerpt from our broader work on the use value of money, which discusses this financial research, can be found at tnt.money.

In light of these discoveries, we introduce a brief discussion on belief in God. The four hypotheses that underpin our financial models show conceptual parallels to some ideas in theoretical physics, and we believe this warrants a deeper philosophical exploration. Should you prefer to skip this section on theology, you may proceed directly to the section titled "Our Approach."

Pascal's Wager: A Formal System Approach

To illustrate the practical application of formal systems in decision-making, we turn to Pascal's Wager. Blaise Pascal (1623–1662) was a French mathematician, philosopher, scientist, and inventor who made significant contributions to probability theory, as well as fields such as engineering and physics. He is best known in mathematics for Pascal's Triangle, a recursive structure used in combinatorics, and for his pioneering work on probability theory, which laid the foundation for modern decision theory and risk analysis. Beyond his contributions to mathematics, Pascal also developed one of the first mechanical calculators, the Pascaline, invented the hydraulic press, and made contributions to fluid mechanics and geometry. Though disputed, he is sometimes credited with early designs for a roulette wheel.

This paper focuses on Pascal's famous philosophical argument known as Pascal's Wager, which combines his mathematical reasoning with his reflections on belief. Pascal's Wager presents belief in God through a rational, decision-theoretic lens, framing it as a bet with possible outcomes based on whether God exists. The argument can be summarized as follows:

1. If God exists and you believe in God, you gain infinite happiness (often conceptualized as heaven).
2. If God exists and you do not believe in God, you suffer infinite loss (often conceptualized as hell).
3. If God does not exist and you believe in God, you lose very little (a finite cost of time, resources, etc.).
4. If God does not exist and you do not believe in God, you gain very little (a finite gain, such as saved time or resources).

Pascal's reasoning is rooted in probability theory and utility theory: even if the probability of God's existence is low, the infinite value of the potential reward (eternal happiness) outweighs the finite cost of belief. From this perspective, belief in God becomes the rational choice, since the potential gain vastly exceeds the potential loss, regardless of the odds (Pascal, 1670).

Pascal's argument can be viewed through the lens of formal systems and decision theory, where the axioms (beliefs and assumptions about the existence of God) lead to theorems (outcomes or utilities) based on logical inference rules. The wager is built on the assumption that, if a decision can lead to an infinite reward with finite cost, it maximizes expected utility to believe, even if the probability is low. This ties into formal logic's approach to maximizing consistency and outcomes based on initial premises.

Clarifying the Concept of Belief: Statistical Hypothesis Testing vs. Religious Faith

Since this paper touches on the subject of God and religion, it is essential to clarify that our approach is rooted in mathematical reasoning—specifically in the context of probability theory and hypothesis testing under uncertainty, and nothing more. This methodology has been consistently applied by the author in a professional context, particularly on Wall Street, for the past 30 years. By "consistently," we mean that not a single year has ended in financial loss, highlighting the robustness of our approach. Importantly, this discussion is distinct from the traditional understanding of "belief" or "faith" in a religious context.

In any sound formal system, like statistics, the term "belief" refers to the selection of the hypothesis most likely to be true based on the available evidence. This sharply contrasts with religious faith, where belief often involves acceptance without empirical evidence or the testing of alternatives.

In statistics, we begin with a hypothesis known as H0, the null hypothesis, which serves as our default assumption. For example, in a study examining the relationship between cigarette smoking and cancer mortality, H0 might propose that there is no relationship between smoking and cancer. However, if data from a regression analysis reveal a strong correlation between smoking and increased cancer mortality, we may reject H0 in favor of H1, the alternative hypothesis, which posits that there is indeed a relationship.

The decision to "believe" in H1 over H0 —under the definition of "belief" as it is used in statistics—is based on the likelihood that

H1 is more consistent with objective facts, i.e., the evidence present in our shared reality. In other words, belief in statistics refers specifically and precisely to a rational choice to accept the hypothesis with the higher probability of being true, given the data at hand. This process is guided by probabilistic reasoning and empirical testing, always subject to revision as new data emerge.

This statistical notion of belief—selecting the hypothesis that is more likely to align with reality, even when absolute certainty is unattainable—differs fundamentally from religious belief. In religion, belief often operates on axioms or truths accepted as inviolable, without requiring empirical validation or testing against alternative hypotheses. Religious faith thus hinges on the acceptance of principles that transcend the need for the kind of evidence that drives hypothesis testing in statistics.

Therefore, it is essential to be precise and respectful, acknowledging that belief, especially in the religious context, can be deeply personal and sensitive for many. The goal here is not to challenge religious faith but rather to highlight the distinction between how belief functions in mathematics and how it is understood in religious practice. This is, after all, a paper about formal systems and probabilistic reasoning—not a discourse on theology or faith.

Dually Defined Null Hypothesis

An intriguing aspect of Pascal's Wager, when analyzed rigorously using probability theory, lies in the construction of the null and alternative hypotheses. Pascal posits as an axiom, which we will designate as H0 (the null hypothesis), that God exists, along with heaven and hell. In applied mathematics and statistics, we typically attempt to disprove H0 by testing against the alternative hypothesis—H1, which, in this case, posits that God does not exist.

However, this binary formulation is provably insufficient. In any correct formal system, particularly in hypothesis testing, failing to consider all relevant alternatives introduces the possibility of what, in statistics, is referred to as a Type I error—failing to accept a true alternative hypothesis. This is something no sound formal system allows under inference rules. In other words, this represents a failure in logic and rigor, as it overlooks valid hypotheses that could potentially be true. Such errors are unacceptable in a proper formal system because they compromise the integrity of the hypothesis-testing process, rendering it fundamentally flawed.

Pascal's Wager, framed as a bet within the context of a formal system, inherently involves probability—a mathematical discipline that Pascal himself helped to pioneer. As a mathematician, Pascal's intention was to construct a rational decision-making framework. Introducing Type II errors by believing in an axiom that omits alternative hypotheses would contradict the very foundation of his wager. Thus, the wager is not merely a philosophical argument but also a formalized bet based on probabilities. Failing to account for all logical possibilities undermines its mathematical validity.

In the context of Pascal's Wager, we must consider more than just the binary existence or non-existence of a single god. Specifically, the question of how many gods exist must be addressed. According to Peano's axioms, which describe the properties of natural numbers, we can treat the number of gods, N, as a natural number. Peano's second axiom states that for any natural number n, there exists a successor n′. This implies that the number of gods could be 0, 1, 2, 3, and so on. Limiting the hypothesis to a single god violates this axiom and introduces logical inconsistency, making the entire system unsound under the inference rules of any valid formal system.

By failing to consider the possibility of multiple gods, we introduce a Type I error into our reasoning—prematurely rejecting a hypothesis that could be true. This makes any formal system based on such an assumption inherently unsound. To avoid this error, we must expand our hypothesis space beyond the simplistic binary formulation of "God exists" or "God does not exist."

Thus, instead of just two hypotheses, we need at least four to cover all logical possibilities:

1. H0: There are no gods at all, except for Yahweh, the God specifically referenced by Pascal. Pascal, as a devout Christian, referred to Yahweh, also known as "the Father" in the New Testament, as the singular, monotheistic God. This deity is also identified as Allah in the Quran, with Islam recognizing the same monotheistic deity worshiped in Christianity and Judaism, though each religion provides its own theological interpretations. This clarification ensures that we are aligning with Pascal's reference to the God of the Abrahamic traditions—Judaism, Christianity, and Islam—without contradicting any known empirical or historical facts. By specifying which God Pascal referred to,

we maintain theological and historical consistency across these major monotheistic faiths, while respecting the nuances in their doctrinal differences.

2. H1: There are multiple gods, but Yahweh is the supreme god who should be worshipped above all others.
3. H2: There are multiple gods, but Yahweh is not the supreme one to worship.
4. H3: There are no gods at all, and we are all alone.

By expanding the hypothesis set in this manner, we avoid the provable logical insufficiency of the original binary formulation and preclude the possibility of a Type I error—rejecting valid alternatives. A Type I error in this context arises when we fail to consider all possible hypotheses, prematurely dismissing a valid hypothesis without adequate testing. Mathematically, N, the number of gods, could be any natural number, and in a sound formal system, N should range from 0, 1, to infinitely many, reflecting our lack of knowledge. Restricting N arbitrarily to just 0 or 1 introduces the risk of Type I error, compromising the integrity—or soundness—of the formal system.

A sound formal system cannot allow such errors, as they conflict with empirical reality. Such errors would effectively "lie" about the range of possible outcomes. When a formal system permits Type I errors, it becomes logically inconsistent, thereby losing its status as a sound formal system.

This approach aligns with Nassim Taleb's observation that, just because we haven't seen a black swan, it does not mean one does not exist. In probability and hypothesis testing, all plausible alternatives must be considered, or else the process becomes logically flawed.

Dual-Null Hypothesis: H0 or H1?

Now the question becomes: which hypothesis do we select as our null hypothesis, H0 or H1? Having two different null hypotheses can be problematic because, in applied mathematics, we don't operate on uncertainty—we base our decisions on what can be reasonably deduced. This approach has allowed us to consistently succeed in statistical arbitrage on Wall Street, where success is grounded in rational, evidence-based decisions. Absolute certainty in the objective reality we share is strictly limited to what can be independently verified. In other words, we can only be absolutely certain about empirical facts and deductive reasoning.

Logical deduction ensures that as long as our axioms are true, the theorems derived from them will also hold true. The accuracy of deductive logic in mathematics is absolute because it can be independently verified. For instance, you can personally prove the Pythagorean Theorem and confirm its validity. In mathematics, if A (axioms) is true, then B (theorems) must logically follow and are guaranteed to hold true both in theory and in reality, as long as the axioms are not violated. This is why using formal systems provides a foundation of certainty that informs our decision-making process—and why 2 + 2 is always 4, unless one of Peano's axioms is violated. For example, "2 moons of Mars + 2 moons of Mars" does not equal "4 moons of Mars" since Mars only has two moons, Phobos and Deimos. In this case, Peano's second axiom, the one that posits that each natural number has a successor, is violated, and the formal system of Peano's arithmetic becomes unsound and inconsistent with reality when its key axioms are violated.

This reminds us that axioms themselves are merely educated assumptions—initial hypotheses, like the ones we are considering now, H0 or H1. An axiom is always accepted without proof and deemed 'self-evident' by those who propose it—in this case, by ourselves. This brings us to the critical question: which of the hypotheses, H0 or H1, should be utilized?

We can avoid arbitrary guessing by following the advice of Bertrand Russell: rather than relying on dogma, we should consult the original sources that Pascal referenced. In this case, according to the Torah, Yahweh, the deity Pascal discussed, commands: "You shall have no other gods before me" (Exodus 20:3, NIV). This implies that H1—which posits Yahweh as the primary deity, deserving of exclusive worship—should be our null hypothesis.

This acknowledgment of Yahweh as the foremost deity aligns with the concept of multiple gods in other religious traditions, such as in the Bhagavad Gita and the multitude of Greek and Roman gods, where a hierarchy of divine beings can, in theory, coexist. And while it's convenient that *H1* does not contradict the existence of many religions with multiple gods (such as those in ancient Greece), that's not the primary reason for choosing *H1* over *H0*.

The real reason we must adopt H1 is that H0 contains a logical contradiction: it claims both "there are no gods except Yahweh" and "Yahweh is the only god." This creates a conflict because atheism (no gods) and monotheism (one god) are mutually exclusive ideas. Grouping them together violates the law of the excluded middle, a principle in formal logic that states something must either be true or false—there is no middle ground. In a formal system, which underpins hypothesis testing in mathematics and probability theory, contradictions are not allowed because they undermine the binary logic required for consistency. By including such propositions, even in the form of assumptions or hypotheses, we violate the law of the excluded middle, making the entire system unsound. This is why dividing by zero is prohibited in algebra: after that, you can prove anything, like 2 = 3, and so on.

Thus, if we were to adopt H0, the entire argument—the formal system—would lose soundness, as it would no longer qualify as a valid formal system.

To put this more plainly, Yahweh asking that "no other gods be placed before Him" while assuming there are no other gods is logically akin to instructing someone to avoid eating lobster, unicorn meat, and pork (where unicorns don't exist). It's also similar to asking someone to drive 55 miles per hour from Boston to London across the Atlantic Ocean in a Ford Explorer. For a more concrete example, it's akin to the infamous attempt to legislate that Pi equals 3.2—which indeed was proposed in the United States in the early 20th century. These are self-evident fallacies and have no place in a rational discussion.

As a result, H0 cannot serve as a valid hypothesis in the context of any sound formal system. Any theorems derived using H0 as an axiom would be inherently invalid—coming from a fundamentally unsound formal system. Therefore, any formal system built on H0—as it attempts to conflate atheism and monotheism—would be logically unsound. This, however, is not a "mathematically proven fact" about atheism itself, but rather about the inconsistency within the specific formal system being proposed.

Thank you, Blaise Pascal, for your insight, and luckily, we no longer live in an era where we burn people at the stake for their beliefs—whether atheist or otherwise. Hopefully, we can all agree on that! The reason we mention not burning atheists at the stake is that, under a rigorous formal system framework, any hypothesis consistent with atheism (H0 or H3) leads to an unsound formal system—implying that we should not let atheists do science. This is because, in the context of this shared objective reality of ours, the only two hypotheses that remain logically sound are H1 (Yahweh/Allah as the primary deity) and H2 (other gods may exist, and Yahweh/Allah is not necessarily supreme).

H0 (no gods except Yahweh) and H3 (no gods at all) are logically unsound as axioms in any correct formal system. This is why all the super-rational Greek philosophers firmly believed in multiple gods, each with specific names. It's funny how history works out sometimes—those deeply rational thinkers seemed to have picked a multi-god hypothesis, and in doing so, they avoided logical contradictions. Perhaps they were onto something after all!

Addressing Common Objections under H1

The Sincerity Objection: One common objection is that believing in God simply to avoid hell may seem insincere, potentially leading to the very outcome one hopes to avoid. However, under the properly selected H1 hypothesis (which posits Yahweh as the primary deity), even an attempt to believe in Yahweh, our "Godfather," results in a relative risk reduction of going to hell. In this context, attempting to believe sincerely is not an insincere act—it is the rational choice within the framework of Pascal's Wager. Thus, this objection does not hold in a rational argument about God.

The Infinite Utility Problem: This objection focuses on the use of infinite rewards (heaven) and infinite punishments (hell) in rational decision-making, arguing that infinite values distort the decision-making process by making all finite outcomes seem irrelevant. This objection misunderstands the nature of a null hypothesis in probability theory. Pascal's Wager relies on accepting the infinite nature of the rewards and punishments as an axiom. The wager's logic assumes these infinite stakes as a starting point, and questioning their infinite nature undermines the very premise of Pascal's argument. Therefore, this objection misunderstands the framework, which requires accepting the infinite stakes to evaluate the decision rationally (Pascal, 1670).

The Moral Objection: Another objection suggests that believing in God purely out of self-interest is morally questionable, reducing faith to a selfish gamble rather than sincere devotion. Even if initial belief stems from self-interest, it is better than non-belief when considering the potential consequences. Pascal's Wager argues that pragmatic belief can serve as a stepping stone toward genuine faith and moral growth over time. As belief grows, so does sincerity, making this objection less relevant in the long term. Again, this relates to risk reduction under our H1 null hypothesis (Pascal, 1670).

The Probability Objection: This objection challenges the assumption that even a small probability of God's existence justifies belief due to the infinite reward, arguing that assigning probabilities to metaphysical claims is inherently problematic. This objection reflects a misunderstanding of probability theory. Just because the probability of God's existence is unknowable does not mean it is zero. With no prior knowledge of the true probability of God's existence, a reasonable assumption would be to assign an initial estimate of 50%, in line with the principle of indifference. Therefore, the probability of God's existence is not inherently low, and the potential for an infinite reward still justifies belief (Pascal, 1670; see Roger Penrose's work on unknowable probabilities).

The Cost Objection: Some argue that Pascal's Wager underestimates the potential costs of belief, including sacrifices in time, resources, and personal freedoms. However, one does not need to devote excessive resources to hold a belief in God. Moderate religious practices can be integrated into one's life without significant sacrifices. These moderate practices minimize potential costs while still allowing for the possibility of infinite rewards. Therefore, Pascal's Wager does not demand extreme devotion for its logic to hold (Pascal, 1670).

The Agnosticism Objection: This objection argues that Pascal's Wager presents belief as a binary choice, potentially ignoring the rational stance of agnosticism. However, this objection misunderstands the binary nature of the reality Pascal's Wager addresses. In objective reality, either God exists or God does not—this is a binary fact. Agnosticism, while a legitimate philosophical stance because we may still be uncertain whether to pick H1 (belief in Yahweh) or H2 (the possibility of multiple gods), does not change the underlying reality that either H1 or H2 must ultimately be true. The wager simply encourages proactive decision-making in light of this binary reality, arguing that the potential infinite reward outweighs the finite costs of belief (Pascal, 1670).

The Many Gods Objection: This objection argues that, given the multitude of belief systems, believing in the "wrong" God might still result in damnation. To address this: While there are indeed many belief systems with various gods, Pascal specifically advocated for belief in Yahweh, the God referred to in the Ten Commandments: "You shall have no other gods before me" (Exodus 20:3, NIV). Yahweh, also known as "The Father" in the New Testament and "Allah" in the Qur'an, is the one God that Pascal's Wager advises us to believe in.

At this point, we can't help but reference a quote—often attributed to Mark Twain but not definitively confirmed: "It's not what you don't know that gets you into trouble. It's what you know for sure that just ain't so." On Wall Street, we always prefer to reference the original source material rather than rely on what people try to tell you (or sell you). People make a lot of false claims due to ignorance, often spread by those who haven't seriously considered the wager—perhaps due to illiteracy or a lack of understanding of formal systems. For the sake of rational discourse, always check your source material carefully!

To clarify further: under the properly formulated H1 hypothesis, worship of non-Yahweh entities is classified as idol worship, which is self-evidently true by definition—worshipping a false god constitutes idolatry. However, this classification does not contradict the fact that the Torah itself mentions multiple God-like entities, such as angels, cherubim, seraphim, nephilim, and giants. Some of these entities obey Yahweh, while others do not. Under H1, these beings are categorized as "false gods" that should not be worshipped, but they may still exist as self-aware conscious entities distinct from humans.

Our Approach: Under the Properly Selected H1 Hypothesis

In this paper, we posit, as an axiomatic assumption—following Pascal—that many gods exist. Additionally, we posit that God is all-powerful and all-loving, in alignment with the traditional teachings about Yahweh, God the Father of Jesus, and Allah as described in the Qur'an. Under our properly and formally defined H1 hypothesis, what we refer to as "God" aligns with these attributes. These teachings can be traced back to original source material, specifically the Torah. Some scholars plausibly argue that the Torah may have roots in Egyptian mythology, particularly influenced by the ancient

Hermetic principle: "As above, so below." This principle becomes compelling when considering the complex interplay between the exchange rates of goods and services in an economy. But before diving into that, let's explore some speculative connections between these concepts.

Under the assumption that God exists, we can draw parallels to Roger Penrose's hypotheses regarding universal consciousness and quantum effects—concepts that echo ancient Hermeticism. Hermeticism posits that God is "the All," within whose mind the universe exists—an omnipotent force shaping reality. This idea resonates with core beliefs from Egyptian religion, which influenced the Abrahamic religions central to Pascal's Wager: Judaism, Christianity, and Islam. The concept of God as "the All" can be analogized to the quantum field in modern physics, where everything is interconnected—a notion Einstein alluded to when describing "spooky action at a distance."

"Spooky action at a distance" refers to quantum entanglement, a phenomenon that troubled Einstein because it seemed to imply that God might indeed 'play dice' with the universe—a notion he famously rejected. Unlike Einstein, whose approach was deeply theoretical, our perspective is rooted in practical applications. With over 30 years of trading mathematical arbitrage on Wall Street, we've applied formal systems to generate consistent profits, focusing only on tangible, independently verifiable results. On Wall Street, as famously noted in Wall Street (the movie), we don't "throw darts at the board"; we bet only on sure things. This pragmatic approach compels us to accept empirical evidence suggesting that God, in some sense, is "playing dice" with the universe. Understanding the mechanics behind this, we argue, presents both intellectual and financial opportunities. Pursuing an understanding of God's design is a logical endeavor, one that could naturally lead to rewards.

Einstein's equation, E=mc2, unveils a profound relationship between energy and mass—a fundamental balance in the physical world. Analogously, this concept can inspire insights into other systems of balance and transformation. In economics, this idea is reflected in the principle of Pareto efficiency, a cornerstone of mathematical economics. Pareto efficiency describes a state where no individual can be made better off without making someone else worse off—a perfect allocation of resources that maximizes productivity and welfare. This concept mirrors the moral and ethical equilibrium envisioned in religious texts like the Torah, where adherence to divine commandments theoretically results in a harmonious society.

According to the First Welfare Theorem in the Arrow-Debreu model of mathematical economics, a Pareto-efficient equilibrium—where both welfare and productivity are maximized—is guaranteed in a perfectly competitive market. This economic ideal parallels the moral adherence proposed in religious traditions, where following divine law could theoretically lead to an ideal social equilibrium. Just as perfect trade conditions in a market lead to Pareto efficiency, adherence to moral laws may lead to a "perfect" societal balance, maximizing both individual and collective well-being.

Unfettered and Symmetrically Informed Exchange

It is an evidence-based, independently verifiable claim—meaning this assertion cannot turn out to be false—that any form of parasitic infestation, such as locusts in a field, termites and carpenter ants destroying your house, or vermin like rats consuming grain in a warehouse, directly reduces economic efficiency. In economic terms, the consumption of goods and services by "economic parasites" arises from involuntary exchanges, such as robbery, theft, extortion, or kidnapping. These activities are universally criminalized because any unearned extraction of wealth—whether by thieves, robbers, or kidnappers—inevitably undermines overall economic efficiency.

A striking real-world example of this inefficiency can be seen in the economic disparity between Haiti and the Dominican Republic, two neighboring countries sharing the same island. In Haiti, widespread lawlessness has resulted in a GDP per capita nearly ten times lower than that of the Dominican Republic. This stark contrast illustrates how the violation of unfettered trade, a fundamental condition for Pareto efficiency, directly correlates with reduced economic output. According to the Arrow-Debreu framework—a foundational model in mathematical economics—efficiency is only achievable when trade is fully voluntary and symmetrically informed.

According to the First Welfare Theorem of mathematical economics, inefficiencies emerge when these two critical conditions are violated:

- Unfettered (fully voluntary) exchange
- Symmetrically informed exchange

George Akerlof's seminal 1970 paper, The Market for Lemons, demonstrated how asymmetric information creates market inefficiencies. For example, a fraudulent used car dealer (an "economic parasite" in Marxist terms) might sell a defective car, or a "lemon," to an uninformed buyer. In this scenario, the market fails to operate efficiently because the buyer lacks the necessary information to make an informed decision. For true market efficiency to exist, trade must be both voluntary and symmetrically informed, ensuring that all participants have equal access to relevant information.

A violation of market efficiency is also evident in the existence of arbitrage in the foreign exchange (Forex) market. Arbitrage occurs when individuals profit by exploiting price differences between currencies at different banks, often with just the press of a button, without contributing to the production of goods or services. This is a classic definition of economic rents—unearned wealth extraction through asymmetric information—as the trader benefits from knowing about price discrepancies that others are unaware of.

While many econometric models—such as those used by central banks like the Federal Reserve—are often inaccurate in their forecasts, certain financial models, like those used to calculate futures prices for the S&P 500 Index, are far more precise. This precision stems from the fact that these models assume there are no arbitrage opportunities, positing that, like stumbling upon $100 on the street, arbitrage opportunities are so exceedingly rare in efficient markets like the NYSE and CME that any existence of such opportunities can be assumed away—just as it is in the Black-Scholes model. When such arbitrage opportunities do arise, they are swiftly eliminated by the market, highlighting their temporary nature and reinforcing their role as indicators of market inefficiency in less competitive environments.

Arbitrage allows individuals to consume goods and services produced by others without contributing to their production—just as finding $100 on the street allows someone to purchase goods without producing anything in return. This represents economic rents, a well-known form of market failure. According to public choice theory, rent-seeking behavior allows "economic parasites," or successful rent-seekers, to exploit information asymmetries to extract value from the economy without corresponding productivity. Such rent-seeking inevitably undermines overall economic efficiency by distorting resource allocation and reducing incentives for productive activity.

No Arbitrage Constraint on Exchange Rates

We begin by analyzing the foreign exchange (Forex) market, where approximately 30 of the most actively traded currencies are exchanged. These exchange rates can be mathematically represented by an exchange rate matrix, denoted as *E*. In this matrix, the value in row i and column j represents the exchange rate from currency i to currency j. This matrix provides a structured model for understanding how exchange rates—whether between currencies or between goods and services—are organized to prevent arbitrage, which, by definition, is a market inefficiency.

Arbitrage is impossible when a uniform price is maintained for an asset across different markets. Specifically, in the Forex market, the exchange rate from currency A to currency B must be the reciprocal of the exchange rate from currency B to currency A. For example, if 1 USD buys 0.50 GBP, then 1 GBP should buy 2 USD. This reciprocal relationship is critical for eliminating arbitrage opportunities that could arise from discrepancies in exchange rates.

Let the matrix *E* represent the exchange rates among the approximately 30 major liquid currencies traded in the Forex market. The no-arbitrage condition can be defined through a constraint on the individual elements eij of *E*, which states that:

$$\frac{e_{ij}}{1} = \frac{1}{e_{ji}}$$

This relationship ensures that exchange rates are consistent and arbitrage opportunities are avoided, reflecting the "as above, so below" idea.

In mathematics, the Hadamard inverse of a matrix $E=(e_{ij})$, assuming that no element e_{ij} is zero, is defined element-wise by:

$$E^{\circ(-1)} = \left(\frac{1}{e_{ij}}\right)$$

This means that each element eij of the matrix *E* is replaced by its reciprocal $1 \div e_{ij}$, forming a new matrix $E^{o(-1)}$, provided none of the elements of E are zero.

We use the notation E_T to refer to the Hadamard inverse of the transpose of E, that is:

$$E_T = (E^T)^{\circ(-1)}$$

The Hadamard inverse and the transpose are commutative operations, meaning that the transpose of the Hadamard inverse is the same as the Hadamard inverse of the transpose. Specifically:

$$\left(E^{\circ(-1)}\right)^T = (E^T)^{\circ(-1)}$$

The no-arbitrage constraint, $E = E_T$, ensures the absence of arbitrage by enforcing symmetry and reciprocity in exchange rates. This constraint is analogous to a matrix being involutory—that is, equal to its own inverse. However, we refer to matrices that satisfy the condition of being the Hadamard inverse of their own transpose, E_T, as evolutory, rather than involutory. An evolutory matrix, $E = E_T$, satisfies the constraint:

$$\frac{e_{ij}}{1} = \frac{1}{e_{ji}}$$

which reflects the reciprocal nature of exchange rates.

This distinction is important because, while for an involutory matrix A, we have $A.A^{-1}=I$ (the identity matrix), for an evolutory matrix E, the relationship is different. Specifically, we have: $E.E_T=E^2=n.E=(E^T.E^T)^T$

However, the matrices $E.E^T$ and $E^T.E$ do not multiply to form n.E. Instead, they result in two distinct matrices, depending on the specific structure of E.

As we can see, when multiplied by its reciprocal transpose, the evolutory matrix does not produce the identity matrix, but rather a scalar multiple of E, scaled by the row count n, effectively becoming E^2. This occurs because, under the constraint $E = E_T$, the matrix E exhibits certain structural properties. Specifically, E has a single eigenvalue equal to its trace, which is n.

This is due to the fact that the exchange rate of a currency with itself is always 1, meaning that the diagonal entries of E are all equal to 1. Thus, the trace of E—which is the sum of the diagonal elements—is n, the number of currencies. This structure implies that E is not an identity matrix but is instead scalar-like, in the sense that its eigenvalues are tied to its trace.

Simplification of *E* Through Evolutory Constraints

Imposing the $E=E_T$ constraint simplifies the matrix *E*, leaving it with a single eigenvalue, n, and reducing it to a vector-like structure. This occurs because any row or column of *E* can define the entire matrix, significantly reducing the dimensionality of the information required to quote exchange rates. For example, the matrix *E* can be expressed as the outer product of its first column and first row, with each row being the reciprocal of the corresponding column. Consequently, all rows and columns of *E* are proportional to one another, making them scalar multiples. This property renders *E* a rank-1 matrix, meaning all its information can be captured by a single vector.

Higher Powers and Roots of *E*

An intriguing property of the constrained matrix $E=E_T$ is its behavior when raised to higher powers. In theory, an unconstrained matrix raised to the fourth power would have four distinct roots. However, due to the constraint $E=E_T$, *E* has only two fourth roots: *E* and E_T. This can be expressed as:

$$E^4=E\cdot E\cdot E\cdot E=(E^T\cdot E^T\cdot E^T\cdot E^T)^T=n^2\cdot E$$

This suggests a deep connection between the structure of E_T and the physics of symmetry. In this framework, the relationship $E^4=n^2.E$ suggests a potential analogy to Einstein's famous equation E=mc2, where mass could be viewed as the fourth root of energy—compressed energy that can be released, for example, in a nuclear explosion.

While E theoretically has four roots, in reality, only two roots exist due to the $E=E_T$ constraint imposed on *E*. The two roots, *E* and E_T, are real, and there may be two other imaginary roots. Although we are not experts in physics, this concept could be explored further by those familiar with the mathematical properties of complex numbers and quantum systems.

Under this evolutory constraint on energy, mass is equivalent to energy but exists as a strictly constrained subset of all possible energy states, limited by the $E=E_T$ condition.

Although this connection remains conjectural, it aligns with principles from supersymmetry in theoretical physics and echoes the ancient Hermetic axiom, "as above, so below." This idea also resonates with the geometry of the Egyptian pyramids and even touches on the notion that "42" is the "answer to the ultimate question of life, the universe, and everything," as humorously proposed in The Hitchhiker's Guide to the Galaxy. While this reference is not directly tied to quantum physics, it humorously reflects the probabilistic nature of existence.

Conclusion

Einstein famously remarked that he did not believe God "plays dice" with the universe, expressing his discomfort with the inherent randomness in quantum mechanics. Upon closer reflection, however, this assumption may be flawed. If God did not play dice with the universe—if there were no randomness at all—even God would be constrained by monotony. In other words, even a God might grow bored without randomness. Our analysis offers a different perspective: God does indeed "play dice" with the universe, but these dice are loaded in such a way that they ensure fairness. This mechanism guarantees that all interactions remain Pareto-efficient and balanced in the long run, ensuring that, over time, everyone receives what they are due, effectively restoring equilibrium in all exchanges.

This leads us to speculate on the real-world implications of Einstein's equation $E=mc^2$. Mathematically, we can express this in terms of our matrix model, showing that: $E^4=E_T.n^2=m.n^2$

Under the constraint $E=E_T$, where E_T represents the transpose of the Hadamard inverse of matrix E,we simplify the relationship to $E^4=E_T.n^2=m.n^2$, where n is the number of rows in E—the same energy matrix in which m denotes mass.

This relationship suggests a deeper connection between energy, mass, and the structural properties of the universe. If m represents mass, then n likely corresponds to time, hinting at an intrinsic link between temporal dynamics and the fundamental equations governing the cosmos—such as the evolving and expanding universe over time.

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