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# A Historical Inquiry into the Relationship Between Theories in Economics and Physics with Emphasis on Adam Smith, Newton, Keynes, and Einstein

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**ABSTRACT**

In light of recent advancements in financial theory, a novel analytical approach—econophysics—has emerged to examine price fluctuations. This interdisciplinary field represents both a contemporary trend within economics and an extension of statistical physics, offering more nuanced analyses of various economic variables. Researchers in econophysics have developed a distinctive framework to model the evolution of financial markets, diverging significantly from traditional financial frameworks. This shift has facilitated the construction of an interdisciplinary paradigm, with theoretical foundations traceable to early parallels identified in the works of pioneering thinkers such as Adam Smith and John Maynard Keynes. Smith's economic theories, for instance, exhibit clear influences from Newton's three laws of motion, while Keynes's insights display conceptual affinities with Einstein's theory of relativity. The present study seeks to investigate the origins of both physics and economics in this context, focusing on their conceptual intersections as evidenced in the works of Smith and Newton, Keynes, and Einstein, among others. Finally, the study addresses the emergence of econophysics as a distinct academic discipline, explores its practical applications in financial markets, and outlines the key challenges currently confronting the field.

**KEWWORDS:** History of Economics and Physics, Econophysics, Smith and Newton, Keynes and Einstein.

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## 1. Introduction

Financial markets have long played a pivotal role in channeling idle capital into productive uses and providing funding for enterprises by enhancing liquidity and lowering transaction costs. This function becomes particularly vital during periods of inflation and declining purchasing power. Excessive volatility in financial markets often prompts abrupt inflows and outflows of capital, exerting profound effects on the economies of developing countries and, in many cases, triggering severe economic shocks. The scope and implications of such fluctuations constitute a critical focus of contemporary economic analysis. As early as 1863, Jules Regnault, an assistant to a French stockbroker, introduced a mathematical framework known as the "random walk" model, drawing on principles of social physics to analyze market behavior. Since then, numerous scholars have endeavored to model the inherent volatility of financial markets using scientific methods, models, and analytical tools. This ongoing effort has catalyzed a rich interdisciplinary dialogue between the fields of physics and finance. By the mid-1990s, in response to substantial advances in theoretical and applied physics, a distinct academic field—econophysics—emerged to examine financial market dynamics (Jovanovic, 2016). The formal establishment of econophysics is often attributed to a 1996 paper by Stanley et al., which introduced the term. However, as noted by Kutner and Grech (2008), its informal roots can be traced to earlier work by Mantegna (1991), who applied the Lévy process to model the evolutionary dynamics of financial systems (Jovanovic, 2016).

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In contrast to traditional economic approaches—which typically begin with foundational assumptions and construct abstract models to explain observed phenomena—econophysicists tend to adopt an empirical perspective. They derive patterns and models directly from observed data, bypassing many of the rationality-based assumptions that underpin classical economic theories. For example, the assumption of transitive preferences is logically inconsistent in certain contexts (Pareto, 1987). Several models from physics have been effectively applied in economic contexts, including diffusion models, chaos theory, and models originally designed for earthquake prediction. Moreover, power-law distributions have been found to accurately describe income inequality across a broad range of countries. Many economic phenomena arise from the interactions of heterogeneous agents, a concept closely aligned with the framework of statistical mechanics, which studies the collective behavior of large numbers of interacting particles. Nonetheless, it is important to acknowledge that humans differ fundamentally from particles. As complex adaptive systems capable of learning, innovation, and strategic behavior, individuals exhibit a diversity of responses that are not easily encapsulated by physical analogies alone. This study aims first to trace the historical development of both economics and physics and then to elucidate their interdisciplinary intersections by identifying conceptual parallels in the theories of foundational thinkers from both domains.

## 2. research background

Since antiquity, humans have sought to comprehend and predict the behavior of the natural world—an intellectual pursuit originally situated within the domain of philosophy. Many early philosophers, including Aristotle and Plato, investigated natural phenomena, with a particular focus on astronomy. Thales of Miletus, one of the earliest known thinkers in this tradition, posited that natural events must have natural causes (Singer, 2008), laying a foundational principle for empirical inquiry. Following the classical period, a significant shift occurred in the early 17th century with the emergence of natural philosophy, a precursor to modern science. This field underwent a profound transformation with the contributions of Galileo Galilei, often referred to as the father of modern astronomy and modern physics (Weidhorn,2005). A defining milestone in this transformation was the publication of Isaac Newton's Philosophiæ Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy) in 1687. In this landmark work, Newton articulated the three laws of motion, which remain central to classical mechanics and continue to underpin much of modern physical science (Isaac Newton; The Principia). By the late 19th and early 20th centuries, physicists began encountering phenomena that classical physics could not adequately explain. This intellectual impasse catalyzed the development of new branches of physics, including statistical mechanics, thermodynamics, and electromagnetism—greatly advanced by scientists such as Ludwig Boltzmann, James Clerk Maxwell, and Nikola Tesla (Buchwald, 1985). Building on the foundational contributions of earlier scholars such as Thomas Young and Leonhard Euler, Max Planck introduced quantum theory, revolutionizing the understanding of energy and matter at microscopic scales. Albert Einstein later expanded on these ideas with his theories of relativity, further solidifying modern physics as a transformative scientific domain distinct from its classical origins (Beiser, 2003). When Galileo (1542-1642) initiated the systematic study of motion and celestial phenomena, progress in other scientific disciplines was relatively limited. The parallel development of mathematics and astronomy played a crucial role in the rise of Newtonian physics (1643-1727). During this era, physics, grounded in mathematical rigor, became the benchmark against which other sciences—such as chemistry and biology—were often evaluated.

In the ensuing period, the social sciences began to take form. Agricultural economics was among the first to emerge, particularly in England, under a framework known as the Physiocratic model (1649-1774). This school of thought gained prominence through the contributions of François Quesnay (1649–1774), whose work coincided with the widespread influence of Newtonian principles. The physiocrats conceptualized the economy as a system composed of interconnected components—such as land, labor, and capital (understood as accumulated past savings). Drawing an analogy to human physiology, they argued that just as the circulation of blood sustains the body's organs, the flow of taxes and rents drives the performance of economic sectors (Chakrabarti, 2006). Shortly thereafter, the mercantilists—most notably Philipp von Hörnigk (1638–1712)—emerged as early pioneers in the field of political economy. Confronted with rising economic instability, increasing unemployment, and persistent trade deficits (i.e., higher levels of imports than exports), they identified the outflow of gold reserves as a fundamental economic concern. This issue was further exacerbated by the absence of effective demand in prevailing economic frameworks. To curb the loss of gold and restore the balance of payments, the mercantilists advocated for protective trade policies, including the imposition of import tariffs. Their proposals laid the groundwork for the concept of a centralized governmental authority tasked with overseeing and regulating economic activity (Chakrabarti, 2006).

Subsequently, Thomas Malthus (1766–1834) introduced a notable model addressing the imbalance between agricultural output and population growth. He argued that agricultural production could only increase arithmetically—by expanding cultivated land—whereas population growth followed an exponential pattern (Chakrabarti, 2006). This disparity, he warned, would inevitably lead to resource scarcity and societal strain. Adam Smith (1723–1790) later played a pivotal role in formalizing economics as a scientific discipline. He introduced the concept of a "natural price" for goods and

advanced the idea of the invisible hand—a metaphor describing how individual self-interest can inadvertently contribute to societal welfare. This notion of self-regulation mirrored earlier principles of self-organization found in the natural sciences, particularly in physics and chemistry. Smith's view of a self-regulating market sharply diverged from the mercantilist emphasis on centralized economic control (Chakrabarti, 2006). In the decades that followed, the nature of price and the intrinsic value of goods became central debates in economic theory. David Ricardo (1772–1823) introduced the theory of rent and the labor theory of value, positing that the value of a commodity is determined by the quantity of labor required for its production. Karl Marx (1818–1883) later expanded upon this concept, developing the theory of surplus value as a cornerstone of his critique of capitalist economies. Nevertheless, neither Ricardo nor Marx satisfactorily addressed key inconsistencies in pricing, such as why diamonds command higher prices than coal, despite requiring comparable amounts of labor. This contradiction highlighted the limitations of the labor theory of value and prompted the emergence of the marginal utility theory. Marginal utility theory proposes that a good's value is derived from the additional satisfaction (utility) gained from consuming one more unit. However, this raised further questions—for instance, if utility determines value, why is water, essential for survival, often cheaper than luxury beverages? The resolution lies in the concept of marginal utility related to abundance: while water is vital, its widespread availability reduces the utility of consuming an additional unit, thereby lowering its market price.

Despite these theoretical advancements, the process of price determination remained partially unresolved. While marginal utility accounted for demand-side behavior, it did not fully explain the role of supply. It became increasingly clear that market prices are shaped by the dynamic interaction between supply and demand: as prices rise, supply tends to expand while demand contracts, driving the system toward equilibrium. This equilibrium-based understanding of markets was further refined in the early 20th century by economists such as Leon Walras (1834–1910) and Alfred Marshall (1822–1924). Their work integrated marginal utility theory with supply-and-demand dynamics, forming a comprehensive framework for equilibrium pricing. This synthesis echoed Adam Smith's earlier ideas of self-regulating systems. In this model, supply is influenced by production factors such as labor, capital, and technology, while demand is shaped by consumer preferences and income levels. Ultimately, the price of a good is determined by the interplay of its relative marginal utility and its availability within the broader set of goods and services in the economy (Chakrabarti, 2006).

Later, John Maynard Keynes (1883–1946) revolutionized macroeconomic thought by introducing the concept of effective demand. In the aftermath of the Great Depression of the 1930s, Keynes challenged classical assumptions of self-correcting markets. He advocated for active government intervention through public expenditure to stimulate aggregate demand and counteract unemployment. This marked a major departure from the laissez-faire views of Adam Smith, Leon Walras, and their intellectual successors. Although Keynesianism dominated mid-20th-century economic policy, its influence waned in the 1970s as microeconomic approaches and market-based frameworks gained prominence (Chakrabarti, 2006). Meanwhile, other notable figures contributed to the field. For instance, Vilfredo Pareto (1848–1923) observed that the wealth of a society gradually declined, as evidenced by the decreasing number of palaces, horses, and other luxury indicators. Josiah Willard Gibbs (1839–1903) proposed that in a state of thermodynamic equilibrium at temperature T, the probability density function $P(\epsilon)$ for particles with energy $\epsilon$ declines exponentially, expressed as $P(\epsilon) \sim \exp\left(-\frac{\epsilon}{T}\right)$.

John von Neumann (1903–1957) introduced game theory into microeconomics, particularly to analyze monopolistic competition. Paul Samuelson (1915–2009) applied Newtonian mechanics to economics, formulating dynamic stability conditions for supply and demand equilibrium through equations of motion (Chakrabarti, 2006). In 1900, Louis Bachelier introduced the foundational concept of the Efficient Market Hypothesis (EMH) in his doctoral dissertation, in which he likened the pricing of financial assets to a random walk (Bachelier, 1900). This hypothesis remained largely overlooked until Paul Samuelson revisited it with greater precision in 1970 (Samuelson, 1965). That same year, the EMH was further expanded by Eugene and Fama (Eugene, 1970). Fama continued this line of inquiry, conducting further research in 1991 that contributed significantly to the development of the EMH framework (Fama, 1991).

Jan Tinbergen (1903–1994) pioneered static analysis of business cycles and econometric modeling, drawing inspiration from disciplines such as physics. His groundbreaking work earned him the first Nobel Prize in Economics in 1969. The following year, Paul Samuelson received the Nobel Prize for his contributions to dynamic economic theory. In 1921, Kenneth Arrow introduced the General Equilibrium Model, which became a cornerstone of economic theory. George Stigler (1911–1991) applied Monte Carlo simulations to market dynamics, drawing analogies between market behavior and thermodynamic systems in physics. In 1928, John Nash formally proved the existence of equilibrium solutions in strategic market scenarios, laying the foundation for modern game theory in economics (Chakrabarti, 2006).

By the late 1990s, researchers such as H. Eugene Stanley, Rosario Mantegna, and their collaborators developed stock market models and price fluctuation patterns based on power-law distributions. At the same time, two influential

physics-inspired models emerged: (1) The Minority Game Model which deviated from the traditional rational-agent framework by incorporating adaptive strategies. Developed by Arthur, Zhang, and colleagues in 1994, it captured strategic diversity and competition among market participants. (2) The Wealth and Income Distribution Model: Analogous to the energy distribution in an ideal gas, this model used a gamma distribution to represent income among low- and middle-income individuals and the Pareto distribution to represent wealth among the affluent. The Kolkata group in India significantly developed this model between 1990 and 2000. The random saving gas model successfully replicated key features of these distribution functions. In the past, there had been incomplete attempts to explain such patterns. Meghnad Saha (1893–1956), the founder of the Saha Institute of Nuclear Physics (later renamed in his honor in Kolkata), discussed in detail in his 1950 book the possibility of applying the Maxwell–Boltzmann velocity distribution (a gamma distribution) in an ideal gas to represent income distribution in society. Later, John Angle proposed a distinctive model in which randomness arises from non-random processes. He demonstrated how disequilibrium in individual saving behaviors could lead to income distribution patterns. Many subsequent studies explored this concept using the gamma distribution to analyze economic inequality (Chakrabarti, 2006).

Ivannik and Schinckus (2013, 2017), in their respective articles, refer to the research of Benoit Mandelbrot, who demonstrated that the long-term price fluctuations of cotton (over 50 years) follow a power-law distribution (Jovanovic & Schinckus, 2013). Mandelbrot emphasized that conventional distributions cannot adequately model the volatility of cotton prices and that a power-law function provides a more accurate representation. According to his findings, speculative fluctuations in the cotton market exhibit a slower decay rate than the Gaussian distribution proposed by Bachelier and instead decline in line with a power law. This discovery by Mandelbrot was pivotal in advancing econophysics, particularly in studies that aim to identify power-law relationships in financial time series.

## 3. Literature Review and Theoretical Commonalities

### 3.1. Newton's First Law and Commodity Value

Newton's First Law, known as the Law of Inertia, states that an object at rest, or moving at a constant velocity in a straight line, will remain in that state unless acted upon by an external force. According to this law, two forces can be identified: Inertial force, which arises from the object's mass and represents resistance to change; and External force, which alters the object's state of motion (Cohen & Whitman, 1999). Similarly, in Chapter 5 of The Wealth of Nations, Adam Smith argues: "The value of any commodity possessed by an individual, which he does not intend to sell or exchange, is equivalent to the amount of labor that enables him to purchase it". According to Smith, the value of labor remains stable over time—labor constitutes the real price, whereas money serves merely as the nominal price (Smith, 1776). This concept allows for an analogy: labor functions like inertia in Newton's First Law, offering a stable reference for the value of goods. Conversely, monetary fluctuations act as external forces, attempting to alter this intrinsic value—just as external forces affect an object's state in Newton's framework (Arnaud, 2011).

### 3.2. Newton's Second Law and the Deviation from Natural Price

Newton's Second Law states that an external force causes an object to accelerate in proportion to the magnitude of the force. In the economic analogy, labor determines the natural price of a commodity—this aligns with the "real price" discussed earlier and corresponds to the inertial state described in Newton's First Law. However, external economic forces—such as profit, rent, or external pressures—function as external forces in Newton's Second Law, disturbing the equilibrium and causing deviations in market prices from their natural state. These forces accelerate changes in value, introducing dynamic price fluctuations (Smith, 1776).

### 3.3. Newton's Third Law, Gravitation, Natural Price, and Market Price

According to Newton's Third Law, for every action, there is an equal and opposite reaction. The gravitational force between two bodies can also be interpreted through this principle. Likewise, in Smith's theory, the natural price serves as a central gravitational point around which market prices fluctuate. When supply and demand fall out of equilibrium, a gap arises between the market price and the natural price—analogous to the gravitational interaction between the Earth and the Moon, where the Moon's elliptical orbit causes variations in its distance from the Earth (Smith, 1776).

### 3.4. Keynes and Einstein

General relativity, developed by Albert Einstein between 1905 and 1915, is a scientific theory of gravitation that fundamentally redefined our understanding of space. The theory compelled a departure from the classical notion of static space—conceived merely as a passive backdrop for physical events—towards a vision of space-time as a

dynamic, deformable continuum. According to general relativity, the presence of matter curves the geometry of space-time, and in turn, objects move along paths determined by this curvature (Einstein, 1920).

In contrast to Isaac Newton, who posited that two particles attract each other through a direct gravitational force, Einstein conceptualized gravity as a field phenomenon. For instance, under Einstein's framework, it is the Earth's gravitational field that causes an object to fall, rather than a direct force acting between the object and the planet. Similarly, John Maynard Keynes, in his macroeconomic theories, emphasized aggregate variables such as total income, total profit, and aggregate capital, referring to them as foundational components of economic analysis. Keynes's use of the term "market forces" can be analogized to Einstein's gravitational fields—both represent indirect, systemic influences rather than discrete or isolated forces. In Keynesian economics, these aggregate variables function much like Einsteinian fields: rather than analyzing individual elements such as profit or supply in isolation, Keynes approached them as interdependent components of a broader, interconnected system. For example, with regard to prices, Keynes argued that they are variable and dynamic, but unlike classical economic theories—such as those proposed by Adam Smith, which implicitly guarantees market equilibrium—prices do not ensure equilibrium on their own. Instead, they influence related markets indirectly, by filtering through aggregate data (Togati, 2001). In other words, from a Keynesian perspective, price changes do not exert direct effects, as posited by classical theories (which parallel Newtonian mechanics). Rather, their impact is field-like and mediated, aligning more closely with Einstein's notion of indirect, structural influence. For instance, changes in wages do not directly affect supply and demand in the labor market. Instead, they influence contractual and institutional data, which in turn form the basis of aggregate demand (Togati, 2001).

### 3.5. Perspectives of Other Scholars

Philip Mirowski argues that neoclassical economists in the 19th and early 20th centuries equated the principle of energy conservation with the concept of utility, which led to the emergence of new issues within neoclassical economics. In physics, the law of conservation of energy states that energy can neither be created nor destroyed, but only transformed from one form to another. In simpler terms, if a physical system is defined and closed, any change in a specific variable (for example, heat) results in corresponding changes in other variables in a way that maintains the system's equilibrium. Mirowski attempted to apply the principle of energy conservation to economics. In addition, with regard to the relationship between physics and economics, other scholars such as Irving Fisher developed tables that presented equivalent concepts between the two fields (Fisher, 1925).

Table 1. Analogous terms in physics and economics (Fisher, 1925)

| Physics | Economics |
|---|---|
| A particle | An individual |
| Space | Commodity |
| Force | Marginal utility or marginal disutility |
| Work | Disutility |
| Energy | Utility |
| Work = force × displacement in space | Disutility = marginal disutility × commodity |
| Energy = force × displacement | Utility = marginal utility × commodity |
| Force is a directional vector in space | Marginal utility is a directional vector in commodity space |
| Force follows vector addition | Marginal utility follows vector addition |
| Work and energy as scalar quantities | Utility and disutility as scalar quantities |

## 4.Establishing a Common Framework

Numerous challenges have arisen in efforts to establish a shared framework between economists and physicists:

- Most physicists are unable to properly grasp even the simplest models of supply and demand, such as the one proposed by Alfred Marshall (Krugmanet et al., 1990).
- Some physicists argue that the teaching of certain topics in microeconomics and macroeconomics should incorporate mathematics, physics, and other foundational sciences (McCauley, 2004).
- In economics, there is a wide array of topics whose outcomes can be enhanced through various testing methods. Moreover, the range of probabilities involved in economic topics may, in some cases, be even broader than those encountered in physics and could be empirically tested on a larger scale (Lillo et al., 2003).

- In physics, theories are typically preceded by detailed descriptions and experimental verification, as exemplified by Newton's laws. In contrast, economics often begins with a theoretical framework, which is then tested against data using econometric methods, followed by its description (Gangopadhay, 2014).
- Articles on econophysics are mostly published in physics journals, and the terminology, methodologies, and modeling approaches used adhere to standards commonly applied in the field of physics. As a result, researchers specializing in econophysics often find it easier to publish in physics journals—where modeling and analogies are physics-based—than in economics journals, due to challenges related to terminology, the publication process, data usage, and methodological alignment (Gilbert & Mulkay, 1984; Bazerman, 1988).
- For physicists, access to comprehensive and robust datasets that help estimate collective behavior or societal reactions is highly attractive. However, when it comes to human factors in society, the equations governing individual behavior are often complex, unknown, and unpredictable. Economics as a discipline plays a key role in managing these challenges (Chakrabarti et al., 2021).
- The term "econophysics" was first introduced in Kolkata, India, by Stanley. Since then, it has gained the attention of numerous scholars. The growing number of studies and research projects in econophysics since its inception reflects the ongoing development of a common framework. It is worth noting that the two disciplines were never completely separate; several physics researchers have completed their doctoral studies in economics. For instance, economist Irving Fisher began as a physics student, and Jan Tinbergen earned a PhD in statistical physics from Leiden University (Ghosh, 2013).
- Physicists are particularly drawn to financial markets due to price fluctuations. In this context, knowledge of statistics—which helps describe such fluctuations—is crucial. The availability of extensive datasets in economics, combined with physicists' advanced programming skills (developed through intensive statistical training in physics), contributes to the formation of a common analytical framework. Additionally, physicists tend to delve into deeper levels of detail, and these datasets facilitate thorough examinations of the micro-level factors that trigger financial shocks. One of the significant contributions of econophysics has been the identification of measurable fluctuations, which play a key role in trading decisions (Gangopadhyay, 2014).
- Early econophysics researchers began solving financial and economic problems using physics-based approaches, particularly principles and laws from statistical physics. They have employed a variety of models to address financial issues in research, including credit-scoring models, development-based models, and complex networks in recent years (Mantegna, 2016).
- Econophysics researchers often construct models that are significantly simpler than those used by most contemporary economists. By exploring possible connections between economic topics and statistical mechanics, they examine how a financial system responds to external shocks. Thus, econophysics provides a quantitative scientific approach to economics using conceptual and computational models and methods derived from statistical physics (Stauffer, 2000).
- From its inception, econophysics has applied physics principles to the study of financial markets, operating under the hypothesis that the economic world behaves like a collection of electrons or a group of water molecules that interact with one another (Săvoiu & Simon, 2013).
- Econophysics uses probability theory and mathematical methods developed in statistical physics to study the statistical properties of complex economic systems made up of large numbers of entities or agents (e.g., firms, households, etc.) (Malkiel, 2001).

As with any emerging discipline, the advancement of econophysics faces numerous challenges. However, given that the two fields were never entirely disconnected—with physicists earning degrees in economics and vice versa—and considering the keen interest among scholars in this field, the steady publication of related articles, and the increasing accessibility and readership of such literature, these extensive efforts are paving the way for the formulation of a shared interdisciplinary framework.

## 5.The Outlook of Econophysics

- The survival and institutionalization of econophysics as a field requires its standardization through the development of a common framework. Over the past two decades, this discipline has increasingly attracted attention, particularly in PhD dissertations at various universities around the world—a trend that is expected to continue. For example, at the University of Houston in the United States, econophysics has been added to the list of academic disciplines available to graduates of economics and physics programs. Numerous conferences have also been held globally, including in Brazil (Jovanovic & Schinkus, 2017).
- The establishment of the Institute for New Economic Thinking by George Soros and the involvement of econophysicists such as Doyne Farmer and Dirk Helbing as traders or advisors reflect efforts to prevent potential financial crises through innovative approaches. The institute utilizes concepts from physics in complex systems to support economic modeling (Pereira et al., 2017).

- The growing interest of econophysics researchers in analyzing and forecasting price fluctuations in financial markets, as well as understanding the influence of various factors that sometimes trigger market shocks, necessitates extensive studies through testing multiple variables using different economic and financial models, data analysis, and risk management techniques (Argyrakis, 2023).
- Notably, two of the 15 most-cited economists in the past decade— Daron Acemoglu and Xavier Gabaix — have incorporated complex systems in their research. Acemoglu, in collaboration with Stanley, has employed fat-tail distributions to explain macroeconomic volatility, while Gabaix, who has taken even greater strides in econophysics, has conducted joint studies with Stanley on power laws. He has received several awards in economics and is a recipient of the prestigious Fischer Black Prize in finance, indicating the growing audience and recognition of econophysics (Perra et al., 2017).
- Physicists and economists are actively advancing the field of econophysics, significantly contributing to solving problems in existing economic models. As a result, econophysics is increasingly gaining attention alongside other branches such as mathematical economics and behavioral economics (Jovanovic & Schinckus, 2017).
- Despite numerous studies since the inception of econophysics, only two major academic textbooks—published in 2010 and 2016—have been compiled. However, there is still no dedicated academic faculty for the field, and more comprehensive research centers must be established to foster deeper investigation and scholarship (Chakrabarti, 2021).
- Advanced applications of quantum field theory and quantum information theory modeling in various economic sciences—particularly in modeling agent behavior under market uncertainty, mathematical modeling, asset pricing, and options valuation—represent significant areas of interest in financial markets that deserve further study (Patra, 2019)

## 6.Conclusion

As highlighted throughout this study, the foundational roots of econophysics stem from the observations and scientific developments in statistical physics during the 1970s, with the formal emergence of the field taking shape in the 1990s. It can be inferred that the evolutionary parallels between economics and econophysics may lead to the integration of econophysical innovations into financial economics (Jovanovic, 2016). The main findings are summarized as follows:

1. Analyzing Newton's First Law—commonly known as the Law of Inertia—and Adam Smith's concept of commodity value reveals a parallel in which labor serves a role similar to inertia, providing a stable basis for value. External influences, such as fluctuations in currency value, act as external forces (akin to Newton's external forces) altering this state. This suggests that Smith implicitly applied Newtonian principles in his economic theories, a conclusion that aligns with the findings from previous studies (e.g. Hetherington, 1983; Redman, 1993; Arnaud, 2011; Deamer & Gell-Mann, 2011; Fioré, 2012).
2. By examining Newton's Second Law and Smith's concept of intrinsic value, where labor determines a good's true value, while factors such as profit and rent act as external forces altering that value, it can be concluded that Smith also employed concepts analogous to Newton's Second Law in discussing commodity prices. This interpretation is consistent with the work of Hetherington (1983), Redman (1993), Deamer and Gell-Mann (2011), and Fioré (2012).
3. From the study of Newton's Third Law and the concept of gravitational attraction concerning Smith's theories of intrinsic and market value, one sees a similar mechanism: intrinsic value functions as a central price point, attracting or repelling market prices depending on imbalances between supply and demand. This mirrors the gravitational force between the Earth and the Moon, where elliptical orbits cause variations in distance. It can thus be inferred that Smith's theories also reflect principles of Newton's Third Law—an interpretation supported by Hetherington (1983), Redman (1993), Deamer and Gell-Mann (2011), and Fioré (2012).
4. A comparative analysis between Einstein's theories in physics and Keynes's theories in economics shows that Keynes referred to market forces that may be likened to Einstein's concept of fields. Furthermore, macroeconomic variables such as total income, profit, and capital behave similarly to fields in Einstein's physics. These parallels indicate that Keynes's economic theories reflect concepts from Einstein's field theory, a conclusion in line with findings by Togati (2001).
5. The growing body of studies and research—particularly theses at various academic levels, peer-reviewed publications, and international conferences—indicates the significance of econophysics stems from two key aspects: (1) Econophysics provides alternative tools for the analytical description of financial uncertainty. (2) It enables more precise analysis and interpretation of economic data and outcomes. Therefore, econophysics holds strong potential to evolve into an independent scientific discipline aimed at addressing a wide range of financial challenges in the future.

Despite the research challenges and issues associated with this emerging field, enhanced collaboration between experts in econophysics and financial economics can lead to numerous research opportunities. Establishing such opportunities and interdisciplinary connections requires the organization of annual conferences, workshops, and symposia dedicated to econophysics. These events would provide platforms for addressing ongoing challenges and fostering dialogue among economists and physicists worldwide, to develop a unified conceptual framework. Furthermore, there is a need for the establishment of more peer-reviewed online journals overseen by specialists in this emerging field, enabling researchers to disseminate their scientific work effectively. In addition, universities can contribute to the institutionalization of econophysics by introducing dedicated academic programs at various levels and enrolling students in these programs. Such initiatives would help transition econophysics from an interdisciplinary status to a distinct and recognized academic discipline.

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