Research on Uncertainty and its Application in Financial Markets

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Abstract. This paper explores the theoretical frameworks and practical implications of uncertainty in economics and decision-making. And also delves into categorical uncertainty, including Economic Policy Uncertainty (EPU), Climate Policy Uncertainty (CPU), and Trade Policy Uncertainty (TPU). These forms of uncertainty can have profound effects on economic activities, market behaviour, and investment decisions. Furthermore, the paper discusses an innovative approach to measuring uncertainty using online big data, particularly Twitter-based uncertainty indices. These indices provide real-time insights into public sentiment and have been shown to impact stock market forecasts, although they are not without limitations, such as potential manipulation and data representativeness issues. The impact of uncertainty on financial markets is multifaceted, affecting different asset classes differently. High uncertainty can lead to increased volatility in stock markets, while oil and digital currency markets are also sensitive to geopolitical and economic uncertainties. The role of technology and algorithmic trading in uncertain markets is highlighted, with High-Frequency Trading (HFT) becoming increasingly prevalent. HFT can provide speed and efficiency but is a subject of debate regarding its impact on market stability. Future research trends may continue to focus on the intersection of technology and market uncertainty, seeking to better understand its implications and potential risks.

Keywords: Uncertainty; Financial Markets; Economic Policy Uncertainty.

1. Introduction

In the ever-evolving landscape of finance and economics, the pervasive influence of uncertainty has become an omnipresent force, shaping the contours of decision-making, investment strategies, and market behaviour. Uncertainty, often delineated as the state of not knowing all relevant details or the probabilities associated with potential outcomes, holds a pivotal position in the world of finance. Understanding the impact of uncertainty has become very important in today's world as one needs to grapple with the increasing complexity of the globalised financial system. This paper's major research goal is to define uncertainty, explain the theoretical framework around it, and then assess how it affects various financial markets as well as how algorithms and high-frequency trading are affected.

The following are the specific analytical ideas in this paper: First, it addresses the theoretical framework of uncertainty, defining the terms used, the efficient market hypothesis, and investor conduct. In Section 3, the classification of uncertainty is examined. In Section 4, the effect of uncertainty on various asset types in financial markets is explored. Additionally, Section 5 examines how technology and algorithmic trading are changing roles in uncertainty. Finally, recommendations are provided together with insights into potential research trends. This study aims to clarify the difficulties of decision-making under uncertainty and provide insightful information for academics, practitioners, and policymakers.

2. Theoretical Frameworks for Uncertainty

In the fields of economics and decision-making, uncertainty theory is frequently discussed, referring to the situation in which individuals or entities lack complete information about the outcomes of their actions or the future state of the world. Economist Frank Knight made significant contributions to this field by distinguishing between "risk" and "uncertainty." He defined risk as situations where probabilities can be assigned to possible outcomes, while uncertainty refers to

situations in which probabilities cannot be accurately estimated due to a lack of historical data or reliable information [1]. This distinction has had a profound impact on addressing decision-making problems in situations where true probabilities are unknown. Uncertainty signifies a state of not knowing all the relevant details or probabilities associated with different potential outcomes. It plays a pivotal role in decision-making, investment strategies, and market behaviour. In the context of economics and finance, several theories and frameworks can support the theory of uncertainty.

2.1. Efficient Market Hypothesis and Its Limitations

The Efficient Market Hypothesis (EMH), proposed by Fama in 1970, argues that a market where prices always reflect existing information is considered efficient, with all available information being incorporated into stock prices at any given time [2]. While EMH assumes that markets fully integrate accessible information, it acknowledges that uncertainty is an inherent part of financial markets. EMH suggests that in an efficient market, market prices will immediately reflect new information, but under uncertain conditions, the direction and magnitude of price changes are unpredictable [3]. However, the Efficient Market Hypothesis still has many limitations. Investor rationality forms the core of EMH, but investors are not always rational. Investor emotions play a significant role in financial markets, influencing market sentiment and behaviour. Human behaviour in financial markets is often driven by emotions and cognitive limitations, leading to deviations from rational expectations. In uncertain environments, people often take actions based on incomplete information, making it challenging for EMH to explain certain financial phenomena.

2.2. Informational Cascades and Herding Behaviour

Herd behaviour and informational cascades represent key concepts originally introduced by the psychologist and behavioural economist Herbert A. Simon during the mid-20th century. These concepts serve to elucidate how individuals frequently imitate the actions of their peers, particularly when confronted with situations characterized by uncertainty. Herd behaviour can result in heightened market volatility and the formation of speculative bubbles. This occurs because, when confronted with market uncertainty, individuals often choose to follow the crowd rather than rely on their own information [4]. The impact of these concepts is especially conspicuous in the realm of capital markets. When investors observe a fervent rush of others purchasing a specific asset, they may succumb to the fear of missing out on an opportunity and subsequently join the buying frenzy, which consequently propels the asset's price upward. In such instances, the market price can rapidly deviate from the true intrinsic value of the asset, giving rise to a speculative bubble. Nonetheless, when group sentiment undergoes a reversal, prices can experience a precipitous decline, ultimately leading to a market crash. These phenomena underscore the significance of irrationality and social influence in the decision-making processes of individuals.

2.3. Subjective Expected Utility Theory

The origin of the Subjective Expected Utility (SEU) theory can be traced back to the early 1940s, when it was introduced by economists John von Neumann and Oskar Morgenstern. This theory is considered an important extension of expected utility theory and has been widely used in economics and decision sciences and is considered one of the standard approaches to theoretical decision making in the context of dealing with uncertainty [5]. SEU theory has a wide range of applications covering a variety of areas ranging from personal financial decision making to public policy making, and provides an important theoretical basis for understanding and optimising decision making. Traditional expected utility theory focuses on decision makers making decisions based on expected outcomes, reducing the decision-making process to a mathematical calculation. However, subjective expected utility theory goes a step further by arguing that people's decisions do not only depend on the expected value of the outcome but are also influenced by their personal beliefs and attitudes towards uncertainty. This means that different individuals may assign different probabilities to the same event

because they have different perceptions and beliefs about the event. This individualised subjective probability assignment reflects each person's unique perception of uncertainty and attitude to risk.

3. Categorical Uncertainty

3.1. Uncertainty based on Economic Policy

When discussing economic policy, uncertainty is defined as a lack of predictability and clarity on upcoming political decisions and economic conditions. Black swan occurrences, like COVID-19, have caused a great deal of uncertainty in markets and economies throughout the world [6]. It constitutes a complex web of unpredictability that casts a pervasive shadow over various facets of the economy, affecting investment, consumer behaviour, and the broader landscape of economic growth. The ever-evolving landscape of economic policy changes continually introduces uncertainty regarding how businesses and individuals should strategize for the future.

Economic Policy Uncertainty (EPU) serves as a valuable gauge for measuring the degree of uncertainty that envelops economic policies. This comprehensive index is influence by monitoring the frequency of news articles that specifically reference policy-related uncertainty. Consequently, the higher the volume of news coverage addressing concerns surrounding economic policies, the more elevated the EPU index tends to be, signifying a heightened level of uncertainty within the economic landscape [7]. Relevant research on the development of economic uncertainty in the United States provides enlightening insights. This study provided a sizable dataset for analysis because it covered the period from the fourth quarter of 1968 to the first quarter of 2016. This empirical investigation reveals a striking and enduring correlation between the macroeconomic uncertainty index and the occurrence of severe economic recessions [8]. This connection underscores the critical role that economic policy uncertainty plays in the broader economic landscape. When the EPU index registers substantial spikes, it often foreshadows or coincides with periods of economic turbulence, where recessions and economic downturns tend to be more pronounced.

An important term in the field of environmental and climate policy is climate policy uncertainty (CPU). It alludes to the degree of uncertainty and unpredictability that surrounds government legislation, programmes, and activities pertaining to climate change and environmental preservation. CPU encompasses the uncertainty regarding the direction, scope, and stringency of climate policies and the potential impacts of these policies on various stakeholders, including businesses, industries, and communities. Increasing air pollution, rising global temperatures and frequent extreme weather events are already significantly affecting people's lives. Globally significant effects of climate change are being felt, and policies to deal with them, as well as investor attitudes towards them, are changing. Risk premiums have grown as a result of the difficulties policymakers have in sending more reliable, long-term signals to the market and the erratic attitude among market players, which has caused considerable disruptions in the financial markets [9].

Trade Policy Uncertainty (TPU) stands as a crucial and increasingly impactful element within the sphere of international trade and economic policies. Its macroeconomic ramifications are steadily gaining prominence [10]. The negotiation and renegotiation of trade agreements, whether they be bilateral engagements or more complex multilateral trade pacts, invariably usher in a substantial degree of uncertainty. The repercussions of Trade Policy Uncertainty extend far and wide, exerting profound influence on the global economic landscape. This multifaceted uncertainty has the potential to impede the flow of international trade, disrupt the meticulous planning and investment strategies of businesses, and infuse an element of risk into the very heart of global markets. In the intricate tapestry of international trade relations, the effects of TPU ripple outward, impacting businesses, industries, and economies on a global scale. The unpredictability surrounding trade policies can sow the seeds of hesitancy among businesses, rendering long-term strategic decision-making a formidable challenge. The delicate balance of supply chains, investment decisions, and market dynamics can be severely perturbed when confronted with the ever-evolving landscape of trade policy.

3.2. Uncertainty based on Network Big Data

This approach to analysing uncertainty through online big data involves measuring uncertainty levels using data collected from digital platforms, social media, news articles and online discussions. The creation of Twitter-based uncertainty indices has drawn a lot of interest in recent years as part of big data research because to the enormous quantity of data that is made accessible on Twitter, which offers real-time insight into public attitude and worries. People express their opinions, emotions, and sentiments online, providing a wealth of data that can be analysed to measure uncertainty. This new approach quantifies the level of uncertainty in various areas by analysing the content and sentiment expressed on the social media platform Twitter. These indices are constructed by tracking and analysing the frequency of tweets containing keywords or phrases associated with uncertainty, ambiguity, or unpredictability, and measuring the emotional tone associated with these tweets through sentiment analysis.

Twitter is a very active social site that gathers a variety of user viewpoints, and the uncertainty index built using social media contains more useful data than the uncertainty index based on newspaper rules. A Twitter-based categorical uncertainty index for the Chinese stock market can, to a certain extent, increase the accuracy of stock market forecasts [11]. However, there are drawbacks to this method of analysis, specifically in the fact that Twitter was created in 2006 and very little data is available from before 2010. In addition, even though more than 50% of the English-speaking users of Twitter are from the United States, there is still no way to represent the U.S. population, as Twitter users are younger than others and have specific political leanings. As a social network, tweets are generally short and informal, making them very susceptible to manipulation by disinformation [12].

4. How Uncertainty Affects Financial Markets

The effect of uncertainty on financial markets is a complex and dynamic phenomenon that can vary across different asset classes, countries, and time periods.

4.1. The Stock Market

Uncertainty can have significant effects on stock markets. H Increased volatility might result from high levels of uncertainty because investors become more cautious and respond to news and events more nervously. Economic and political uncertainties, such as trade disputes, geopolitical tensions, or unexpected policy changes, can lead to sharp market movements. Methods to analyse this impact often involve measuring volatility, analysing market sentiment, and studying the correlation between market movements and major events. Different countries and times can yield different outcomes. For instance, during times of economic recession or geopolitical tensions, stock markets might experience more pronounced downward movements. However, some sectors might benefit from uncertainty, like safe-haven assets such as gold and utilities [13].

4.2. The Oil Market

Oil markets can be highly sensitive to geopolitical and supply-demand uncertainties. Geopolitical tensions in oil-producing regions can disrupt supply, causing oil prices to spike. Conversely, economic uncertainties can lead to changes in demand expectations, impacting oil prices as well. Analysing how uncertainty affects oil markets requires information on supply levels, demand projections, and geopolitical happenings. Since oil prices and "news" are frequently related, a Tweet-based uncertainty index can affect oil investors' choices and oil prices by gathering important information from a variety of sources. The research shows that Tweet-based uncertainty index plays a great role in predicting the volatility of oil futures [14].

4.3. The Digital Currency Market

Digital currencies, like Bitcoin and other cryptocurrencies, can also be affected by uncertainty. Some investors view cryptocurrencies as "safe haven" assets during times of financial instability, like

how gold is sometimes seen. The speculative character of digital currencies, however, can also result in increased volatility during tumultuous times. And economic policy uncertainties may also have an impact on the bitcoin market [15]. The results demonstrate that investor mood may foretell cryptocurrency price direction, demonstrating the direct influence of herding and anchoring bias [16].

5. Algorithmic trading and Uncertainty

In the future of financial market trading algorithmic trading have become integral components of financial markets, particularly in uncertain times. They offer speed, efficiency, and data-driven insights that can be invaluable for traders and investors. The evolving role of technology and algorithmic trading in uncertain markets is a dynamic and multifaceted topic that reflects the rapid advancements in financial technology and the profound impact of algorithmic trading strategies on financial markets during uncertain times. In uncertain markets, algorithms can analyse market data and execute trades at speeds and frequencies impossible for human traders, allowing for real-time responses to market developments. These algorithmic trading systems are equipped with risk management features that can automatically adjust positions, stop losses, and portfolio allocations in response to market fluctuations, helping mitigate potential losses during periods of uncertainty.

On the other side, with the advancement of fintech, more and more trading firms are using High Frequency Trading (HFT). The involvement of HFT algorithms in uncertainty can further complicate market conditions. Algorithms are difficult to predict when markets are highly uncertain. The reliance on algorithms for trading decisions and execution poses serious risks when algorithms operate in ways one would not expect. Algorithmic failure can trigger a domino effect, disrupting trading and even affecting market liquidity in unstable market conditions. This risk increases with the speed of trading. Past events have also shown that algorithmic trading can exacerbate existing uncertainties and create new ones through errors and vulnerabilities [17].

6. Conclusion

In conclusion, this paper has unravelled the complex interplay between uncertainty, theoretical frameworks, and practical implications in the realms of finance and economics. The major goals of this study are to define the theoretical framework around uncertainty, its definition, its effects on various asset classes in the financial markets, and ultimately, its effects on algorithmic trading. In order to give a thorough assessment of the influence of uncertainty on financial markets and to provide thorough summaries and analyses, the research concepts in this article are developed from several angles. The paper begins with a theoretical perspective that delves into the theoretical framework of uncertainty. Next, we explore the specific manifestations of categorical uncertainty from the perspectives of economic policy, climate policy and trade policy. An in-depth look at how uncertainty triggers volatility in markets such as equities, oil and digital currencies is provided. The paper concludes by exploring the controversies and benefits of HFT in terms of market stability. As we navigate an uncertain future, the ability to comprehend and adapt to uncertainty will continue to be a critical determinant of success in the world of finance and economics. Looking ahead, the importance of understanding and navigating uncertainty in financial markets remains undiminished. As global financial systems become increasingly interconnected and volatile, the need for robust risk management strategies and innovative approaches to uncertainty measurement will persist.

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