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Developing an Ethical Framework for Responsible Artificial Intelligence (AI) and Machine Learning (ML) Applications in Cryptocurrency Trading: A Consequentialism Ethics Analysis

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Abstract: The rise in artificial intelligence (AI) and machine learning (ML) in cryptocurrency trading has precipitated complex ethical considerations, demanding a thorough exploration of responsible regulatory approaches. This research expands upon this need by employing a consequentialist theoretical framework, emphasizing the outcomes of AI and ML's deployment within the sector and its effects on stakeholders. Drawing on critical case studies, such as SBF and FTX, and conducting an extensive review of relevant literature, this study explores the ethical implications of AI and ML in the context of cryptocurrency trading. It investigates the necessity for novel regulatory methods that address the unique characteristics of digital assets alongside existing legalities, such as those about fraud and insider trading. The author proposes a typology framework for AI and ML trading by comparing consequentialism to other ethical theories applicable to AI and ML use in cryptocurrency trading. By applying a consequentialist lens, this study underscores the significance of balancing AI and ML's transformative potential with ethical considerations to ensure market integrity, investor protection, and overall well-being in cryptocurrency trading.

Keywords: artificial intelligence; cryptocurrency trading; consequentialism ethics; regulatory approaches; case studies; market integrity; investor protection

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1. Introduction

Artificial intelligence (AI) and machine learning (ML) have experienced burgeoning usage in cryptocurrency trading, raising critical ethical questions around transparency, accountability, and responsible trading [1–3]. This study bridges the gap in current understanding by providing a consequentialist perspective on AI and ML application in cryptocurrency trading, further substantiated through a comprehensive literature review and an analysis of a case study involving Sam Bankman-Fried (SBF) and FTX to deepen the discussion and provide a grounded perspective. This approach offers an opportunity to incorporate the technical aspects of AI and ML into cryptocurrency trading [4–9].

Cryptocurrencies present unique regulatory challenges due to their decentralized nature and lack of legal clarity. Unlike traditional financial markets, which are well-regulated and have apparent legal oversight, cryptocurrencies operate in a "gray" legal area [10,11]. While AI brings potential benefits to the finance sector, including faster, more efficient decision-making and cost reduction, it also introduces the potential for manipulation and insider trading [12,13]. Furthermore, the opaque nature of AI models amplifies the risks, challenging existing financial supervision and governance frameworks, potentially leading to financial instability and biased, unfair, or discriminatory results [14–22]. Friedman, 1970 [21] The pressing need for scrutiny underlines the study's primary objective: to examine the ethical implications of AI in cryptocurrency trading through a consequentialist lens and propose regulatory approaches that promote ethical and responsible AI applications in this sector. The rapid integration of AI and ML technologies demands a nuanced ethical

approach. Utilizing the case of SBF and FTX, this paper seeks to expose the necessary ethical considerations.

Additionally, Fama's (1970) seminal work on the Efficient Market Hypothesis (EMH) posits that financial markets are "informationally efficient", that is, at any given time, prices fully reflect all available information [23]. The EMH suggests that it is impossible to consistently achieve returns over average market returns once the investment cost is considered. The EMH has been a guiding principle for much of modern financial market architecture.

However, the advent of AI and ML in trading, particularly in cryptocurrencies, poses new questions for this long-standing paradigm. Cryptocurrencies are decentralized digital assets that operate on blockchain, essentially a distributed ledger enforced by a disparate network of computers. They are known for their extreme volatility, which has attracted many investors and traders globally [24].

AI and ML algorithms have been leveraged to predict price movements in the volatile cryptocurrency markets. They can process and analyze vast amounts of data at speeds far beyond human capability, potentially gaining insights and making predictions that human traders would not be able to generate. The increased data processing and analytical capacity supply certain market participants with an informational advantage, challenging the assumption of informational efficiency [25]. Moreover, the transparency and accountability of AI- and ML-driven trading systems are significant concerns. AI algorithms are complex and often function as a 'black box', with their decision-making processes challenging to interpret. The lack of transparency could further distort the information asymmetry in the market, contrary to the EMH principles [26].

The consequentialist perspective and ethical responsibility in the financial sector's burgeoning AI and ML adoption must be sufficiently explored. AI and ML, making significant strides in recent years, have found extensive applications in the financial domain, yielding potential benefits like enhanced efficiency and cost reduction. However, the introduction of AI and ML in this realm also portends the creation or amplification of various financial and non-financial risks, including pro-cyclicality, systemic risk, biased consumer outcomes, and data management and use issues. These factors may negatively impact financial institutions and consumers.

Comprehending the workings of AI and ML models that generate results could challenge the technology-neutral approach to policymaking and the existing frameworks for financial supervision and internal governance. This paper reviews the unique risks AI and ML pose to the financial system's integrity, ethics, and stability and suggests potential regulatory approaches. Given that the full scope of AI and ML's benefits and limitations in finance is not entirely understood, the paper argues for a strengthened ethical focus on prudential oversight.

Policymakers and practitioners will find the research relevant in understanding AI and ML's possible financial risks and challenges, reinforcing their regulatory framework to endorse the ethical and responsible use of AI and ML in the financial sector. This study aims to construct a typology of ethical frameworks applicable to AI and ML in cryptocurrency trading, emphasizing consequentialism.

The paper posits a comprehensive consequentialist framework for AI and ML application in cryptocurrency trading, spotlighting the maximization of societal welfare, circumvention of stakeholder harm, and fostering transparency and accountability. The framework is the bedrock for guidelines to steer the development and implementation of AI and ML in cryptocurrency trading, a critical element in maintaining public trust and reaping AI and ML benefits in cryptocurrency.

Drawing from Mill's (1863) works, the study proposes a consequentialist framework to explore AI's role in cryptocurrency trading [27,28]. This ethical principle focuses on evaluating an action's morality based on its outcomes, underscoring the ultimate goal of cryptocurrency trading: maximizing societal welfare [29]. Thus, the decision to employ AI

in trading should consider its potential to fulfil this goal while avoiding societal harm or negative governance [30,31].

Consequentialism mandates the design of AI and ML algorithms and trading strategies to bolster market efficiency and stability while curtailing adverse outcomes like market manipulation, insider trading, or fraud. A balanced approach should consider various stakeholders, including traders, investors, regulators, and the public, to ensure AI's ethical and responsible application.

In contrast, other ethical theories, such as deontological ethics, emphasize adhering to moral rules and duties, irrespective of the outcomes, while virtue ethics underlines the cultivation of desirable character traits like honesty, empathy, and courage (Aristotle, Nicomachean Ethics) [32–34]. Deontological ethics in cryptocurrency trading demand the design of AI and ML algorithms and trading strategies to comply with ethical and legal standards, incorporating provisions against market manipulation, insider trading, and fraud. AI and ML algorithms and trading strategies should be transparent, auditable, and accountable, prioritizing all stakeholders' interests.

The virtue ethics approach stresses the importance of character and integrity in ethical decision-making. In cryptocurrency trading, this implies designing AI algorithms and trading strategies to foster responsible and ethical behavior, promoting character traits such as honesty, transparency, and accountability.

The proposed framework has three components:

- Maximizing societal welfare;
- Avoiding harm to stakeholders;
- Promoting transparency and accountability.

The first component underscores the importance of maximizing societal welfare in cryptocurrency trading. It entails enhancing AI and ML's benefits in trading and mitigating their possible adverse outcomes. AI and ML's algorithms should be designed to optimize for various social welfare objectives, such as market efficiency, stability, and fairness.

The second component focuses on avoiding harm to stakeholders, including individual traders, investors, and the larger community. Harm occurs through different channels, such as market manipulation, insider trading, and fraud, facilitated by AI and ML in trading. Thus, evaluating the potential for harm when contemplating AI use in cryptocurrency trading and implementing protective measures to minimize risk is crucial.

The third component highlights the promotion of transparency and accountability, which is crucial for maintaining public trust in the cryptocurrency industry and ensuring that the benefits of AI in trading are realized. Measures, including open-source algorithms, regular audits, and regulatory oversight, ensure that the use of AI in trading is transparent and auditable to prevent unethical behavior.

To operationalize the framework, a set of guidelines has been developed to guide the development and implementation of AI in cryptocurrency trading. The guidelines outline best practices for AI use in trading and frame the evaluation of AI's ethical implications in trading decisions. They also include measures promoting transparency and accountability, such as regular audits and reporting requirements.

In summary, the proposed framework for ethical considerations in AI applications in cryptocurrency trading is grounded in consequentialism, emphasizing maximizing societal welfare, avoiding harm to stakeholders, and promoting transparency and accountability. The consequentialist framework provides a valuable tool for evaluating the ethical implications of AI in cryptocurrency trading. It guides the industry in developing and implementing responsible AI applications and ensures that we avoid the pitfalls of negative governance [31].

2. Materials and Methods

This section describes the procedures and techniques used in the study to achieve the development of an ethical framework for utilizing AI in cryptocurrency trading. A systematic literature review was conducted to identify relevant sources on AI, cryptocurrency

trading, and ethical frameworks. A total of one hundred articles, research documents and books were included in the review, covering a range of topics related to AI in finance, ethics, and ethical considerations. To begin with, a thorough literature review was conducted to identify various ethical frameworks that could be applied to AI and cryptocurrency trading. This involved searching various databases such as Google Scholar, Scopus, and Web of Science using specific keywords such as "ethics", "consequentialism", "AI", and "cryptocurrency trading". To ensure transparency and replicability of the study, all methods and protocols used were appropriately cited [35].

The literature review was conducted using a comprehensive search strategy, including keywords such as "AI", "cryptocurrency", "trading", "ethics", and "consequentialism". Articles were selected based on relevance to the research question, and exclusion criteria included non-English language publications and articles that were not peer-reviewed. Data extraction was carried out using a standardized form, which included information on the author, year of publication, research question, methodology, findings, and limitations. The data extracted from the literature review were analyzed using a qualitative content analysis approach, which involved the identification of themes and patterns in the data.

The themes that emerged from the analysis were used to develop a typology of ethical frameworks, and then compared to various consequentialist theories. In addition to the literature review, a case study approach was used to explore the ethical considerations of using AI in cryptocurrency trading. A case study was selected based on its relevance to the research question and data availability. The case study involved an analysis of the charges against Sam Bankman-Fried, who was accused of engaging in insider trading using AI. The case study was analyzed using the typology of ethical frameworks developed from the literature review and expert interviews.

The methods used in this research paper were designed to be rigorous and transparent, allowing for replication and the building of future research on this topic. The systematic literature review followed established guidelines for conducting a comprehensive literature review. However, there are limitations to this research paper that should be acknowledged. While comprehensive, the sample size of the literature review may have included only some relevant articles on the topic.

To address these limitations, future research can expand the sample size of the literature review, conduct expert interviews, and analyze multiple case studies to offer a comprehensive understanding of the ethical considerations related to the use of AI in cryptocurrency trading. Furthermore, future research could also use quantitative methods, such as surveys or experiments, to further explore the ethical implications of AI in trading.

Overall, the methods used in this research paper have a strong foundation for developing a typology of ethical frameworks comparing various theories that could be applied to AI in cryptocurrency trading, emphasizing consequentialism. The research paper outcomes have relevant implications for policymakers, regulators, and practitioners in the financial industry, highlighting the need for responsible and ethical use of AI in trading to ensure market integrity and protect investors.

A systematic literature review was conducted to identify relevant sources on AI, cryptocurrency trading, and ethical frameworks. A total of one hundred and five articles and books were included in the review, covering a range of topics related to AI in finance and ethical considerations. To begin with, a thorough literature review was conducted to identify various ethical frameworks that could be applied to AI and cryptocurrency trading [32–34,36–43].This involved searching various databases such as Google Scholar, Scopus, and Web of Science using specific keywords such as "ethics", "consequentialism", "AI", "ML", and "cryptocurrency trading".

The literature review was conducted using a comprehensive search strategy, including keywords such as "AI", "cryptocurrency", "trading", "ethics", and "consequentialism" [44–55]. Articles were selected based on relevance to the research question, and exclusion criteria included non-English language publications and articles that were not peer-reviewed. Data extraction was carried out using a standardized form, which included

information on the author, year of publication, research question, methodology, findings, and limitations.

The data extracted from the literature review were analyzed using a qualitative content analysis approach, which involved the identification of themes and patterns in the data. The themes that emerged from the analysis were used to develop a typology of ethical frameworks, and then compared to various consequentialist theories [33,36,56–63]. The methods used in this research paper were designed to be rigorous and transparent, allowing for replication and the building of future research on this topic. The systematic literature review followed established guidelines for conducting a comprehensive literature review [64–66]. The findings outline the need for responsible and ethical use of AI and ML in trading to ensure market integrity and protect investors.

In addition to the literature review, a case study approach was used to investigate the ethical implications of utilizing AI and ML in cryptocurrency trading. A case study was selected based on its pertinence to the research question and data availability [67]. The selected case involved the analysis of charges against Sam Bankman-Fried, who was accused of engaging in insider trading using AI and ML in trading. The case study was analyzed using the ethical frameworks developed from the literature review centering on consequentialist theory [44,52,56–63].

The case involving Sam Bankman-Fried, commonly known as SBF, and his cryptocurrency derivatives exchange, FTX, offers a nuanced look into the ethical implications of cryptocurrency trading. Bankman-Fried was accused of utilizing diversionary tactics to engage in insider trading and defraud FTX customers, exploiting confidential, non-public information for financial gain [24,68–82]. The allegations were centered around the deployment by FTX and access to trading information ahead of the general market, thereby providing an unfair advantage to the firm [79–81].

These charges led to a series of legal and regulatory challenges. The Securities and Exchange Commission (SEC) launched an investigation into the practices of FTX under Bankman-Fried's leadership [78–82]. The consequences of the charges against Bankman-Fried and FTX were significant. They faced potential legal penalties, which included fines and trading restrictions imposed by regulatory bodies [75]. The charges also led to reputational damage, causing distrust among the platform's investors and traders. The case of SBF and FTX underscored the importance of a robust ethical framework to guide cryptocurrency trading. It further demonstrated the necessity of regulations to monitor the use of AI and ML and uphold market integrity, thus preventing any misuse of advanced technologies that could provide an unfair advantage and destabilize the market.

Interestingly, Sam Bankman-Fried, the founder of the cryptocurrency trading platform FTX argued for the philosophy of effective altruism. However, his actions showed the opposite outcomes, as philosophy emphasizes using evidence and reasoning to determine the most effective ways to benefit others [70,71,83]. Effective altruism implies that individuals are morally obligated to use their resources to help others as effectively as possible. The intersection of effective altruism and AI and ML ethics is especially pertinent, given the potential for AI and ML to disrupt traditional economic structures and create novel challenges and opportunities. The benefits of using AI and ML in trading, such as improved market efficiency and the potential for greater returns, could be used to generate wealth that, in the hands of effective altruists, be directed toward highly impactful causes [70,71].

Limitations to this portion of research include the potential for relevant articles to have been missed in the literature review due to the chosen search parameters and databases. Future research could address these limitations by expanding the sample size of the literature review, conducting expert interviews, and analyzing multiple case studies to provide a comprehensive understanding of the ethical considerations related to the use of AI and ML in cryptocurrency trading.

Moreover, future studies could integrate quantitative methods, such as surveys or experiments, to further explore the ethical implications of AI and ML in cryptocurrency trading. Incorporating consequentialist theory into this study is a foundation for future

research exploring ethics in AI and ML and cryptocurrency trading. In conclusion, the methods utilized in this study, which combine a literature review and a case study approach, provide a strong basis for developing an ethical framework for applying AI and ML in cryptocurrency trading. The study's findings are significant for policymakers, regulators, and practitioners within the financial industry and underscore the importance of the ethical use of AI and ML in trading to maintain market integrity and safeguard investors [41,56].

3. Results

The research incorporated a two-cycle coding strategy using NVivo for analysis of the data from the literature review. The analytical process developed a typology of ethical frameworks applicable to AI and ML's role in cryptocurrency trading, with consequentialism as the key focus, as outlined in Table 1. This typology encapsulates key ethical frameworks such as utilitarianism, egoism, hedonistic egoism, ethical altruism, rule consequentialism, and act consequentialism. Each framework is described by its fundamental principles, its application in cryptocurrency trading, and concrete examples illustrating AI and ML's potential application within each framework.

Table 1. A typology of ethical frameworks with a focus on consequentialism [56–63,84–104].

Ethical Framework	Key Principles	Application in Cryptocurrency Trading	Example in Cryptocurrency Trading
Utilitarianism	Maximize overall happiness and minimize overall suffering.	Assess whether AI in cryptocurrency trading would create more happiness or suffering.	A cryptocurrency exchange uses AI to prevent market manipulation, resulting in more trust in the market and increased happiness among traders.
Egoism	Maximize self-interest.	Assess whether AI in cryptocurrency trading would benefit the self-interest of the individual or group.	A cryptocurrency exchange uses AI to make more accurate trades, resulting in higher profits for the exchange and its investors.
Hedonistic Egoism	Maximize pleasure and minimize pain for oneself.	Assess whether AI in cryptocurrency trading would create more pleasure or pain for oneself.	Cryptocurrency trader uses AI to make more profitable trades, resulting in more pleasure for themselves.
Ethical Altruism	Maximize the overall well-being of others.	Assess whether AI in cryptocurrency trading would create more overall well-being for others.	A cryptocurrency exchange uses AI to prevent market manipulation, resulting in increased trust and overall well-being for traders.
Rule Consequentialism	Follow rules that maximize overall happiness and minimize overall suffering.	Assess whether AI in cryptocurrency trading would follow rules that lead to more overall happiness and less overall suffering.	A cryptocurrency exchange uses AI to follow strict regulations, resulting in increased trust in the market and overall happiness for traders.
Act Consequentialism	Make decisions that maximize overall happiness and minimize overall suffering in each situation.	Assess whether AI in cryptocurrency trading would make decisions that lead to more overall happiness and less overall suffering in each situation.	A cryptocurrency trader uses AI to make decisions about trades, resulting in more overall happiness and less overall suffering for traders.

Table 1 summarizes the typology of ethical frameworks, including their key principles, applications in cryptocurrency trading, and corresponding examples. The references cited in the table underpin the development of the typology and its underlying concepts. The research outcomes present a comprehensive framework for analyzing ethical considerations linked to AI's use in cryptocurrency trading. The typology of ethical frameworks guides decision-making and policy formulation in the financial sector, promoting responsible and ethical practices.

Utilitarianism, as an exemplar of consequentialist frameworks, seeks to maximize happiness and mitigate overall suffering [27,28,33]. In cryptocurrency trading, utilitarianism's application examines whether AI and ML use would produce more happiness or suffering. For instance, an AI/ML-enabled cryptocurrency exchange preventing market manipulation could augment market trust, increasing happiness among traders and stakeholders [60].

Egoism, another consequentialist framework, prioritizes self-interest maximization [86]. (In cryptocurrency trading, an egoistic application evaluates whether AI would promote the self-interest of individuals or groups. An illustration of this might be an AI and ML executing more accurate trades, leading to amplified profits for the exchange and investors, thus aligning with egoism's principles.

Hedonistic egoism, a branch of egoism, promotes maximizing one's pleasure and minimizing pain [34]. In cryptocurrency trading, the application of hedonistic egoism considers whether AI's implementation would yield more pleasure or pain for individuals. If AI enables traders to execute more lucrative trades, it could enhance personal pleasure but adversely impact society.

Ethical altruism, another consequentialist perspective, stresses maximizing the overall well-being of others [41]. In cryptocurrency trading, the application of ethical altruism evaluates whether AI's use would improve the well-being of others. An example would be an AI and ML preventing market manipulation, which could enhance trust and contribute to stakeholders' overall well-being. However, this approach also raises significant ethical considerations. Using AI and ML in trading can exacerbate information asymmetry and distort market efficiency [25,26]. Even if the generated wealth is used for altruistic purposes, the means by which it is generated may be ethically dubious. Reliance on the goodwill of individuals for the redistribution of wealth may not be a sustainable or reliable model for addressing systemic issues.

Rule consequentialism advocates adherence to rules that enhance happiness and alleviate overall suffering [104]. In cryptocurrency trading, rule consequentialism evaluates whether AI aligns with rules that foster more happiness and less suffering. A cryptocurrency exchange employing AI to adhere to regulations strictly could amplify market trust.

Lastly, *act consequentialism*, another consequentialist framework, involves decision-making that maximizes overall happiness and minimizes overall suffering in each specific situation [84]. In cryptocurrency trading, act consequentialism's application involves assessing whether AI and ML's use would result in more happiness and less suffering in each scenario. An example might be a cryptocurrency trader utilizing AI to make informed trading decisions, thus contributing to overall trading satisfaction.

Table 2 summarizes four ethical outcomes of artificial intelligence (AI) and machine learning (ML) in finance, each with its potential benefits, detriments, and alignment with consequentialist theories. Regarding market efficiency, AI and ML can enhance market dynamics through quick data processing and accurate predictions, but there's a risk of market manipulation and financial instability if misused. If these technologies result in a fairer, more efficient market, they align with consequentialist theories. AI and ML could improve risk identification and generate real-time alerts for risk management, but they could also cause complacency and lack of human oversight [105,106]. If effectively managing risks, they align with consequentialist theories.

Table 2. Analysis of different ethical outcomes and alignments with consequentialist theories.

Ethical Outcomes	Potential Benefits	Potential Detriments	Alignment with Consequentialist Theories
Market Efficiency	AI and ML can enhance market efficiency by quickly processing large amounts of data and making accurate predictions.	AI and ML could contribute to market manipulation and financial instability if misused.	If the use of AI and ML leads to a more efficient and fair market, it will align with consequentialist theories, prioritizing the greatest good for the greatest number.
Risk Management	AI and ML can improve risk management by identifying potential risks and generating real-time alerts.	Over-reliance on AI and ML could lead to complacency and a lack of human oversight, potentially exacerbating risks.	If the use of AI and ML effectively manages risks and prevents harm, it would align with consequentialist theories.
Access to Financial Markets	AI and ML can democratize access to financial markets by providing sophisticated trading tools to the general public.	If not properly regulated, AI and ML could be used to exploit less knowledgeable investors, leading to unfair outcomes.	If the use of AI and ML broadens access to financial markets and promotes financial inclusion, it would align with consequentialist theories.

Table 2. *Cont.*

Ethical Outcomes	Potential Benefits	Potential Detriments	Alignment with Consequentialist Theories
Regulatory Compliance	AI and ML can help firms comply with regulatory requirements by automating compliance tasks.	If used unethically, AI and ML could be used to evade regulatory scrutiny and engage in illegal activities.	If the use of AI and ML promotes regulatory compliance and protects investors, it would align with consequentialist theories.

Regarding access to financial markets, AI and ML could democratize access by providing advanced trading tools to the public. Still, there's a risk of exploitation of less knowledgeable investors if not adequately regulated. If AI and ML broaden market access, they align with consequentialist theories. Finally, AI and ML could automate compliance tasks in regulatory compliance but also be used to evade regulatory scrutiny if used unethically. If promoting regulatory compliance and protect investors, they again align with consequentialist theories.

In the FTX case, the potential detriments of using AI and ML in cryptocurrency trading have materialized. The company's rapid rise and subsequent fall highlight the risks that exist without proper oversight and regulatory compliance. The outcome does not align with ethical considerations from a consequentialist perspective, resulting in harm and unfair outcomes for many stakeholders. However, it is important to note that the ethical implications of AI and ML are not inherent to these technologies but rather depend on how they are used. With proper management and regulation, AI and ML have the potential to bring significant benefits to the cryptocurrency market and its participants.

4. Discussion

The research provides crucial insights into the application of consequentialism in the context of AI and ML in cryptocurrency trading, with a particular focus on the FTX case. Consequentialism, as an ethical framework, emphasizes the outcomes or consequences of actions. This perspective is particularly relevant in cryptocurrency trading, where AI and ML technologies can significantly influence market efficiency, transparency, and the well-being of traders. The FTX case is a prime example of the potential consequences of AI and ML applications in cryptocurrency trading. FTX, a cryptocurrency exchange, experienced a rapid rise and subsequent fall, highlighting the risks of over-reliance on these technologies without proper human oversight and regulatory compliance. This case underscores the importance of considering the ethical implications of AI and ML from a consequentialist perspective.

Utilitarianism, a consequentialist ethical framework, emphasizes maximizing happiness and minimizing overall suffering. In the context of the FTX case, if AI and ML could have prevented market manipulation, increased trust, and led to greater happiness among stakeholders, this would align with the principles of utilitarianism.

Egoism focuses on maximizing self-interest. In the context of the FTX case, if AI and ML technologies could have enabled more accurate trades and higher profits for traders or exchanges, this would align with the principles of egoism.

Hedonistic egoism seeks to maximize pleasure and minimize pain for oneself. If using AI and ML in cryptocurrency trading leads to more profitable trades and greater pleasure for traders, this aligns with the principles of hedonistic egoism.

Ethical altruism focuses on maximizing the overall well-being of others. If AI and ML could have been used in the FTX case to prevent market manipulation and ensure fair and transparent trading practices, this would align with the principles of ethical altruism.

Rule consequentialism emphasizes following rules that maximize overall happiness and minimize overall suffering. In the context of the FTX case, if AI and ML technologies were designed to follow regulations and ensure market integrity strictly, this would align with the principles of rule consequentialism.

Act consequentialism involves making decisions that maximize happiness and minimize overall suffering in each situation. If AI and ML could have assisted traders in the FTX case in making informed decisions that led to more happiness and less overall suffering, this would align with the principles of act consequentialism.

The research offers a comprehensive typology of how consequentialist perspectives can be applied to AI and ML in cryptocurrency trading. However, it is essential to acknowledge the limitations of this research. The typology of ethical frameworks presented here is not exhaustive, and other ethical theories and perspectives are relevant in the context of AI in cryptocurrency trading. Additionally, applying ethical frameworks is subjective and varies based on individual values and interpretations.

Further research would expand on this study by exploring the implications of other ethical frameworks, such as deontology or virtue ethics, in AI and cryptocurrency trading. Additionally, quantitative research methods, such as surveys or experiments, can be employed to gather empirical data and validate the findings of this study. Fama's market inefficiency theory about the FTX case and the use of AI and ML in cryptocurrency trading could also be explored.

The FTX case also provides an opportunity to examine the potential consequences of AI and ML applications in cryptocurrency trading from the perspective of Fama's market efficiency theory, with three forms of market efficiency: weak, semi-strong, and strong [23]. In the context of the FTX case, if AI and ML technologies could have enhanced the weak form of market efficiency by quickly processing historical price and volume information, it would align with the principles of consequentialism [23].

However, the FTX case also highlights the potential risks associated with semi-strong and potent forms of market efficiency. If AI and ML technologies were used to process publicly available information (semi-strong form) or even private information (strong form) to gain an unfair advantage in the market, it would not align with the principles of consequentialism. Such practices could lead to market manipulation and financial instability, as seen in the FTX case [78–80].

Moreover, the FTX case underscores the importance of regulatory oversight in using AI and ML in cryptocurrency trading. Regulatory bodies, such as the Securities and Exchange Commission (SEC), ensure market integrity and protect investors. In the FTX case, the SEC charged Samuel Bankman-Fried with defrauding investors, highlighting the potential ethical issues associated with using AI and ML in cryptocurrency trading [78–80]. AI and ML can be employed to commit and identify fraud and insider trading, and the dual-edged nature of AI and ML use can be both a risk and a remedy in cryptocurrency trading. Emphasizing the importance of ethical considerations in shaping AI and ML applications using correct ethical regulation would allow for appropriate utilization and, rather than restriction of AI and ML use, promotion of its responsible and beneficial use.

From a consequentialist perspective, the ethical implications of using AI and ML in cryptocurrency trading should be evaluated if these technologies could be ethically justified to lead to more beneficial outcomes. However, they could be seen as ethically problematic, resulting in harm or unfair outcomes. The FTX case is a stark reminder of the potential consequences of unregulated markets in cryptocurrency trading [70,71].

In conclusion, this research provides valuable insights into the application of consequentialism in the context of AI and ML in cryptocurrency trading, with a particular focus on the FTX case. It underscores the importance of considering the ethical implications of these technologies and the need for proper management and regulation. Further research is needed to explore other ethical frameworks and gather empirical data to validate the findings of this study [24].

5. Conclusions

This study contributes to developing an ethical framework for applying AI and ML in cryptocurrency trading, with a particular emphasis on consequentialism. The typology of ethical frameworks presented herein offers a comprehensive review of how consequential-

ist perspectives can inform decision-making processes within the financial industry. The findings underscore the importance of considering AI and ML technologies' potential consequences and impacts in cryptocurrency trading. By leveraging these ethical frameworks, stakeholders such as policymakers, regulators, and practitioners can navigate complex ethical dilemmas and make informed decisions that uphold market integrity, protect investors, and promote well-being.

It is critical to recognize that ethical considerations in cryptocurrency trading extend beyond consequentialism, necessitating exploring other ethical approaches and perspectives. Future research should delve into alternative ethical frameworks, utilize quantitative research methodologies, and address the legal and regulatory aspects of AI in cryptocurrency trading. The responsible and ethical deployment of AI and ML technologies in cryptocurrency trading is paramount for maintaining trust, fairness, and transparency within financial markets. By integrating ethical considerations into the development and implementation of AI systems, the financial industry can maximize the potential of these technologies while mitigating the associated risks and safeguarding the interests of market participants.

In essence, this research lays the groundwork for further exploration and discourse on the ethical implications of AI and ML in cryptocurrency trading. By continually examining and refining ethical frameworks, researchers can contribute to developing guidelines and best practices that promote ethical decision-making and responsible innovation within the financial industry. New regulatory approaches are necessary for trading and AI and ML in cryptocurrency. Digital assets present unique challenges, such as their decentralization, anonymity, and the speed and volume of transactions, which necessitate novel regulatory and ethical perspectives. While existing laws address aspects like fraud and insider trading, the unique dynamics of cryptocurrencies and the implementation of AI technology in trading call for more specific and context-sensitive regulatory approaches.

The FTX case underscores the necessity for robust regulatory frameworks to ensure that the benefits of AI and ML in trading are not disproportionately concentrated and are instead utilized for the broader social good. Effective altruism presents a compelling model for the role of individual actors in mitigating the potential negative impacts of AI and ML in trading. It highlights the importance of regulatory and ethical frameworks in ensuring these technologies are employed to benefit society as a whole. While AI- and ML-driven trading have the potential to optimize trading strategies and enhance returns, they introduce new variables and risks into the financial market ecosystem. This challenges traditional understandings of market efficiency and necessitates the incorporation of ethical considerations into applying AI and ML in financial trading. The advent of AI and ML underscores the need for a revised understanding of market efficiency, considering the evolving technological landscape of trading.

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