AI Trading and the Limits of the EU Enforcement Regime in Deterring Market Manipulation

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Long abstract version. Please, do not circulate!

Abstract

Thanks to technological and regulatory innovations, algorithmic trading (AT) has become a fundamental component of everyday trading activities in global financial markets. The financial trading industry certainly was a pioneer in adopting artificial intelligence (AI) solutions. Today, the most innovative machine learning (ML) methods applied to financial trading promise to further revolutionise financial trading, leading to several efficiency gains for society. Nevertheless, financial innovation may also come with some drawbacks. When considering the technical specificities of specific ML methods that allow for approximating truly autonomous trading agents (i.e. the "black box" problem), some technological-related risks are emerging. The latter, if not properly regulated, could ultimately impair the fair and smooth functioning of EU capital markets, as well as undermine their stability.

Hence, this study makes two fundamental claims in analysing the implications of ML-powered AT strategies for market integrity. First, the current liability framework under MAR can fail to deter AI market manipulation effectively. And this highlights the inability of EU financial law to force wrongdoers to internalise the costs of their unlawful conduct, thus causing the market to bear the negative externalities of market manipulation by AI trading. Second, the EU lacks a sound policy strategy to guide technological innovation in finance towards enhancing social welfare, as shown by an already outdated regime of market conduct supervision and other enforcement mechanisms. In light of this, this study questions the efficacy of the EU MAR/MAD enforcement regime to ensure credible deterrence.

Generally, AI trading poses severe challenges for effective detection (i.e. given EU capital markets' cross-border and fragmented nature). Moreover, the autonomous, self-learning and black-box nature of specific AI applications add an additional layer of complexity for liability attribution for AI misconduct. Delegating agency to AI can frustrate the safe application of traditional legal concepts of liability. The law usually requires prosecutors to prove the *scienter* (or other relevant mental states) to count misconduct as a crime. With this in mind, this study explores and discusses the merits of a number of possible changes to the EU legal systems to update it to evolving market dynamics and achieve legal certainty and credible deterrence:

1. Abandon the *scienter*-based assessment of market manipulation in favour of a new legal definition and test that emphasises market harm.
2. Adopt new liability rules and further harmonisation of enforcement regimes within the EU.
3. Revise existing supervisory arrangements towards enhanced centralisation of powers on ESMA and introduce innovative market-based solutions to MAR enforcement (i.e. "bounty-hunters").

Overall, these proposals aim to reform the current EU enforcement regime to achieve credible deterrence *vis-à-vis* AI market manipulation to safeguard EU capital markets' integrity and stability, in view of effectively attaining the Capital Market Union project.

Keywords: Algorithmic Trading; Artificial Intelligence; Market Manipulation; Liability; Enforcement.

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I Introduction

Artificial intelligence (AI) and particularly machine learning (ML) methods are considered today as the game-changer for our socio-economic system, as already witnessed in many real-life applications.

In the run towards AI, the financial industry certainly was a pioneer in adopting the most advanced technological solutions to enhance their business efficiency, benefitting from increased automation and optimisation of tasks. Algorithmic trading strategies first emerged as so-called "expert systems" (or rule-based, deterministic approach to computational finance profoundly dependent on human expert knowledge within a specific domain). Today, thanks to constant progress being made in ML methods, coupled with advancements in computational power and the fostering of Big Data science, it is possible to foresee future capital markets having a minimal human intervention, if not exclusively populated by truly autonomous algorithmic trading agents.[2]

Autonomous AI trading agents, capable of self-learning through their own interactions with market dynamics and without the need for constant human oversight, could lead society to several efficiency gains (e.g. in terms of costs, speed, informativeness). However, delegating cognitive agency and financial decision-making to AI agents can also expose markets to novel sources of risks. Specifically, if not properly developed and supervised by human experts, AI trading agents can lead to optimised forms of market abuse (e.g. market manipulation and 'tacit' collusion) even without any prior human intent to do so.[3] Whenever this is the case, current enforcement regimes of market abuse regulation can fall short of deterring AI forms of market abuse, as traditionally rooted in the intent-based definition of market abuse and legal tests.[4] Not to mention all the practical difficulties for market conduct supervisors in detecting algorithmic forms of market abuse.[5] For all these reasons, regulators and enforcement authorities need to start assessing the need to reform the current legal framework against the prohibition of market abuse, given the fast-changing reality of markets (i.e. AI agents increasingly replace humans in financial decision-making).

In light of the above, this paper aims at answering the following questions. Does the current EU Market Abuse Regulation (MAR) framework deter novel forms of market abuse introduced by AI trading effectively and credibly? If not – as this study claims – what ought to be the legal response? In dealing with all such issues, the paper proceeds as follows. Building upon the Law & Economic literature, Section II introduces and discusses deterrence theory and highlights the main limitations in achieving effective deterrence. It also explains the critical role of credible deterrence against market abuse in the regulation of capital markets. This discussion will also serve as a normative framework to inform our analysis and support the paper's central arguments. Then, Section III explains in detail the current EU MAR/MAD enforcement regime against market manipulation (i.e. the legal definition of the prohibition; related legal tests of liability; supervisory arrangements; division of responsibilities between different market actors and regulators; and other enforcement mechanisms) within highly fragmented EU markets characterised by enhanced cross-border trading activity. It then outlines the main criticisms related to issues of credible deterrence within the EU enforcement regime of market abuse. All this will prepare the grounds for Section IV, where new market abuse risks led by the most innovative (and future) AI trading strategies are presented from a conceptual standpoint. Specifically, this section focuses on the technical specificities of specific AI trading techniques that leverage the most innovative ML methods applied to financial trading. It shows how certain AI trading strategies' autonomous and black box nature can lead to new forms of market manipulation that could ultimately jeopardise market integrity whenever not properly detected and punished. Building on the above, Section V shows how the current EU MAR enforcement regime can fall short of achieving credible deterrence *vis-à-vis* AI trading misconduct. It, therefore, pinpoints the vulnerabilities of the current legal framework in dealing with the additional risks introduced by financial innovation such as AI trading. Hence, Section VI put forward a number of policy proposals intended to enhance the enforcement toolkit of EU regulatory and

[2] Azzutti et al., 'Machine Learning, Market Manipulation, and Collusion on Capital Markets: When the "Black-Box" Matters' (2021) 43 University of Pennsylvania Journal of International Law (Forthcoming).
[3] Azzutti et al. (2021).
[4] Azzutti et al. (2021); Gina-Gail S. Fletcher, 'Deterring Algorithmic Manipulation' (2021) 74 Vanderbilt Law Review 259; Bathaae (2019); Yadav (2016); Scopino (2015).
[5] Yadav (2019); Austin (2017).

supervisory authorities and, thus, achieve credible deterrence of AI market manipulation on EU capital markets. Section VII concludes.

II The Law & Economics of the Deterring Market Manipulation

This section first introduces deterrence theory as proposed within the law & economics scholarship interested in understanding the roles of different sanctions and enforcement regimes in curbing people behaviours towards socially optimal outcomes. It then discusses why credible and effective deterrence serves one of the main goals of capital markets law and regulation: i.e. ensuring market integrity. This preliminary discussion will be then instrumental for us to put deterrence theory in the context of the prohibition of market abuse on capital markets. The focus, however, is precisely on one of the trickiest forms of market abuse faced by enforcement authorities and victims alike, namely market manipulation by means of algorithmic trading.

II.1 Deterrence theory

Deterrence theory has been developed within the law and economics scholarships interested in understanding the interplay between different sanction regimes and people behaviour in abiding by the law. In general terms, deterrence theory proposes that an individual will break the law if his/her expected utility from committing the crime is greater than not doing it.[6]

Therefore, in a financial trading context, the theory would suggest that a trader would only enter into unlawful conduct whenever his/her expected benefits outweigh expected costs. In other words, if a trader presumes to face greater penalty risks than gains, he/she will be deterred from engaging in abuse market practices, such as manipulation.[7] Consequently, in principle, the law can deter market manipulation by altering the balance between expected benefits and costs favouring the latter, thus making the misconduct less desirable from an *ex-ante* perspective.

In classical models of deterrence, expected costs faced by would-be criminals depend upon two main factors: (a) the "certainty" of punishment (i.e. the probability of being caught and convicted) and (b) the "severity" of the punishment. Under very simplified assumptions about people behaviours and socio-economic interactions, classical law and economics approaches would suggest deterring crimes, such as market manipulation, by setting fines high enough to discourage misconduct from taking place.

Classical models of deterrence, rooted in rational choice theory, had traditionally solely relied on these two factors to explain optimal deterrence. Given their limitations in explaining people behaviours and preferences, those models have been developed further to include essential insights from behavioural economics studies, which can help us better capture the behavioural dynamics behind criminal activity. For instance, modern models of deterrence also consider both behavioural aspects and other subjective elements of crimes: e.g., criminals' risk aversion and time sensitivity to losses, among others.[8] In scaling down the emphasis on the "severity" of punishment, neo-classical models instead suggest leveraging on "certainty" of punishment to achieve optimal deterrence. Nevertheless, the "certainty" of punishment is by default constrained by two main considerations. First, it requires legal certainty as to which conducts are actually prohibited by law. Second, (un)certainty is also closely linked to states ability to detect and prosecute crimes, which depends on the tools, expertise, and economic resources available to them.

Corporate crimes are crimes committed within an organisation by one or more of its employees within the scope of their employment and motivated by some intent to benefit the organisation.[9] Now, a firm can either induce crimes through compensation schemes that alter the incentives for employees to

[6] See the seminal paper by Gary S. Becker, 'Crime and Punishment: An Economic Approach' (1968) 76 Journal of Political Economy 169-217 (advancing an economic model for the analysis of criminal punishment in order to develop optimal public and private policies to fight illegal activities).
[7] Gina-Gail S. Fletcher, 'Deterring Algorithmic Manipulation' (2021) 74 Vanderbilt Law Review 259, 267-268.
[8] Jennifer Arlen (2012).
[9] Arlen (2012).

commit unlawful acts or inhibit potential wrongdoers because of their potential ability to assist public authorities in crime enforcement. That is why neoclassical models of deterrence introduce corporate criminal liability (in addition to individual liability) to achieve optimal deterrence, moving from the baseline assumption that states cannot prosecute all crimes by just setting fines high enough to daunt criminals.

[Besides acknowledging the need to integrate this part, in the remaining, I will also discuss (i) different liability rules; (ii) the trade-off between corporate and individual criminal liability; (iii) the role of corporations in assisting public enforcement.]

II.2 Safeguarding market integrity: why deterrence matters

Economic theory suggests that financial markets' vocational and institutional roles should efficiently allocate financial resources and risk-sharing among market players.[10] To this end, financial instruments' market prices play a fundamental role in directing investors' decision-making process by providing signals for the efficient allocation of investments.[11] Essentially, the interactions between supply and demand on a particular financial instrument, say a stock, influence the price at which it is quoted on financial markets.

As first theorised by Fama, an efficient market is where many rational and profit maximisers actors compete with each other to predict the future market values of assets and where all current information is almost freely accessible to all participants.[12] Price sensitive information is therefore vital for investors to steer their investment decisions.

Contrariwise, malicious market actors can affect the efficiency of markets by leveraging on information and thus influencing market prices. Actually, the behaviour of malicious investors can take place through two main economic phenomena, or alternative forms of market abuse, sometimes used in combination: insider trading and market manipulation.[13] Notably, "*[i]t is widely admitted that no behaviour is a more potent enemy of market efficiency and bigger destroyer of investor confidence than market abuse*."[14] In this respect, market abuse constitutes a form of market failure that ultimately delivers an inefficient allocation of resources and, as such, negatively affects the allocative role of capital markets.[15] Market failure refers to a situation where the market does not work in an expected ideal way and leads to suboptimal outcomes for society, which thus justify regulatory intervention.[16] Market abuse is primarily an economic phenomenon, and, as such, its economic objective is the "*extraction of profit that would not otherwise be available to the perpetrators of the practice, or, at the very least, would not be available to the same extent*."[17] Market abuse has negative effects on the informational efficiency of capital markets. Thus, it is a tremendous source of negative externalities. But absent a market mechanism able to address them, there is the need for regulatory intervention to incentivise positive market behaviours and align them to broader public goals (i.e. market integrity).[18]

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[10] *See*, e.g., Franklin Allen, 'Stock Markets and Resource Allocation' In: C. Mayer and X. Vives (eds.), Capital Markets and Financial Intermediation (CUP, Cambridge, 1993), 81-108.

[11] E.g., Sanford J. Grossman and Joseph E. Stiglitz, 'On the Impossibility of Informationally Efficient Markets' (1980) 70 The American Economic Review 393 (concluding that because information is not cost-free, prices are not able to perfectly reflect all the information available on the market. If this was the case, they argue, those who spend resources to gather an information advantage would not receive any compensation from that. Thus, there may be a potential conflict between the information efficiency of markets and investors' incentives to acquire new information).

[12] *See* Eugene F. Fama, 'Random Walks in Stock Market Prices' (1965) 21 *Financial Analyst Journal* 55.

[13] For the sake of clarity, the reader should be aware that the present study only deals with the issue of market manipulation.

[14] Emilios Avgouleas, *The Mechanics and Regulation of Market Abuse – A Legal and Economic Approach* (OUP, New York, 2005), 4.

[15] Nahm Moloney, *EC Securities Regulation*, (Oxford, 2008), 931.

[16] This is the classical approach used by the 'Public Interest' theory of economic regulation, see Richard A. Posner, 'Theories of Economic Regulation' (1974) 5 *Bell Journal of Economics* 335.

[17] Avgouleas (n 14) at 96.

[18] To note, this argument is even reinforced when one looks at financial markets as a (global) public good. On the matter, c.f. Inge Kaul *et al.*, 'Defining Global Public Goods.' In: *Global public goods: International Cooperation in the 21st Century* (OUP, New York, 1999).

Deterring market abuse needs, therefore, being a policy priority for regulators.[19] And failures to design an effective and credible deterrence regime can lead to inefficient markets (e.g. with increased cost of capital and reduced allocative efficiency). As inefficient enforcement can expose markets to market abuse such as manipulation, it thus imposes several deadweight costs on society.

[Besides acknowledging the need to integrate the above, in the remaining, I will also discuss which purposes a securities fraud regime should fulfil and what trade-offs need to be considered in light of what has been said in Section II.1. (E.g. what are the risks in terms of: legal uncertainty, under-deterrence and over-deterrence? Which authorities and organisations should be part of the enforcement regime? Which liability rules can best serve the purpose of credible deterrence?)]

II.3 Interim conclusion

As presented by the law & economics scholarship, deterrence theory offers a valuable toolkit to understand the interplay between different liability rules and other enforcement mechanisms applied to corporate and individuals and effective deterrence of torts and crimes under some stylised settings. However rudimentary this methodology is, it can nevertheless offer essential insights into approaching new problems (e.g., how to deal with AI agency). When considering the latter's innovative character and ability to alter the traditional scenario under the lens of L&E, it is possible to measure the gap between the new and old scenario under analysis. As we will see in Section IV, when financial decision-making is delegated to autonomous AI systems (i.e. algorithmic trading agents), the traditional scenario of market manipulation is altered, and new solutions need therefore being explored.

III The EU MAR enforcement regime against market manipulation

Within the EU, the Market Abuse Regulation (MAR) provides for the legal regime against the prohibition of market abuse. Entered into force on 3 July 2016, the MAR establishes a common regulatory framework that targets three different types of market abuse: insider trading, the unlawful disclosure of inside information, and market manipulation.[20] The EU MAR is complemented by the Market Abuse Directive (MAD), a minimum harmonising piece of legislation that establishes minimum rules across the EU Member States concerning the definition of criminal offences and sanctions in the area of concern. The scope of the remaining is twofold. First, to introduce the current EU market abuse legal regimes under MAR/MAD. Second, to assess it in terms of deterrence theory as explored in Section II above.

III.1 The scope of the prohibition of market manipulation

Before looking into the actual scope of MAR, it is worth focusing on the rationale behind this piece of EU legislation. To this end, the Recitals of the EU legal act may serve as guidelines to interpret the scope of the law. Recital (1) recognises that a genuine internal market for financial services is a precondition for supporting economic growth and employment in the EU. Recital (2) further specifies that market integrity constitutes a prerequisite to achieving an integrated and transparent financial market. Moreover, any form of market abuse represents a threat to market integrity. It can undermine public confidence in the fair functioning of financial markets. That is why Recital (7) describes market abuses as unlawful behaviours, as they prevent full and proper transparency of financial markets' information, which is a fundamental condition for all market operators in order to orientate their investment decisions.

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[19] Fran H. Easterbook and Danierl R. Fischel, 'Mandatory Disclosure and the Protection of Investors' (1984) 70 Virginia Law Review 674-677 (arguing that legal rules against forms of market abuse are more efficient than solely relying on market-based alternatives).

[20] This study exclusively focuses on algorithmic forms of market manipulation.

As enshrined by Article 1 of MAR, the primary rationale of fully harmonising EU legislation for market abuse is to ensure the integrity of EU financial markets as well as to enhance investor protection and confidence; two policy objectives considered the two sides of the same coin of EU financial law.[21] In addition, Recital (38) states that, in order to be effective, MAR should also consider all possible developments in technology and thus provide measures able to adapt to new forms of trading and strategies, such as those in the realm of algorithmic trading.

We can now turn to the core issue of our analysis: the prohibition of market manipulation. Albeit not providing for any decisive legal definition of market manipulation, the MAR establishes a list of activities and behaviours that can be deemed as forms of market manipulation. In general terms, Art. 12(1) provides for a non-exhaustive list of five activities that amount to market manipulation in trading on financial markets. For the sake of our assessment, however, only three of them are of interest. First, Article 12(1)(a)(i) refers to any trading activity that can give false or misleading signals as to the interest for or price of a financial instrument. Second, Article 12(1)(a)(ii) prohibits any trading activity that is able to secure, or even likely to do so, the price of a financial instrument at an abnormal or artificial level. Finally, Article 12(1)(d) regulates the prohibition of benchmark manipulations by, for example, providing false or misleading inputs necessary for the calculation of a benchmark.[22]

At first glance, therefore, it may be asserted that the EU legislator has opted for some kind of effect-based approach in defining market manipulation. This could be explained by the intention to facilitate the prosecution and punishment of manipulative conduct.[23] In fact, in the MAR definition of market manipulation, only objective elements of the illegal conduct are expressed: namely, the *false* and *misleading signals* and the *effects on prices*. On the contrary, no subjective component is considered, i.e. the *intention* to manipulate, when determining the manipulative nature of trading behaviours. However, for the purpose of discerning legitimate trading activity from unlawful conduct, it is nevertheless necessary to prove the scienter (or another relevant mental state, such as negligence or recklessness) of manipulators to count specific conduct as a crime.[24]

In addition, the two forms of market manipulation prohibited by Art. 12(1)(a) follows within the category of trade-based manipulation, i.e. those carried out only through market transactions and orders, thus without any other action that does not constitute trading activity. However, the perpetrators can always prove their innocence by providing legitimate reasons for their conduct; for example, by demonstrating that their behaviour falls within the category of "accepted market practices"[25]. As to the prohibition enshrined by Art. 12(1)(d), instead, it is worth noticing that this provision was absent in the previous version of market abuse legislation. In light of the events of the LIBOR scandal, but also considering the increasing role played by benchmarks in today's financial markets as reference values for the pricing of other financial instruments and products, the inclusion of benchmark manipulation in the MAR has only to be welcome.

The general provisions of Article 12(1)(a) are further developed and contextualised by Article 12(2), which provides a (non-exhausting) list of six manipulative behaviours. Among these, Article 12(2)(a) refers to the prohibition of creating and securing a market dominance position in a particular financial instrument with the effect of fixing prices or other unfair conditions. Article 12(2)(b), instead, concerns those trading practices that, just by happening at particular trading times (e.g. 'opening' or 'closing'), are capable of altering market prices with the effect of misleading other investors relying on those reference prices for their investment strategy.

More importantly, Article 12(2)(c) directly targets possible manipulative behaviours made possible by means of technological-advanced trading strategies, namely AT and HFT. Specifically, this provision aims to avoid that investment firms recurring to AT and HFT strategies would circumvent the

[21] See Klaus J. Hopt, 'Grundsatz- und Praxisprobleme nach dem Wertpapierhandelsgesetz' (1995) 159 *ZHR* 153.

[22] However, the reader should also be aware of the existence of an *ad hoc* legislation on benchmarks that introduce governance and technical requirements for benchmark administrators. See Regulation (EU) 2016/1011 of the European Parliament and of the Council of 8 June 2016 ('Benchmark Regulation').

[23] See, e.g., Avgouleas (n 17) at 276.

[24] Lehmann and Kumpman (2019).

[25] See Art. 13 MAR. Importantly, establishing an AMP is a strict competence of national competent authorities (NCAs) within their respective jurisdictions, subject to the European Securities Market Agency (ESMA) opinion that assists NCAs in consistent implementation and application of MAR provisions.

prohibitions enshrined by Art. 12(1)(a) and (b). In particular, possible examples of these include: causing disruption/delay to the normal functioning of trading venues or even just attempting to do so; confusing other market participants regarding genuine trading activity in a given electronic order book; or, finally, creating false/misleading signals on a financial instrument able to initiate or intensify a trend in the market.

Nevertheless, both Article 12(1) and (2) should be read in conjunction with Annex I, which lists a number of indicators that give rise to a presumption of market manipulation when met. Albeit non-exhaustive, Commission Delegated Regulation 2016/522 supplements Annex I, and it provides more detailed indicators to be taken into account when assessing any potential market manipulation.

Nevertheless, it should also be noted that with its decision in the case IMC Securities, the CJEU clarified that there is no duration requirement for manipulative market conduct to be recognised as such. Therefore, market manipulation can happen regardless of the lifetime of the abuse on the market.[26] This latter consideration seems to assume particular relevance when trading happens at the speed of light.

Further integration is needed.

III.2 Market conduct supervision and other enforcement mechanisms

This subsection will discuss existing supervisory arrangements under MAR regarding the division of supervisory competencies in detection and other enforcement tasks and the current sanctions regime under MAR/MAD (i.e. administrative and criminal regimes). The aim is, among others, to expose existing gaps in the EU market conduct supervisory architecture, as well as in the harmonisation of sanction regimes across the EU Member States.

III.3 Other safeguards: the governance of algorithmic trading and electronic trading platforms

This sub-section will discuss other legal provisions (i.e. MiFID II and complementary legislation) that, together with the MAR framework of algorithmic market abuse, form the perimeter of the governance of algorithmic market misbehaviour (i.e. market disruption and market abuse).

The governance of algorithmic trading applies at three levels: (a) investment firms, (b) market operators, and (c) competent authorities (including ESMA). It entails a number of accountability and governance requirements (i.e. for the cases of (a) and (b)) and regulatory and enforcement powers to public authorities. All of this will be discussed here.

III.4 Interim conclusion

This interim conclusion critically assesses the current MAR/MAD framework in light of what discusses in Section II. As an outcome, I will identify the gaps between theory and reality. The hypothesis here is that, after introducing the concept of autonomous AI trading agents in Section IV, these gaps will become even more evident and severe.

IV AI trading and financial crime

This section provides an overview of the most innovative AI trading strategies made possible by constant achievements in the AI subfield of ML and Big Data science alike. It first gives a brief overview of the

[26] Case C-445/09, IMC Securities BV gegen Stichting Autoriteit Financiële Markten [2011] ECR I-5917 (according to the CJEU ruling, even a single abusive transaction can fall within the definition of market manipulation, that is irrespective of the actual crime duration).

main technical specificities and additional uncertainties relating to ML-powered trading strategies by focusing on enhanced and novel risks of market manipulation. In doing so, it offers a non-exhaustive list of optimised AI-style forms of market manipulation that can arguably take place on EU capital markets.

Please note, Section IV will extensively rely on my previous paper (Azzutti et al. 2021). Importantly, the analysis will focus on the easiest case of using AI for trading: i.e. AI applications in proprietary algorithmic trading. While we acknowledge, of course, that AI solutions are also increasingly adopted for agency trading, this second case also raises further questions that are specific to the precise contractual relationships involved in agency trading (i.e. customer – broker/asset manager). In addition, we assume that proprietary trading may involve greater risks of market manipulation than agency trading.

IV.1 AI, ML, and algorithmic trading

This sub-section introduces the use of AI and particularly ML methods applied to financial trading. It highlights the main technical differences between first-generation AI-based algorithmic trading strategies and systems (i.e. so-called "expert systems", a more deterministic generation of AI applications) and most innovative solutions based on ML methods (e.g. deep and reinforcement learning).[27]

This sub-section also clarify and show that any algorithmic trading system (ATS) should be conceived as an ecosystem of algorithms.[28] This aspect is of primary importance as dealing with multiple algorithmic components/agents can further complicate our subsequent analysis on the failure of traditional legal concepts.

In dealing with innovative AI applications to financial trading, this section also pinpoints a number of technological-specific risks (i.e. "black box" problem underpinning the issues of AI "transparency", "explainability", "auditability", "accountability", "trustworthiness", etc.) inherent to certain ML methods (e.g., deep and reinforcement learning).

IV.2 AI trading and market manipulation

This sub-section will describe both old and new market manipulation techniques made possible by AI trading and provides a non-exhaustive list of possible examples.

IV.3 Interim conclusion

After having introduced the new risks by AI trading, this interim conclusion adds to the one being made in Section III.4 by pinpointing the additional uncertainties introduced by AI trading agents for the purpose of effective deterrence and enforcement.

V The questionable efficacy of the EU MAR enforcement regime to deter AI crime

This section builds on what has been discussed above, namely in Section III (i.e. on the EU MAR/MAD enforcement regime) and Section IV (i.e., how AI trading is transforming the mechanics of market manipulation). It provides a critical account regarding the efficacy/effectiveness of the current EU MAR

[27] See Azzutti et al. (2021).
[28] Treleaven et al. (2021).

enforcement regime to deal with circumstances of market manipulation by AI trading and particularly to guarantee effective deterrence.

V.1 Shortcircuits in the safe application of traditional legal concepts of liability

This sub-section discusses possible ways in which algorithmic trading, particularly AI trading, can subvert the established concept of liability (i.e. intent, negligence). It, therefore, expose the weakness of the current EU framework in deterring AI forms of market manipulation.

Please, note that Section V.1 will extensively rely on my previous paper (Azzutti et al. 2021).

V.2 Uncertain legal prohibitions

This sub-section adds a novel idea to my previous study on the same subject (Azzutti et al. 2021). It questions the very definition of market manipulation as enshrined in the EU MAR. This part builds on the current debate within the US legal scholarship[29] and transposes its findings within the EU context.

V.3 Incentives problems within an inadequate supervisory architecture

In light of what has being discussed and argued in Section III and Section IV, this sub-section bridges the respective findings by highlighting the weaknesses of the current supervisory architecture and strategy under MAR. The recent reports by ESMA on both the revision of MiFID II and MAR will be used as a primary source.

This section will focus on what I identify as the "knowledge gap" faced by both regulators and supervisors regarding the functioning of AI trading systems (e.g. lack of transparency in and understanding of AI model, data, and algorithmic decision-making outputs). It shows how the current supervisory architecture fails to cope appropriately with the issue at stake (i.e. ensuring transparency, auditability and accountability in algorithmic trading strategies).

VI Filling the gaps in the EU MAR enforcement regime: the pathways towards credible deterrence and effective enforcement mechanisms

In this last section, the paper discusses possible solutions to the puzzle of effective enforcement under the EU MAR legal regime in dealing with instances of AI financial crime. The three main ideas to explore and addressed in this last section are as follows. (1) Moving from intent-based to harm-based definition and liability legal test of market manipulation. (2) Changing liability rules to incentivise market participants to internalise the costs of AI manipulation and ultimately deter them from manipulating by using algorithms in the first place. This part also includes assessing the desirability of granting personhood to AI agents by considering the option to disentangle criminal and civil aspects of the involved misconduct. (3) Improving current supervisory architecture to ensure "credibility" of punishment; by also (4) exploring the case for market-based solutions such as "market manipulation bounty hunters".

[29] E.g., Flecher (2021).

VI.1 From the intent-based to a harm-based definition and legal test of market manipulation

US scholars are exploring the idea to move towards a harm-centric definition of market manipulation. Given the similarities of EU capital markets in terms of novel market abuse risks introduced by AI, it seems timely and relevant to assess this possibility for the EU case.

This section discusses the merits of a harm-based definition of market manipulation within the EU legal system. It will argue that a harm-based approach could provide more legal certainty and thus effective remedies to restore market functioning and address harm of affected parties while also punishing wrongdoers.

This enhanced threat to manipulators is thought to serve as an incentive for investment firms in taking due care about the development, deployment, and subsequent monitoring of their AI systems.

Please, note that although we focus on cases of AI proprietary trading, we also make another assumption to simplify our analysis. In the remaining, we will consider proprietary AI trading systems as fully developed internally within the single organisation that use AI for financial trading on its own account. Whenever we include the role of third-party providers, then our analysis will be slightly different.

VI.2 AI trading misconduct and liability rules

Following the discussion from Section VI.1, this sub-section will explore optimal liability rules to achieve effective and credible deterrence. This part also includes assessing the desirability of granting personhood to AI agents, by also considering the policy option to disentangle criminal and civil aspects relating to the involved misconduct. The scope is to compare different liability rules (i.e. strict liability, negligence, contributory negligence (with the involvement of exchanges), and recklessness standards) to identify the optimal liability framework leading to credible deterrence (e.g. making malicious actors internalising the costs of their conducts and rendering manipulation economically unattractive).

VI.3 Improving the EU market conduct supervisory architecture

In light of all so far discussed, this sub-section closes the cycle by discussing possible policy proposals to enhance the EU market conduct supervisory architecture given all the shortcomings identified above in Section V, and in light of the normative framework provided by Section II.

With the achievement of the CMU, more centralisation of powers and tasks on ESMA seems inevitable in the Europeanisation of capital markets. However, given the high level of expertise and resources to effectively supervise over AI market manipulation, some delegation of supervisory powers and responsibility to private organisations (i.e. market operators and even investment firms) is necessary, as the current framework already contemplates. The sub-section will therefore pinpoint a number of incremental progress that could be made. Given the fundamental role played by the role of data in the AI age (e.g. for business purposes, but also for supervisory and enforcement actions), I will also explore whether there is a need to regulate and centralise the flow of market data in EU capital markets.

Besides, an effective EU supervisory framework also requires more harmonisation in Member States' criminal laws and enforcement regimes vis-à-vis cases of market abuse.

VI.4 Solving the credible deterrence puzzle through the market: A primer on "market manipulation bounty hunters".

In concluding the round of proposals to achieve credible deterrence, this sub-section introduces and discusses the merits and legal feasibility of introducing a new market actor within the already complex population of financial institutions: namely, "market manipulation bounty hunters".[30]

I will discuss how "market manipulation bounty hunters" can help achieve effective deterrence, especially if combined with the other policy proposals above, by enhancing the "credibility" of punishment according to deterrence theory. However, it is necessary to consider both advantages and disadvantages inherent to delegating enforcement tasks to private organisations such as "bounty hunters". Other economic industries can serve as an illustrative case here.

I will also discuss other related legal issues arising from the occurrence of a new category of market actors within the global financial industry and in light of existing EU legal systems.

[30] This is the first paper to discuss this concept within the EU capital markets context. For a first exploration of the idea from a more global perspective, see Miles Kellerman (2020).

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