Regulating algorithmic trading in the new capital markets:

a critical analysis of the European Union regime

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ABSTRACT

Regulating algorithmic trading in the new capital markets: a critical analysis of the European Union regime

Trading in modern capital markets is currently dominated by algorithms and concerns over the impact of algorithmic trading on market quality have led a number of jurisdictions to regulate this new type of trading. The European Union ('EU') has been no exception to this trend.

This thesis offers a critical analysis of the EU algorithmic trading regime, arguing that it rests on three fundamental misconceptions: that simpler execution algorithms carry less risk than other algorithms; that algorithmic trading has meaningfully added to the risk of market manipulation; and that the benefits and risks of different high-frequency trading ('HFT') strategies can be considered and discussed as if HFT were a monolithic category of trading.

As a result, the EU algorithmic trading regime mistakenly leaves unregulated a type of algorithmic trading that carries significant risk for the quality of its capital markets, creates unnecessary suspicion that certain algorithmic trading behaviour carries an abnormally high risk of market manipulation, and unwarrantedly imposes onerous requirements on all high-frequency traders, regardless of the particulars of their strategies.

In response to these errors, this thesis proposes three main solutions: amending the EU definition of algorithmic trading to include all execution algorithms; eliminating the add-ons introduced by the EU regime to the EU definition of market manipulation; and removing 'HFT' as a regulatory category—which should be accompanied by extending the rules needed to govern the activity of algorithmic traders (and only those rules) to all proprietary investment firms with disintermediated access to EU markets.

Ultimately, the EU algorithmic trading regime should nonetheless be praised for its structure, comprehensiveness, proportionality and ability to effectively address many of the risks created by algorithmic trading and by the strategies inspired by this trading. As such, this thesis proposes small incremental changes to the EU regime, rather than its complete overhaul.

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AFM	Dutch Autoriteit Financiële Markten
Algo	algorithm
AMF	French Autorité des Marchés Financiers
AOR	automated order routing/router
ASIC	Australian Securities and Investments Commission
BCN	broker crossing network
CAGR	compound annual growth rate
CAT	consolidated audit trail
CDR	Commission Delegated Regulation
CEO	chief executive officer
CESR	Committee of European Securities Regulators
CFTC	United States Commodity Futures Trading Commission
CPU	computer processing unit
CRD IV	European Union Capital Requirements Directive
CRR	European Union Capital Requirements Regulation
DEA	direct electronic access
DMA	direct market access
DNB	De Nederlandsche Bank
DOT	designated order turnaround
EBA	European Banking Authority
EC	European Commission
ECB	European Central Bank
EESC	European Economic and Social Committee

EMIR	European Market Infrastructure Regulation
ESMA	European Securities and Markets Authority
EU	European Union
FAQ	frequently asked question
FBA	frequent batch auction
FCA	United Kingdom Financial Conduct Authority
FINRA	United States Financial Industry Regulatory Authority
FinTech	financial technology
HFT	high-frequency trading
HFTrader	high-frequency trader
IBM	International Business Machines Corporation
ID	identification
IEX	Investors Exchange
IOSCO	International Organization of Securities Commissions
IPO	initial public offering
IT	information technology
Knight Capital	Knight Capital Group
LOB	limit order book
LSEG	London Stock Exchange Group
MAD	European Union Market Abuse Directive
MAR	European Union Market Abuse Regulation
MiFID	European Union Markets in Financial Instruments Directive
MiFIR	European Union Markets in Financial Instruments Regulation
MS	European Union Member States
MTF	multilateral trading facility

NMS	national market system
NYSE	New York Stock Exchange
OJ	Official Journal of the European Communities
OTC	over the counter
OTF	organised trading facility
OTR	order-to-trade ratio
RegTech	regulatory technology
Regulation AT	CFTC proposed Regulation Automated Trading
RM	regulated market
SA	sponsored access
SEC	United States Securities and Exchange Commission
SI	systematic internaliser
SOR	smart order routing/router
TFEU	Treaty on the Functioning of the European Union
TWAP	time-weighted average price
UCITS	Undertakings for the Collective Investment in Transferable Securities
UK	United Kingdom
US	United States
UTC	Coordinated Universal Time
VWAP	volume-weighted average price

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1. INTRODUCTION

1.1 The robots of Wall Street

The last three decades[1] have witnessed radical change in capital markets around the world. The picture of loud brokers and screaming phone calls ingrained in the collective imagination is no longer representative of most markets: currently, most trading in shares[2] is conducted by computer algorithms in electronic trading floors. The 'wolves of Wall Street' have been all but replaced by robots.

The European Union ('EU') capital markets,[3] in particular, are now fragmented networks of automated platforms,[4] within which most players rely on electronic infrastructure to support their interactions. And traders, specifically, have widely incorporated automated-trading technology into the mechanisms of their activity, increasingly relying on pre-programmed algos to formulate and implement trading decisions on their behalf—in a practice that has become known as 'algorithmic trading.'[5]

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[1] *See,* i.a., Maureen O'Hara, 'High Frequency Market Microstructure' (2015) 116 Journal of Financial Economics 257.

[2] While automated-trading technology has influenced the trading of most securities, algo-trading is particularly widespread in the context of equity trading (*see* Merritt B Fox, Lawrence R Glosten and Gabriel V Rauterberg, *The New Stock Market: Law, Economics, and Policy* (1st edn, Columbia University Press 2019)).

[3] Ian Domowitz and Benn Steil, 'Automation, Trading Costs, and the Structure of the Securities Trading Industry' (1999) 2 Brookings-Wharton Papers on Financial Services.

[4] John Armour and others, *Principles of Financial Regulation* (Oxford University Press 2016).

[5] Some algorithms are self-learning and can overcome their initial program instructions. These algorithms are increasingly being used in financial markets (*see*, i.a., Den Boer and Arnoud,

The generalised adoption of algo-trading mechanisms has naturally encouraged traders to review their strategies and business models,[6] but not just them: market-facilitating institutions—including trading venues and other intermediaries—have also responded to the widespread popularity of algo-trading by modifying their own (trade-facilitating) behaviour.

The effects of this change are still being worked out—with opinions divided as to how algo-trading and the strategies it inspires have impacted the quality of modern markets[7]—but that has not stopped regulators around the globe from targeting it with various legislative proposals. As a result, many jurisdictions now have special algo-trading regimes: some designed to attract algo-trading,[8] and

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'Dynamic Pricing and Learning: Historical Origins, Current Research, and New Directions' (2015) 20 Surveys in Operations Research and Management Science 1).

[6] *See* Robert A Schwartz, John Aidan Byrne and Antoinette Colaninno, *Technology and Regulation: How Are They Driving Our Markets?* (Springer Science & Business Media 2009). These strategies and business models often rely on non-traditional talents and skills: according to recruiter Options Group, 'the world is becoming more technologically demanding, and a lot of firms now need computer scientists that can code algorithms' (*see* Robin Wigglesworth, 'Hedge Funds Poach Computer Scientists from Silicon Valley' (*Financial Times*, 22 November 2015)).

[7] Much of the discussion has centred on HFT. For a summary of the literature on both sides of the debate, *see,* i.a., Albert J Menkveld, 'The Economics of High-Frequency Trading: Taking Stock' (2016) 8 Annual Review of Financial Economics 1; and Foresight, 'The Future of Computer Trading in Financial Markets: An International Perspective' (Foresight, Government Office for Science 2012) Final Project Report.

[8] *See* Michael Morelli, 'Implementing High Frequency Trading Regulation: A Critical Analysis of Current Reforms' (2017) 6 Michigan Business & Entrepreneurial Law Review. Even in Europe, the Netherlands used to have a regime that highly favoured HFTraders—which, however, was recently deemed incompatible with EU Law by the EBA (*see* EBA, 'EBA Closes Breach of Union Law Investigation against DNB and Will Monitor Transitional Measures Adopted to Redress the Case' (2017)) and duly amended by DNB (*see* DNB, 'Re: Amendment of Supervision Framework for Proprietary Traders' (13 November 2017)).

others to hinder it—or at least the sub-set of algo-trading strategies known as high-frequency trading ('HFT').[9]

Particularly in the EU, some Member States ('MS')—including Germany,[10] Italy[11] and France[12]—have used the last decade to regulate the algo-trading taking place in their markets.[13] Most significantly, the EU itself has enacted its own algo-trading regime, which the European Commission ('EC') has dubbed the 'toughest package' of automated trading-centred measures in the world.[14]

While some have praised the new EU algo-trading regime as 'the world's first and most comprehensive set of rules to tackle the risks of the modern trading paradigm,'[15] others have raised concerns about the considerable regulatory

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[9] *See,* in Europe, the German, Italian and French algo-trading and HFT regimes (described in fns 10-12).

[10] The Hochfrequenzhandelsgesetz ('German HFT Act') entered into force on 15 May 2013 and was amended on 3 January 2018 following the transposition of MiFID II.

[11] In Italy, paragraphs 491-500 of article 1 of Legge del 24 dicembre 2012 no. 228 introduced a tax on financial transactions that applies to HFT. Currently, algo-trading is further regulated under article 67-ter of Decreto Legislativo del 24 febbraio 1998, no. 58.

[12] In France, the first attempt to regulate algo-trading came with the enactment of its new Loi no. 2013-672 du 26 juillet 2013 de séparation et de régulation des activités bancaires, which added a special section to the Code Monétaire et Financier. Currently, algo-trading is regulated under article L533-10 of the Code.

[13] In many ways, these regimes anticipated the EU algo-trading regime. In particular, the original version of the German HFT Act imposed the same type of organisational and conduct requirements on algo-traders (*see* articles 3 and 5 of the German HFT Act) and venues (*see* articles 1 and 3 of the German HFT Act) that are currently found in the EU regime.

[14] *See* EC, cited by Martin Wheatley (*in* Martin Wheatley, 'Regulating High Frequency Trading' (*FCA*, 4 June 2014) <https://www.fca.org.uk/news/speeches/regulating-high-frequency-trading> accessed 31 July 2020).

[15] Tilen Čuk and Arnaud Van Waeyenberge, 'European Legal Framework for Algorithmic and High Frequency Trading (Mifid 2 and MAR): A Global Approach to Managing the Risks of the Modern Trading Paradigm' (2018) 9 European Journal of Risk Regulation 146, 152.

burden that this regime places on market players[16]—with potentially negative consequences[17] for the overall quality of EU capital markets.[18]

This thesis offers the first thorough critique of the EU algo-trading regime—determining how algo-trading has impacted the EU capital markets, establishing the conditions necessary for an effective algo-trading regime, and evaluating whether the EU regime meets those conditions.[19]

Notably, this thesis argues that the effectiveness of the EU regime is hurt by three fundamental misconceptions about algo-trading: that simpler execution algorithms carry less risk than other trading algorithms; that algo-trading has

[16] For instance, CFTC commissioner Brian Quintenz recently noted that the EU regime refers to concepts which have been 'specifically rejected' by the CFTC and that no 'comparable regulatory requirements' should be approved by the CFTC in regard to algo-trading until it 'has more appropriately considered what would be the best policy' for US markets (*see* CFTC, 'Remarks of Commissioner Brian Quintenz at the Institute of International Bankers Membership Luncheon' (21 June 2018)). Recent Foresight reports on algo-trading have also noted that compliance with certain provisions of the EU regime might represent a substantial financial burden for certain algo-traders (*see* Foresight, 'The Future of Computer Trading in Financial Markets: An International Perspective' (n 7); and Foresight, 'Regulatory Scrutiny of Algorithmic Trading Systems: An Assessment of the Feasibility and Potential Economic Impact' (Foresight, Government Office for Science 2011) Economic Impact Assessment EIA16).

[17] Philip Stafford, 'Tighter HFT Capital Rules Will Only Harm Eurozone Market Trading' (*Financial Times*, 19 June 2018).

[18] The full impact of the EU regime may remain difficult to measure for years to come, but the EC has recently launched a consultation with the purpose of reviewing the MiFID/MiFIR framework (*see* EC, 'Public Consultation on the Review of the MiFID II/MiFIR Regulatory Framework' (2020) <https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/2020-mifid-2-mifir-review-consultation-document_en.pdf> accessed 31 July 2020), to which ESMA will contribute with advice on algo-trading (*see* ESMA, '2020 Annual Work Programme' (2019) ESMA20-95–1132)—and which is hoped to shed some light on the matter.

[19] As noted in chapter 2, the effectiveness of any algo-trading regime should be assessed by its ability to improve the functioning of the financial markets, in particular by increasing their efficiency and fairness. For a discussion of the goals of financial regulation, *see*, i.a., Armour and others (n 4).

meaningfully added to the risk of market manipulation; and that HFT raises concerns as a monolithic whole.

As a result, the EU algo-trading regime mistakenly leaves unregulated a type of algo-trading that carries significant risk for the quality of its markets, unwarrantedly targets beneficial algo-trading behaviour for heightened scrutiny when it comes to the enforcement of its prohibition on market manipulation, and problematically introduces ‘HFT’ as a regulatory category—through which it subjects all traders engaging in HFT (‘HFTraders’) to the same (harsher) rules, regardless of the variety of strategies they may employ.

In the end, this thesis argues that the EU regime should nonetheless be praised for its comprehensiveness and ability to mitigate the risks inherent in the use of algo-trading mechanisms—as well as the risks arising from the strategies developed by trading venues and other intermediaries in response to the popularisation of algo-trading—without unduly sacrificing their benefits.

Still, three simple changes could significantly improve the effectiveness of the EU regime: amending the EU definition of algo-trading to include all execution algorithms; eliminating the add-ons introduced by that regime to the EU definition of market manipulation; and doing away with the regulatory category of ‘HFT’ and the rules in the EU regime that apply specifically to HFTraders—which should be accompanied by an extension of the rules needed to govern the activity of algo-traders (and only those rules) to all proprietary investment firms with disintermediated access to EU markets.

1.2 Thesis structure and scope

1.2.1 Structure

This thesis evaluates the effectiveness of the EU algo-trading regime by determining whether it reveals an accurate understanding of the impact of automated-trading technology on EU capital markets—and whether the rules that comprise it are an adequate response to that impact.

This evaluation is guided by the notion that financial regulation should be a cost-effective response to market failure—and this notion is fully reflected in the structure of this thesis, as divided into two parts: the first identifying what it is about algo-trading that may warrant regulation, assessing both the benefits and risks inherent in algo-trading and related strategies (*chapters 1-3*); and the second determining whether the EU algo-trading regime identified and responded appropriately to that change (*chapters 4-9*).

Specifically, the first part of this thesis opens with an explanation of its arguments, structure and scope (*chapter 1*); *chapter 2* then introduces algo-trading and measures its importance within the EU. This serves as the starting point for determining the channels through which automated-trading technology has affected EU markets—which involves both considering how this technology has changed (and not changed) these markets.

The task of examining the change brought by automated-trading technology to EU capital markets is continued in *chapter 3*, which analyses both its direct and indirect effects: first, its direct impact on the mechanisms employed by the traders in EU markets; and, second, its broader indirect impact on the strategies employed more widely by all players in these markets.

At this point, this thesis starts its analysis of the EU algo-trading regime, with *chapter 4* examining its basic building blocks—concerns, purposes, scope and structure—for clues as to whether the EU properly understood the impact of automated-trading technology on its capital markets. In the end, the EU is commended for including in its regime both rules that apply every time traders employ algo-trading mechanisms, regardless of strategy, and rules that apply specifically to particular strategies associated with algo-trading.

The first category of rules is then examined in *chapters 5-6*, which address the provisions applicable to algo-traders under MiFID[20]/MiFIR[21] and MAD[22]/MAR.[23] The second is analysed in *chapters 7-9*, which look at the provisions applicable to the algorithmic trading-inspired strategies more widely adopted across EU markets—not just by traders, but also by trading venues and other market intermediaries. *Chapter 10* concludes.

[20] EU Markets in Financial Instruments Directive (‘MiFID’).

[21] EU Markets in Financial Instruments Regulation (‘MiFIR’).

[22] EU Market Abuse Directive (‘MAD’).

[23] EU Market Abuse Regulation (‘MAR’).

1.2.2 Scope

The scope of this thesis is fundamentally determined—if not entirely limited—by reference to the EU algo-trading regime, which is here understood as the set of rules approved by the EU with the specific purpose of regulating algo-trading and the strategies inspired by algo-trading (the 'EU algo-trading regime'/'EU regime').[24]

The reason why the scope of this thesis is fundamentally determined by the EU regime is intuitive. The main goal of this work is to evaluate the rules that comprise that regime, and *chapters 4-9* are entirely devoted to analysing each of those rules. As a result—given the extent of the regime and its relative newness—this thesis is essentially focused on 'the law on the books,' steering clear of discussions about enforcement and liability. At the same time, this thesis also avoids in-depth analysis of radical alternatives to the EU algo-trading regime—either coming from other jurisdictions, or proposed by academics.

Still, the scope of the EU regime does not entirely limit the scope of this thesis: its first half is spent determining what algo-trading is and how automated-trading technology has changed EU markets (*chapters 2-3*)—namely, the EU secondary equity markets, where algo-trading is particularly prevalent.[25] As such,

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[24] The EU regime is headlined by the latest version of MiFID—which has been essentially in force since 3 January 2018—but it also includes provisions scattered across MiFIR, MAR, and a number of level 2 instruments.

[25] Indeed, algo-trading is currently more popular in equity markets than in non-equity markets (*see* fn 2). Therefore, most data on algo-trading comes from equity markets—and the conclusions of most empirical work on algo-trading may be limited to these markets. As such, when this thesis discusses the impact of algo-trading on market quality it does so by reference to the EU secondary

these first chapters refer to all algo-trading, and not just the type of algo-trading effectively captured by the EU regime—allowing this thesis to determine whether the EU has truly understood the nature of this type of trading, and whether its algo-trading regime successfully regulates all the risks that arise from algo-trading and the strategies inspired by this type of trading.

1.3 Thesis contribution

The popularisation of algo-trading and the influence of automated-trading technology on equity markets around the globe have been amply documented by finance literature.[26] Most work on the topic offers theoretical and empirical analysis of particular algo-trading strategies and studies their impact on different

equity markets—and any references to 'EU capital markets' or to 'EU markets' should be read as references to the 'EU secondary equity markets.'

[26] Classic micro-structure models relevant for analysing algo-trading include those developed by Kyle (*see* Albert S Kyle, 'Continuous Auctions and Insider Trading' (1985) 53 Econometrica 1315) and Glosten and Milgrom (*see* Lawrence R Glosten and Paul R Milgrom, 'Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders' (1985) 14 Journal of Financial Economics 71). O'Hara offers a helpful overview of the market microstructure literature (*see* Maureen O'Hara, *Market Microstructure Theory* (1st edn, Wiley 1998)). More recently, Focault, Pagano and Röell (*see* Thierry Foucault, Marco Pagano and Ailsa Röell, *Market Liquidity: Theory, Evidence, and Policy* (1st edn, Oxford University Press 2013)), on the one hand, and Hasbrouck (*see* Joel Hasbrouck, *Empirical Market Microstructure - The Institutions, Economics, and Econometrics of Securities Trading* (1st edn, Oxford University Press 2007)), on the other hand, have produced comprehensive accounts of the theory and empirics of (modern) market micro-structure (respectively). Finally, Cartea offers an overview of how classic and modern micro-structure notions apply in an algo-trading environment (*see* Álvaro Cartea, Sebastian Jaimungal and José Penalva, *Algorithmic and High-Frequency Trading* (3rd printing 2017 edition, Cambridge University Press 2015)). For a less technical—but nonetheless comprehensive—account of the new automated markets, *see* Walter Mattli, *Darkness by Design* (Princeton University Press 2019).

aspects of market quality—chiefly, liquidity and price-accuracy—assuming particular market structure configurations.[27]

The regulation of algo-trading has received less attention in the literature. Important work by Fox, Glosten and Rauterberg[28] offers a framework of analysis centred around the concept of 'information asymmetry' that provides notable insights on how the new automated markets should be regulated. Kirilenko and Lo provide a broad blueprint for regulators looking to modernise their approach to algo-trading.[29] Other authors, still, engage in more specific debates about how algo-trading—or particular algo-trading strategies—should be regulated.[30]

There has also been some discussion of how the EU has approached the regulation of algo-trading,[31] but this thesis is the first in-depth analysis of the EU algo-trading regime—making a number of contributions to the literature.

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[27] The sub-type of algo-trading most frequently targeted by the literature is HFT, with most studies addressing only specific HFT strategies (*see,* i.a., Eric Budish, Peter Cramton and John Shim, 'The High-Frequency Trading Arms Race: Frequent Batch Auctions as a Market Design Response' (2015) 130 The Quarterly Journal of Economics 1547; Albert J Menkveld, 'High Frequency Trading and the New-Market Makers' (2013) 16 Journal of Financial Markets 712; and Vincent van Kervel and Albert J Menkveld, 'High-Frequency Trading around Large Institutional Orders' (2019) 74 The Journal of Finance).

[28] Fox, Glosten and Rauterberg (n 2).

[29] Andrei A Kirilenko and Andrew W Lo, 'Moore's Law vs. Murphy's Law: Algorithmic Trading and Its Discontents' (2013) 27 The Journal of Economic Perspectives 51.

[30] *See,* i.a., Yesha Yadav, 'How Algorithmic Trading Undermines Efficiency in Capital Markets' (2015) 68 Vanderbilt Law Review.

[31] *See,* i.a., Danny Busch, 'MiFID II: Regulating High Frequency Trading, Other Forms of Algorithmic Trading and Direct Electronic Market Access' (2016) 10 Law and Financial Markets Review 72; Pierre-Henri Conac, 'Algorithmic Trading and High-Frequency Trading (HFT)', *Regulation of the EU Financial Markets: MiFID II and MiFIR* (Danny Busch and Guido Ferrarini, Oxford University Press 2017); Čuk and Waeyenberge (n 15); Johannes Karremans and Magnus G Schoeller, 'MiFID II between European Rule-Making and National Market Surveillance: The Case of High-Frequency Trading', *Governing Finance in Europe: A Centralisation of Rulemaking?* (Heritier and Schoeller, Edward Elgar Publishing Ltd 2020); and Megan Woodward, 'The Need

First, it proposes a new method for identifying algo-trading and understanding its nature as a product of automated-technology, as well as a new framework for analysing the broader change brought by this technology to financial markets—both in terms of its direct impact on the mechanisms employed by traders, and indirect impact on the strategies more widely adopted by market players—and for considering the various benefits and risks that attach to these different mechanisms and strategies.

A central insight of this thesis is then that an effective algo-trading regime should not only regulate the use of algo-trading mechanisms, but also the strategies inspired by its popularisation across the new financial markets—and apply different sets of rules to different such mechanisms and strategies.

Second, this thesis uses these insights to determine the extent to which the EU misunderstood the change brought by automated-trading technology to its markets—and to assess whether these misunderstandings have had a negative impact on the effectiveness of its algo-trading regime. This is done by uniquely reorganising that regime into different sets of rules, and using those divisions to undertake a functional assessment of those rules—culminating in a number of original and feasible suggestions for improving the EU regime.

Finally, this thesis offers frameworks that can be employed beyond the EU regime, both to evaluate the effectiveness of different algo-trading rules across

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for Speed: Regulatory Approaches to High Frequency Trading in the United States and the European Union Notes' (2017) 50 Vanderbilt Journal of Transnational Law 1359.

other jurisdictions, and to inform discussions of more radical alternatives for the regulation of this type of trading—even if the analysis of these rules and alternatives is beyond its scope.

2. RISE OF THE MACHINES

2.1 Introduction

This thesis sets out to discuss how the availability of automated-trading technology and the popularisation of algo-trading have impacted the quality of EU capital markets,[32] and to evaluate the 'tough'[33] regulatory package approved by the EU in response to that impact.[34]

A key step in the evaluation of that response is determining whether it has been motivated by a proper understanding of algo-trading. As such—and even before engaging with the EU algo-trading regime—this thesis examines what algo-trading is, as well as the channels through which automated-trading technology has changed the EU capital markets.

This chapter thus starts by introducing algo-trading from both qualitative and quantitative perspectives: first, proposing a definition of 'algo-trading' (*2.2*), and, second, illustrating how widespread this trading has become within EU capital markets (*2.3*). Afterwards, this chapter considers how automated-trading technology has changed these markets—discussing both what is the same (*2.4*) and what is different (*2.5*) about the new EU markets.

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[32] *See* chapters 2-3.

[33] *See* EC, cited by Martin Wheatley (*in* Wheatley (n 14)).

[34] *See* chapters 4-9.

Ultimately (*2.6*), it is argued that algo-trading should be defined as the type of trading whereby a machine formulates and implements trading decisions by following pre-coded rules.[35] It is also suggested that most trading in EU markets is now conducted through algorithms—a trend which is at least indicative of how much these markets have changed over the last decades.

And, indeed, much is different about these new markets—including not just the mechanisms and strategies employed by traders, but also the strategies adopted more widely by venues and other intermediaries in response to algo-trading.

2.2 'Hi, tech'

Expressions like 'algo-trading' and 'machine-trading' have become part of our shared vocabulary, but their precise meaning is not evident. Attempts to define algo-trading are rare in the literature[36]—and while the EU has put forward a

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[35] As noted in chapter 4, this definition does not coincide with the EU regulatory definition of 'algo-trading,' resulting in the EU regime targeting only a sub-set of algo-trading. Still, because this thesis discusses how the algo-trading taking place in EU markets should be regulated—all algo-trading and not just the algo-trading captured by the EU regime—the analysis of the changes brought by automated-trading technology and algo-trading to these markets is based on the definition of algo-trading proposed in this chapter.

[36] The first research efforts dedicated to machine-led 'algo-trading' date from the late 1990s and the first papers to discuss its impact on market quality were not published until the late 2000s (*see,* i.a., Terrence Hendershott, Charles M Jones and Albert J Menkveld, 'Does Algorithmic Trading Improve Liquidity?' (2011) 66 The Journal of Finance 1). The automation of trading systems and venues caught the attention of academia somewhat earlier, in the mid-1990s (*see,* i.a., Allan D Grody, Hughes Levecq and Bruce W Weber, 'Global Electronic Markets: A Preliminary Report of Findings' (Stern School of Business, New York University 1994)), when it also entered the radar of US regulators (*see* SEC, 'Market 2000: An Examination of Current Equity Market Developments' (1994)).

definition of algo-trading,[37] most regulators have been less eager to assign it a definitive meaning.

Still, defining algo-trading is essential to understanding it—and is, in fact, the first step towards assessing how much EU markets have changed following the availability of automated-trading technology, and ultimately determining whether the EU regime reflects an appropriate understanding of the phenomenon it tried to regulate. The next sections then define algo-trading (*2.2.1*), discuss its inner-workings (*2.2.2*) and speculate how it might develop in the future (*2.2.3*).

2.2.1 Defining algo-trading

Algo-trading is a type of financial markets trading[38] that can be identified in just two steps: by looking, first, at who formulates and implements a particular trading decision and, second, at how that decision is formulated and implemented.

According to these two parameters, algo-trading is the subset of financial markets trading carried out by machines—instead of by humans—formulating and implementing trading decisions within the limits of pre-coded rules—instead of by following human intuition[39] (Table 2-1):

[37] MiFID II, article 4(1)(39).

[38] *See*, i.a., Kevin O'Connell, 'Has Regulation Affected the High Frequency Trading Market?' (2019) 27 Catholic University Journal of Law and Technology 145; and Mohith Nirmal Kumar and others, 'Market Analysis: A Bigdata Solution' (2019) 14 International Journal of Applied Engineering Research 3820.

[39] The reason might be that this trading has already been thoroughly defined by the industry, with its meaning often considered as 'self-evident' (*see,* i.a., CFTC, 'Regulation Automated Trading - Notice of Proposed Rulemaking' (2015) 6351-01-P). For examples of algo-trading definitions, *see*, *i.a.,* Charles M Jones, 'What Do We Know About High-Frequency Trading?' (2013) Columbia Business School Research Paper 13–11; Sriram Kannan, 'Algorithmic Trading and Its

Process / Author	Discretionary	Rule-based
Human	Manual discretionary trading	Manual algorithmic trading
Computer	Computerised discretionary trading[40]	Computerised algorithmic trading

Table 2-1—Defining algo-trading

The notion that this type of trading mechanically follows pre-coded rules derives from the very concept of algorithm, which is intuitively essential to defining algo-trading. An algorithm can be described[41] as a set of rules that determines the outcome of a calculation[42] or another problem-solving operation[43]—transforming a given set of inputs into a different set of outputs.[44]

Implications on Capital Markets' (2014) <https://papers.ssrn.com/abstract=2884777> accessed 31 July 2020; and Ian Domowitz and Henry Yegerman, 'The Cost of Algorithmic Trading: A First Look at Comparative Performance' (2006) 1 The Journal of Trading 33.

[40] This category is more theoretical than practical: arguably, a machine or computer is always programmed to follow particular rules, even if those rules are complex or might change as the machine becomes more experienced, learns and evolves. As such, a computer trading program may never be entirely discretionary, no matter how closely it is able to emulate discretionary human thinking.

[41] For a discussion, *see* Yuri Gurevich, 'What Is an Algorithm?', *SOFSEM 2012: Theory and Practice of Computer Science* (Springer, Berlin, Heidelberg 2012).

[42] EC, 'Glossary of Useful Terms Linked to Markets in Financial Instruments' (2016).

[43] Lauren Henry Scholz, 'Algorithmic Contracts' (2017) 20 Stanford Law Technology Review.

[44] Tarleton Gillespie, 'The Relevance of Algorithms', *Media Technologies - Essays on Communication, Materiality, and Society* (Cambridge, MA: MIT Press 2012); Rob Kitchin, 'Thinking Critically About and Researching Algorithms' (2014) 20 Information Communication and Society 14; and Shintaro Miyazaki, 'Algorithmics: Understanding Micro-Temporality in Computational Cultures' (2012) 2 Computational Culture.

Naturally, not all algorithms are computer-based,[45] even if it is less clear whether they need to at least be 'Turing-computable.'[46] In fact, one of the most famous algorithms in history was developed in around 300 BC by Euclid.[47]

Ultimately, a strict interpretation of the expression 'algo-trading' would then include all trading that follows pre-coded rules, whether through the actions of humans or machines. However, technological development has allowed most algos to be turned into computer code[48]—and the phrase 'algorithmic trading' has come to refer only to computerised/automated algo-trading.

In this most common sense, algo-trading should also be understood as the one direct use-case of automated-trading technology in the context of financial markets[49]—where this technology is incorporated into the mechanisms used by traders to exchange securities in those markets—and it is this

[45] Gillespie (n 44).

[46] *See* Gurevich (n 41). A 'Turing machine', first theorised by Alan Turing (*see* Alan Turing, 'On Computable Numbers, with an Application to the Entscheidungsproblem' (1936) s2-42 Proceedings of the London Mathematical Society 230), is an abstract machine capable of solving problems through a formal binary system (*see* Robert Gehl, 'The Computerized Socialbot Turing Test: New Technologies of Noopower' (2013) 14 International Communication Association).

[47] Euclid, *The Thirteen Books of the Elements, Vol. 2* (2nd edition, Dover Publications 2012).

[48] *See* Donald E Knuth, *The Art of Computer Programming*, vols 1-Fundamental Algorithms (3rd edition, Addison-Wesley 1968); Wendy Hui Kyong Chun, *Programmed Visions. Software and Memory.* (Ed Matthew Fuller, The MIT Press 2011); and Andrew Goffey, *Algorithm*, vol Software Studies-A Lexicon (Ed Matthew Fuller, MIT Press 2008).

[49] Automated-trading technology is as a sub-type of algorithmic technology—with the latter being comprised of all technology rooted in the use of algorithms. Automated-trading technology, in particular, refers only to the technology specifically rooted in the use of trading algorithms, ie, algorithms programmed to automate the trading process; algo-trading is then a use-case of automated-trading technology, whereby this technology is incorporated into the mechanisms used by traders to exchange instruments in financial markets. For a discussion of other use-cases of algorithmic technology in these markets, *see* Expert Group on Regulatory Obstacles to Financial Innovation (ROFIEG), '30 Recommendations on Regulation, Innovation and Finance' (EC 2019)).

computerised/automated algo-trading that is targeted by algo-trading regimes around the world, including the EU regime. Therefore, it is with this narrower meaning of 'algo-trading' in mind that this thesis proceeds.

2.2.2 The inner-workings of algo-trading

Reflecting on how algo-trading works can also help in understanding it. In practice, algo-trading typically involves a machine gathering, processing and feeding market data to its algorithms—which then guide it in automatically formulating and implementing trading decisions in response to that data.[50]

The automated formulation of trading decisions involves the machine determining what/whether to buy/sell (through 'investment decision algorithms'), and/or determining how to optimise the execution of previously-formulated investment decisions (through 'execution algorithms')[51]—ultimately resulting in the automatic determination of individual order parameters[52] (including quality, quantity, direction, price, timing and place of execution). The automated

[50] Tara Bhupathi, 'Technology's Latest Market Manipulator - High Frequency Trading: The Strategies, Tools, Risks, and Responses' (2009) 11 North Carolina Journal of Law & Technology 377.

[51] The distinction between 'investment decision algorithms' and 'execution algorithms' in this chapter echoes—but does not match exactly—the distinction between 'investment decision algorithms' and 'execution algorithms' made by the EU regime. For a discussion, *see* FCA, 'Algorithmic Trading Compliance in Wholesale Markets' (2018) 005614; and chapter 4.

[52] Nathan D Brown, 'The Rise of High Frequency Trading: The Role Algorithms, and the Lack of Regulations, Play in Today's Stock Market' (2011) 11 Appalachian Journal of Law 209.

implementation[53] of trading decisions may then see the machine placing orders, or modifying/cancelling pre-existing orders.[54]

Crucially—regardless of whether a machine follows investment decision algorithms, execution algorithms, or both—classifying an instance of trading as 'algorithmic' always depends on the machine decision-maker actually implementing the decision it previously formulated. In other words, trading is only algorithmic if (investment and/or execution) decisions are both formulated and implemented by machines.

Consequently, if a trader uses an algorithm to determine what to trade, but then implements the resulting decision manually (imputing by hand the parameters of the order into a computer), they are not engaging in algo-trading. And the same happens when a trader uses algorithms to determine how to optimise the execution of an investment decision—in particular by deciding on the timing and destination of that decision—but then implements it manually.[55]

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[53] The implementation of a trading strategy should be distinguished from its formulation—even if such strategy revolves around execution optimisation. In other words, execution strategy and actual execution are two different things, and all algo-trading involves the automation of both decision-making and decision-implementation.

[54] *See* Jonathan Brogaard, 'High Frequency Trading and Its Impact on Market Quality' <http://www.fsa.gov.uk/static/FsaWeb/Shared/Documents/pubs/consumer-research/jonathan-brogaard-hft.pdf> accessed 31 July 2020; Terrence Hendershott and Ryan Riordan, 'Algorithmic Trading and Information' (2009) 09–08 <http://people.stern.nyu.edu/bakos/wise/2009/papers/wise2009-3b2_paper.pdf> accessed 31 July 2020; and Andrew J Keller, 'Robocops: Regulating High Frequency Trading after the Flash Crash of 2010' (2012) 73 Ohio State Law Journal 1457.

[55] The distinction between 'execution optimisation' and 'implementation' is not widely made in the literature. This might be due to most accounts of algo-trading conflating the notions of 'investment decision,' 'execution decision' and 'implementation'—failing to distinguish between different types of algorithms—and thus refraining from discussing the meaning of 'execution algorithms' in the first place. Often, in fact, algo-trading is almost entirely equated with execution-optimisation (*see* O'Hara (n 1)). The few existing discussions on execution algorithms often assume that their use necessarily involves also the 'automated submission of orders and quotes' (*see,* for example,

This is true even when a decision involves a combination of different types of algorithms—whereby algorithms are used both to decide what to trade and how to trade: as long as the resulting decisions are implemented manually, the trading is manual.

For example, a trader may use an algorithm that determines that they should buy 600 IBM shares and another algorithm that establishes that they should buy those shares by placing market buy orders of 50 shares each every 10 minutes over the course of the next 2 hours, with Euronext; if that trader then manually places an order to buy 50 IBM shares every 10 minutes for the next 2 hours, with Euronext, that trader is not engaging in algo-trading—even though the 'what?' and the 'how?' of their decision have been fully decided by algorithms.[56] In short, (manual) trading with the help of algorithms is different from (automated) algo-trading.

Finally, automatically implementing trading decisions that have been formulated without resorting to algorithms—for example by scheduling a manually-formulated decision for a particular date and time (at which point the corresponding order is automatically placed/modified/cancelled)—is also manual

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CDR 2017/589, recital (5)). Some, however, decompose classic execution-optimising strategies like VWAP into two components: determining optimum trading strategy and implementing that trading strategy (*see*, i.a., James McCulloch and Vladimir Kazakov, 'Optimal VWAP Trading Strategy and Relative Volume' (Quantitative Finance Research Centre, University of Technology, Sydney 2007) Research Paper Series 201 <https://econpapers.repec.org/paper/utsrpaper/201.htm> accessed 31 July 2020)—which comes closer to the idea that strategizing about execution optimisation and implementing those strategies can (and should) be distinguished.

[56] This is an example of the category 'manual algo-trading' in table 2-1—ie, of trading with the help of algorithms (as opposed to engaging in algo-trading)—where the machines are responsible for everything but the actual implementation of the trading decisions.

trading. While such a decision was implemented by machines, it was determined by human ingenuity.

2.2.3 The future of algo-trading

Algo-trading has been defined as the type of trading whereby a machine follows pre-coded rules—but this does not mean that all algorithms follow fixed rules. Crucially, trading algorithms have been evolving from straightforward rule-following tools into complex learning-instruments that use examples and trial-and-error to modify the rules originally conceived by their developers.[57]

A more realistic depiction of algo-trading identifies three trends that might shape the future of this type of trading (Table 2-2):

Process / Author	Discretionary	Rule-based
Human	Manual discretionary trading	~~Manual algorithmic trading~~
Computer	(Hybrid) computerised trading / The new algorithmic trading	

Table 2-2 – Trends in trading

First, manual algo-trading may be set to become a marginal phenomenon in the absence of strong reasons why unambiguous rule-following should be undertaken by humans instead of machines.[58] Second, manual discretionary-

[57] Ai Deng, 'An Antitrust Lawyer's Guide to Machine Learning' (2018) 32 Antitrust 82.

[58] Indeed, there are not many reasons why a human decision-maker would be better at applying pre-determined rules than a computer. However, this does not mean that humans have no place in trading (beyond programming trading algorithms): humans might still be better than machines at reading 'soft' data and making predictions about human (and potentially irrational) behaviour.

trading might itself become progressively computerised, as machine-learning algos become better at (if never fully capable of) emulating human thinking.

Finally, the dividing border between the (artificial) category of computerised discretionary-trading[59] and computerised algo-trading might become progressively blurred as purely quantitative funds start responding to the competition from machine-learning traders.[60] The algo-trading of the future might then combine the 'hard' rules preferred by traditional quantitative funds with the 'soft' rules at the heart of machine-learning.

2.3 'Hello, world'[61]

This thesis started with the assertion that financial markets—and EU markets in particular—have witnessed radical change following the availability of automated-trading technology. Crucially, the significance of that change is

As such—and as long as machine-learning applications remain unable to perfectly emulate human thinking—there might always be a place for human discretionary trading.

[59] *See* fn 40.

[60] The use of AI and machine-learning in the financial services industry is still taking its first steps: while some investors are 'pure AI hedge funds,' others would rather not outsource certain management aspects to machines (*see* Eurekahedge, 'Artificial Intelligence: The New Frontier for Hedge Funds' (2017) Eurekahedge Report 1). Still, it appears that increasing numbers of professional investors find machine-learning to be 'central to their investing process' (*see* Lindsay Fortado and Robin Wigglesworth, 'Machine Learning Set to Shake up Equity Hedge Funds' *Financial Times* (25 May 2017)).

[61] 'Hello world' is the name of the program most often used when first programming on a new device, resulting in the device displaying 'Hello world' back to the programmer (*see* James A Langbridge, *Professional Embedded ARM Development* (Wrox 2014)).

illustrated not just by the fact that algo-trading is qualitatively different from non-algorithmic trading, but also by its quantitative significance.

Indeed, the sheer popularity of algo-trading—the fact that most trading in EU capital markets is now algorithmic—is key to showing just how much these markets have changed over the last three decades. As such, the next sections examine the factors behind the advent of algo-trading (*2.3.1*) and determine just how popular it has become (*2.3.2*).

2.3.1 The advent of algo-trading

The potential of automated-trading technology for inducing change within EU markets is most clearly revealed by the sheer popularity of algo-trading. Regardless of how this technology has actually affected these markets,[62] the fact that most of their traders now employ trading-algos, that most of their venues now host algo-trading, and that most of their intermediaries now facilitate algo-trading—are all at least indicative of its potential for transformation.

Before illustrating the current popularity of algo-trading, it is worth considering the main factors behind its introduction and evolution—and which include not just the advent of algorithmic-technology as a pre-condition for this type of trading, but also the construction of fast communication and information channels, and the improvement of data-retrieving and -processing systems.

[62] *See* chapter 3.

Intuitively, the development of code capable of translating algos into 'machine' language executable by computer processing units ('CPUs')—or, in other words, the development of algorithmic-technology—was necessary for the development of computerised algo-trading. While algorithms have been around for centuries,[63] their computerisation is fairly recent: the first high-level computer programming language was developed in the early 1940s[64] and the first programmable digital electronic computer dates only from 1946.[65]

The development of algo-trading was also dependent on the creation of channels for algo-generated orders to reach the markets—a process which started in the 1970s, with venues like the New York Stock Exchange ('NYSE')[66] developing the infrastructure necessary to host electronically-transmitted orders and, eventually, algo-trading.

As faster market channels started being built, more traders felt encouraged to automate their trading mechanisms. Now, market players communicate faster

[63] *See* section 2.2.1.

[64] Friedrich L Bauer and Hans Wössner, 'The "PlankalkuL" of Konrad Zuse: A Forerunner of Today's Programming Languages' (1972) 15 Communications of the ACM 678.

[65] Mechanical computing devices have been around since the 13th century, but the first electronic automatic computer, the ENIAC, was not developed until the 20th century (*see* William Nordhaus, 'The Progress of Computing' (2001) Cowles Foundation for Research in Economics, Yale University 1324).

[66] Christopher Keith and Allan Grody, 'Electronic Automation at the New York Stock Exchange', *Managing Innovation - Cases from the Services Industries* (Bruce R Guile and James Brian Quinn (eds), National Academy Press 1988).

than ever[67]—along high-speed dedicated fiber-optic cables[68] laid out strategically to minimise latency,[69] or by air,[70] through microwave towers.[71]

These improvements have been further encouraged by a variety of services offered by venues and other intermediaries: direct electronic access ('DEA') services allow traders to connect directly to venues of which they are not members; and co-location services allow traders to situate their servers in relative proximity of venue matchmaking engines, saving time in order transmission.[72] Together, these services help modern traders secure microsecond speeds.[73]

But the story of how algo-trading came to dominate most markets is not just a story of how automated trading decisions have become, or how fast they are now communicated: advancements in information technology ('IT') have also come to influence the content of these decisions, allowing traders to access and

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[67] Budish, Cramton and Shim (n 27).

[68] Fox, Glosten and Rauterberg (n 2).

[69] In 2010, the company Spread Networks famously built tunnels for the construction of a new fiber optic cable connecting the New York and Chicago markets in a nearly straight line, with an estimated cost of $300 million. The new cable allowed the round-trip communication time between these markets to decrease from 16 to 13 milliseconds (*see* Budish, Cramton and Shim (n 27)).

[70] Because light travels faster by air than through fiber-optic glass, micro-wave technology has significantly reduced round-trip transmission times (*see*, i.a., Jones (n 39); and Budish, Cramton and Shim (n 27)).

[71] *See*, i.a., Andriy Shkilko and Konstantin Sokolov, 'Every Cloud Has a Silver Lining: Fast Trading, Microwave Connectivity and Trading Costs' (2020) Forthcoming The Journal of Finance; and Gregory Laughlin, Anthony Aguirre and Joseph Grundfest, 'Information Transmission between Financial Markets in Chicago and New York' (2014) 49 Financial Review 283.

[72] Marcos Lopez de Prado, 'Advances in High Frequency Strategies' (2011) doctoral dissertation <https://papers.ssrn.com/abstract=2106117> accessed 31 July 2020.

[73] O'Hara (n 1).

process the significant volumes of ('big data')[74] information that flood the market daily[75]—covering everything from credit-card transactions to satellite imagery.[76] More recently, advances in machine-learning have also begun to shape the content of trading-algos—turning them into intelligent tools capable of the sort of nuanced analysis that has so far been the prerogative of human traders.

Ultimately, the combination of these technological advances—from the computerisation of trading-algos, to the IT and communication technology revolutions—has encouraged most markets to evolve into fully automated environments, increasingly dominated by algo-trading.[77]

2.3.2 The popularisation of algo-trading

Algo-trading had its first appearance in the early 1970s[78]—following the introduction of the NYSE Designated Order Turnaround system ('DOT,' today 'SuperDOT'), which allowed the electronic transmission of orders to exchange

[74] Dong-Jin Pyo, 'Can Big Data Help Predict Financial Market Dynamics? Evidence from the Korean Stock Market' (2017) 21 East Asian Economic Review 147.

[75] *See,* i.a., Menkveld (n 7); and van Kervel and Menkveld (n 27).

[76] Robin Wigglesworth, 'The Quickening Evolution of Trading — in Charts' (*Financial Times*, 11 April 2017).

[77] Steffen Kern and Giuseppe Loiacono, 'High Frequency Trading and Circuit Breakers in the EU: Recent Findings and Regulatory Activities', *Global Algorithmic Capital Markets - High Frequency Trading, Dark Pools, and Regulatory Challenges* (Walter Mattli, Oxford University Press 2019).

[78] Michael J McGowan, 'The Rise of Computerized High Frequency Trading: Use and Controversy' [2010] Duke Law & Technology Review.

specialists[79]—and, by the end of the 20th century, it had become a dominating force within the United States ('US') capital markets.[80]

In 2006-2007, algo-trading experienced its first boom[81] and now accounts for 70%[82]-90%[83] of all trading volume hosted by the most developed economies in the world—with recent estimates suggesting that it represents around 85% of their market value.[84] In fact, some would argue[85] that algo-trading is the basic mechanism for 'virtually all trading' in modern capital markets[86]—and this

79 Keith and Grody (n 66).

80 *See* Michael Goldstein and others, 'Computerized and High-Frequency Trading' (2014) 49 The Financial Review 177. This growth in popularity was not significantly affected by the 1987 stock market crash, which was partially blamed on program-trading (*see* Mark A Carlson, 'A Brief History of the 1987 Stock Market Crash with a Discussion of the Federal Reserve Response' (2006) Federal Reserve Board Staff working papers).

81 This boom was not affected by the 2007 financial crisis and may actually have benefited from it: faced with significant price swings and a changing market environment where order execution was harder, investors had no choice but to turn to algo-trading (*see* Morton Glantz and Robert Kissell, *Multi-Asset Risk Modelling: Techniques for a Global Economy in an Electronic and Algorithmic Trading Era* (Academic Print - Elsevier 2014)).

82 Yadav (n 30).

83 In the most liquid US markets, algo-trading is thought to represent as much as 90% of all trading volume (*see* Dan Ryan and others, 'CFTC's Proposed Algorithmic Trading Rules' (PwC 2016) Regulatory brief).

84 This estimate includes 'the execution's end product,' ie, situations where investors route orders to brokers who then use algorithms to execute the trade (*see* Glantz and Kissell (n 81)).

85 *See*, i.a., O'Hara (n 1), 4. A recent JP Morgan estimate notes that traditional 'manual' investors represent only about 10% of US equity trading (*see* Robin Wigglesworth, 'Volatility: How "Algos" Changed the Rhythm of the Market' *Financial Times* (9 January 2019)). In 2013, the Australian Securities and Investments Commission ('ASIC') estimated that as much as 99.6% of the trading taking place within its markets came from algo-trading (*see* ASIC, 'Dark Liquidity and High Frequency Trading' (2013) Report 331).

86 Assessments of the impact of algo-trading on market quality may vary according to different definitions of algo-trading. For example, chapter 4 notes that the EU regime excludes certain categories of algo-trading from its regulatory definition of algo-trading—and reliance on such narrow definitions can be incompatible with these bolder assessments.

seemingly radical assessment might not be far from the truth, particularly in the context of EU markets.

Indeed, the technology required to engage in algo-trading is more accessible than ever—and, with most intermediaries currently offering DEA services, investors do not even need to become venue members to engage in this type of trading.[87] Even retail traders (who do not typically enjoy disintermediated access to the markets) will see their brokers executing most of their orders via execution algorithms,[88] which are no longer a luxury exclusive to sophisticated traders: they have become required tools to navigate markets as highly-fragmented and complex as most modern markets.[89]

Ultimately, it is difficult to know what the future holds for algo-trading, but a recent market report on the global algo-trading market estimates that it is still growing,[90] and should continue to expand at a compound annual growth rate

[87] Some intermediaries even help clients build and implement simple algo-trading strategies—and the development of trading-algos is, itself, easier than ever, thanks to user-friendly programming tools, on-line courses, and software designed to translate 'plain English' into trading-algos (*see*, for example, the AI sold by Algoriz on their webpage <https://algoriz.com>).

[88] Algo-trading is, by definition, disintermediated (*see* chapter 3), which means that traders using algorithms to support their own (manual) decision-making, or traders that have their orders automatically executed by their brokers are not—themselves—algo-traders (although their execution intermediaries most likely are).

[89] Marcos Lopez de Prado, 'Low-Frequency Traders in a High-Frequency World: A Survival Guide' (2012) SSRN paper 2150876 <https://papers.ssrn.com/abstract=2150876> accessed 31 July 2020.

[90] Even though certain algo-trading strategies have been experiencing dwindling profit margins (*see* Nicole Bullock, Gregory Meyer and Joe Rennison, 'How High-Frequency Trading Hit a Speed Bump' (*Financial Times*, 1 January 2018); and Alexander Osipovich, 'High-Frequency Traders Fall on Hard Times' *Wall Street Journal* (21 March 2017)).

('CAGR') of 6% between 2020-2024.[91] Regardless, the fact remains that most trading in modern capital markets is currently algorithmic—which meaningfully illustrates the potential of automated-trading technology for changing these markets.

2.4 The new (old) EU capital markets

Previous sections have used the qualitative uniqueness and quantitative significance of algo-trading to show the potential of automated-trading technology to change the EU capital markets. This section now argues that the availability of automated-trading technology has indeed transformed these markets—and has done so through two channels: first, by directly changing the mechanisms employed by most of their traders, and, second, by indirectly changing the strategies adopted by their players—including not just algo-traders, but also venues and other intermediaries.

However—before examining what has changed in EU capital markets following the widespread availability of automated-trading technology (*2.4.2*)—this thesis takes a brief excursus to discuss what has not (*2.4.1*).

[91] Research and Markets, 'Global Algorithmic Trading Market 2020-2024' (2020).

2.4.1 A not-so-radical change

The claim with which this thesis opened—that EU markets have been radically transformed by automated-trading technology—could be read as suggesting that everything about these markets is now different from what it was thirty years ago.

This is the time to clarify that there is much about the new EU markets that has actually remained impervious to the influence of this technology. At their core, these new (old) markets have the same nature and are hoped to perform the same functions—evaluated by the same indicators and supported by the same categories of market players—that they always have, long before algo-trading came along.

Determining what has remained unchanged about the new EU markets serves two functions: first, it helps isolate the change that EU markets did experience as a result of automated-trading technology; and, second, it clarifies that such change can (and should) be assessed against the same frameworks that have long been used to evaluate new market phenomena.

Ultimately, this section suggests that the only changes experienced by EU markets following the availability of automated-trading technology and the popularisation of algo-trading have been the adoption of new market behaviours—new mechanisms and strategies—by market players, with potential impact on their ability to act as channels for improving the efficiency and fairness of those markets.

2.4.1.1 The nature and functions of the new (old) markets

Financial markets are typically[92] regarded as the nexus of mechanisms that bring together buyers and sellers with complementary interests in tradable instruments, while setting the prices at which demand meets supply and trading occurs.[93]

The core nature of financial markets—including EU capital markets—has remained virtually unchanged since their beginning: while the particularities of the process of trading securities have varied significantly across time, geographies and instruments, its core has not; at their core, these markets have always been about linking together traders while supplying the rules that guide the formation of security prices[94]—and they still are.

Likewise, the criteria to evaluate the functioning of these markets have also remained unchanged over the last thirty years. Now, as before, determining the extent to which markets create value essentially depends on their (relative)

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[92] Definitions of 'market' range from observational (markets as geographical locations, marketplaces, or bodies of individuals who meet to enter into transactions), to functional (markets as allocative, price-defining, equilibrium-setting, and knowledge-dissemination mechanisms), or structural (markets as social institutions that facilitate exchange-type activities in the context of relatively stable relationships): *see* Eckehard F Rosenbaum, 'What Is a Market? On the Methodology of a Contested Concept' (2000) 58 Review of Social Economy 455.

[93] *See* Armour and others (n 4). According to O'Hara, 'any trading mechanism can be viewed as a type of trading game in which players meet (perhaps not physically) at some venue and act according to some rules' (*see* O'Hara (n 26), 8).

[94] O'Hara (n 26).

(1) efficiency and *(2)* fairness[95]—which remain the two main goals of EU financial markets regulation.[96]

(1) Efficiency as a regulatory goal

One of the core goals of financial regulation is to help markets become more efficient: to maximise existing productive capacity, and to promote an optimal allocation of resources and capital across the economy and over time.[97]

In theory, a perfectly efficient market—a Pareto-efficient market—is a market where no one can be made better-off without at least one other participant being made worse off.[98] In practice, markets are never perfectly efficient, but only relatively so.[99]

There are a number of reasons for this. First, markets are unable to reunite all market participants in the same place, at the same time—while having them place orders that perfectly translate rational supply and demand and are also unaffected by the conduct of other participants. Second, markets are largely

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[95] Fairness-based considerations are taken to include, i.a., goals of investor/consumer protection, or promotion of competition.

[96] For a discussion of other goals (or subgoals) of financial regulation *see*, i.a., Armour and others (n 4).

[97] For a discussion of efficiency as a regulatory goal, *see*, i.a., ibid; Fox, Glosten and Rauterberg (n 2); and Louise Gullifer and Jennifer Payne, *Corporate Finance Law: Principles and Policy* (Third Edition, Hart Publishing 2020). Arguably, markets are also hoped to optimise risk allocation by allowing risk-averse investors to hold diversified portfolios that protect them from the volatility of future cash flows experienced by individual assets (*see* Fox, Glosten and Rauterberg (n 2)).

[98] Vilfredo Pareto, 'Il Massimo Di Utilità Dato Dalla Libera Concorrenza' (1894) 9 Giornale degli Economisti.

[99] Ronald J Gilson and Reinier H Kraakman, 'The Mechanisms of Market Efficiency' (1984) 70 Virginia Law Review 549.

incapable of consistently matching supply and demand at prices that instantaneously[100] reflect full, rational agreement over value.[101]

In other words, real markets are neither frictionless, nor self-equilibrating;[102] players are not in fact all present in markets at the same time, and the limited number of players who are can have rather distinct views about value—which are only revealed over time, typically through trading[103]—as well as different incentives for trading—causing trading outside of equilibrium.[104]

Ultimately, this translates into persistent relative (in)efficiency—which, however, can be measured and improved upon. As will be demonstrated, the way to measure market efficiency is through quality indicators—which are, in turn, driven by the activity of market participants. The key to improving market efficiency then rests in optimising the activity of such participants: their mechanisms and strategies. Market dynamics matter—market microstructure matters—and they can be refined.

[100] Even under the fiction of an Walrasian auctioneer (costlessly) aggregating (the entire) demand and supply for a given security to find a market-clearing price, prices would still arise over time—following a series of preliminary auctions—instead of instantaneously (*see* O'Hara (n 26)).

[101] Foucault, Pagano and Röell (n 26).

[102] Glosten and Milgrom (n 26).

[103] Foucault, Pagano and Röell (n 26).

[104] There are many reasons why someone might want to trade in the financial markets, and which are entirely unrelated to information, including hedging and portfolio rebalancing (*see* ibid).

The discussion of how markets fulfil their desired functions with the help of market participants is postponed for a moment;[105] for now, it is only important to keep in mind that the two indicators used to measure the efficiency of EU markets are—now as before algo-trading—liquidity and price-accuracy.[106]

In this context, liquidity measures the extent to which securities can be quickly traded at prices that translate, as closely as possible, the relatively informed consensus reached over how much they are worth.[107] Price-accuracy, in turn, measures the extent to which the prices thus formed reflect a fully informed consensual prediction of value ('fundamental value'),[108] resulting in more or less accurate—but never entirely efficient—prices.

This means that the differences between real market prices and theoretical fundamental values are both explained by the relative (il)liquidity and the relative price (in)accuracy of markets.

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[105] *See* section 2.4.1.2.

[106] For a discussion of liquidity and price-accuracy as measures of efficiency, *see,* i.a., Armour and others (n 4); Fox, Glosten and Rauterberg (n 2); and Gullifer and Payne (n 97).

[107] It is worth noting that measuring liquidity is more than just measuring bid-ask spreads: liquidity is a multi-varied concept reflecting a variety of trade-offs—which include not just speed of execution, but also the size of the order and the probability of its execution. As a general rule, the larger the order, the more a trader will have to pay to execute it, also depending on how fast they want to execute it, and how much they are willing to risk not executing it at all. Thus, liquidity should also be examined from a dynamic perspective as 'depth, breadth and resilience,' in the sense that a liquid market will provide large incremental quantities available to be bought (sold) below (above) the best bid (ask) quotes, will host many traders with even market power, and any price variations associated with trade size and order flow pressure will be small and temporary. For a discussion, *see* Foucault, Pagano and Röell (n 26).

[108] The 'fundamental value' can be defined as the price that would subsist in perfectly efficient markets. For a discussion, *see* Ronald L Goettler, Christine A Parlour and Uday Rajan, 'Equilibrium in a Dynamic Limit Order Market' (2005) 60 The Journal of Finance 2149.

However, this does not mean that liquidity and price-accuracy make entirely independent contributions to efficiency. Indeed, markets that are more liquid (with less transaction costs) are more encouraging of trading, and—since trading is the main channel through which information travels into prices—higher liquidity should contribute to price-accuracy. In turn, the costs of providing liquidity—which arise, in particular, from the differential of information between liquidity-providers and informed traders—are also lower in markets where prices are more informed. It would then appear that market efficiency is straightforwardly benefited—at once—by the actions of both liquidity-providers and informed traders.

In practice—and as discussed below—the relationship between market participants is significantly more nuanced, and market quality is also driven by a series of negative trade-offs inherent in their interactions.[109] And that is as true today as it was before algo-trading took over the EU capital markets.

(2) Fairness as a regulatory goal

Although efficiency represents the core goal pursued by financial markets regulation, markets are also judged on their relative fairness.

The concept of (un)fairness measures the extent to which a market produces unbalanced outcomes for its constituents, allowing particular players to engage in practices that increase their wealth at the expense of other players.

[109] S*ee* section 2.4.1.2; and chapter 3.

While trading is a zero-sum game, certain market practices lead to particular groups of players being consistently and disproportionately worse-off than others—and the effects of this imbalance can become concerning when these players are also especially vulnerable,[110] leading to the aggravation of pre-existing inequalities.[111]

While fairness is widely perceived as one of the main goals of financial markets regulation, there are two problems with using fairness to measure market quality. First, fairness is difficult to define:[112] some fairness definitions are narrow and focus only on determining whether particular practices cause unavoidable and uncompensated harm to retail investors in aggregate;[113] others go as far as demanding that all market participants enjoy equivalent processing capabilities and bargaining power.[114]

Second, efficiency and fairness do not always go hand in hand—and even a Pareto-efficient market could reflect an undesirable allocation of resources. Indeed, particular mechanisms and strategies can, at once, both increase the

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[110] Armour and others (n 4).

[111] Fox, Glosten and Rauterberg (n 2).

[112] Fox *et al* note that 'allegations of unfairness are often (but not always) rather superficial' and that there are 'too many and too multifarious' conceptions of fairness (*see* ibid, 49).

[113] These factors correspond to the definition of 'unfair' used in the context of consumer protection under the US Dodd-Frank Act (*see* Dodd-Frank Act, Subtitle C, Section 1031). Indeed, the protection of retail investors—or 'consumers'—is often a main goal of financial regulation; for a discussion of the reasons for awarding special protection to retail investors (by contrast with professional investors), *see* Armour and others (n 4).

[114] *See*, i.a., the notion of 'fairness' put forward by Hersh Shefrin and Meir Statman, 'Ethics, Fairness and Efficiency in Financial Markets' (1993) 49 Financial Analysts Journal 21.

efficiency and decrease the fairness of markets (and vice versa)—leading to seemingly irreconcilable tensions when evaluating the impact of new market conduct. At the same time, only markets seen as fair can aspire to be efficient, as players hesitate to enter markets perceived as unfair, and player interaction is a necessary channel for efficiency.[115]

In the end, fairness concerns thus add to the challenge of regulating new market conduct—and they are as relevant in the case of algorithmic trading-inspired conduct as they have ever been.

2.4.1.2 The microstructure of the new (old) markets

The previous section noted that the new (automated) EU markets—like the EU markets of thirty years ago—are neither frictionless, nor self-equilibrating:[116] they are always relatively (in)efficient, displaying persistent order imbalances[117] and price inaccuracies. But there are channels for absorbing these disparities.[118]

It is now argued that the channels through which the *(1)* liquidity and *(2)* price-accuracy of the new (automated) EU markets can be improved are supplied

[115] There is then a case for regulating a practice perceived as unfair (and which, as a consequence, drives away market players), even if such practice is not actually unfair. The case is harder to make if, despite being perceived as unfair, that practice is efficiency-enhancing; in such case, it might be preferable to educate the market as to the harmlessness of the practice. If a practice is both (actually or perceivably) unfair *and* efficiency-enhancing, the decision of how to regulate it should depend on any observable trade-offs.

[116] Glosten and Milgrom (n 26).

[117] An unbalanced order flow is that in which the proportion of buy and sell orders are not roughly equivalent (*see* Foucault, Pagano and Röell (n 26)).

[118] ibid.

by the same broad categories of players that have always helped these markets perform their desired functions—and that the relationships between these categories of market players are still shaped by *(3)* the same types of complementarities and tensions that have always characterised these relationships.

(1) Channels for liquidity

In capital markets, liquidity is typically enabled by trading venues—which set up floors where traders can meet, and enlist specialists/dealers willing to make markets. However, in most modern (order-driven or hybrid) markets, any trader posting (non-marketable) limit orders is a liquidity-provider[119]—and, in fact, most liquidity in these markets is supplied by proprietary traders engaging in professional liquidity provision. These traders place orders on both sides of the book and stand ready to buy and sell the same financial instruments, making the spread on each round-tip trade.[120]

The fact that any trader in these markets can provide liquidity does not mean that all traders are equally valuable channels for liquidity. Indeed, different categories of market players use different mechanisms and strategies to manage the costs of providing liquidity[121]—arising in particular, from asymmetric

[119] For a discussion, *see* chapter 3.

[120] Originally, the only professional liquidity providers were the specialists and dealers (formally) employed by exchanges. Nowadays, liquidity in modern markets is often provided by HFTraders (*see* Menkveld (n 27)).

[121] The risks arising from asymmetric information reflect the fact that liquidity providers lose out whenever they trade with informed traders; the risks inherent in inventory-management come from the fact that liquidity suppliers accumulating positions in a particular instrument become

information,[122] inventory management, and order-processing[123]—and the extent and nature of their contribution to liquidity depends on their ability to mitigate these costs.

(2) Channels for price-accuracy

Previous sections have noted that financial markets—and EU markets, in particular—are neither frictionless, nor self-equilibrating. In practice, the (imperfectly rational) investors in these markets are incapable of accurately and instantaneously acquiring, analysing and trading on new information.

As a result, prices in these markets do not perfectly reflect all relevant information—nor do they adjust immediately to newly-discovered information.[124]

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exposed to adverse movements in its price; and the risks arising from order-processing reflect the challenges of engaging in the business of providing liquidity, as measured by the real cost of processing orders in a competitive market. These risks correspond roughly to the different components of the bid-ask spread. For a discussion, *see,* i.a., Foucault, Pagano and Röell (n 26); and Hasbrouck (n 26).

[122] The fact that liquidity providers face risks arising from asymmetric information does not mean that they are the ultimate bearers of that loss, to the extent that they can pass it on to traders (who might ultimately pass it on to share issuers).

[123] Additionally, an imperfectly competitive environment generates rents that are also reflected in the bid-ask spread (*see* Foucault, Pagano and Röell (n 26)).

[124] In other words, real markets are not efficient under the efficient markets hypothesis, whereby the prices of securities traded in a (perfectly) efficient market fully incorporate all available information about the issuer of those securities; depending on which categories of information are actually available to be incorporated into prices, markets can then be classified as being efficient in the 'weak' form—if its prices reflect all relevant historical information,—in the 'semi-strong' form—if its prices reflect, in addition, all relevant public information,—or in the 'strong' form—if its prices further reflect all relevant private information (*see* Eugene F Fama, 'Efficient Capital Markets: A Review of Theory and Empirical Work' (1970) 25 The Journal of Finance 383). According to Gilson and Kraakman, markets are only relatively efficient and, ultimately, 'the mechanisms that operate to reflect new information in price are more or less efficient depending on how quickly they yield efficient equilibrium prices' (*see* Gilson and Kraakman (n 99)). *See*, also, the empirical evidence discussed *in* Frederic Palomino, Luc Renneboog and Chendi Zhang, 'Information Salience, Investor Sentiment, and Stock Returns: The Case of British Soccer Betting' (2009) 15 Journal of Corporate Finance 368.

Therefore, prices in these markets do not change only as new information is explicitly discovered and analysed, but also in response to trading pressures.[125]

This is as true for the new (automated) EU markets as it has ever been. Now as before, trading in these markets takes place 'over time,'[126] with the order flow itself becoming an important source of information.[127] Consequently, price-discovery in these markets is not just achieved through the activity of (traditional) informed traders[128]—including insiders, fundamental value traders and announcement traders—but also through the efforts of derivatively-informed traders,[129] working to decode that order flow.[130]

In theory, all (traditional and derivatively) informed traders can help price-discovery*.* In practice, different categories of traders make markedly different

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[125] Ultimately, market prices should then respond to information about the issuer (which can variously include historical information, public information, or private information, depending on the form of market-efficiency), but also, crucially, to information decoded from variations in order flow. Additionally, they will also respond to non-information sources of variation in prices, including sentiment and relative liquidity.

[126] Glosten and Milgrom (n 26).

[127] The idea that trading itself can be a source of volatility has long been supported by empirical studies: *see,* in particular, Kenneth French and Richard Roll, 'Stock Return Variances: The Arrival of Information and the Reaction of Traders' (1986) 17 Journal of Financial Economics 5; and Richard Roll, 'A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market' (1984) 39 The Journal of Finance 1127.

[128] In this context, the notion of 'traditional informed trading' is limited to trading activity determined by price-relevant information made available about the securities issuer; 'non-traditional informed trading' includes all trading activity guided by information on how others are trading.

[129] This sub-classification of informed traders reflects the initial distribution or availability of price-relevant information (*see* Gilson and Kraakman (n 99)).

[130] As noted, it is not only traders who contribute to price-accuracy within EU markets: venues and other intermediaries also play an important role in helping traders meet each other and translate their views into orders. However, the main channel for price-accuracy within EU markets is, now as before, trader activity.

contributions to price-accuracy,[131] which—much like those of liquidity providers to liquidity—also vary in nature and extent depending on the mechanisms and strategies employed by the participants in each category of traders.

For example, insiders may make only a small contribution to price-accuracy: while the extent of relevant private information can be significant, the nature of insider-dealing means that the revelation of information through this activity only slightly accelerates—when it does not delay—price-discovery.[132]

Differently, fundamental value traders can make prices significantly more informed, and more informed in the long-term.[133] This is because they uncover or produce information that may be difficult to access or piece together, and which often refers to medium/long-term predictions of value.[134] By contrast, the contribution of announcement traders to price-discovery is negligible, as the

[131] Fox, Glosten and Rauterberg (n 2).

[132] Insiders are often liquidity-constrained and produce a noisy trading signal—ultimately limiting their contribution to price-discovery. To the extent that insider dealers might also be biased in their evaluation of private information, or cause an issuer to delay information disclosure (as a way of maximising their own gains), insider dealing might even delay price-discovery. For a discussion, *see, i.a.,* Fama (n 124); Fox, Glosten and Rauterberg (n 2); and Gilson and Kraakman (n 99).

[133] The way in which this information is used determines whether fundamentally-informed traders can be classified as 'anti-mistake traders' or 'price-sensitive fundamental value traders.' Both categories piece together publicly available information to estimate the value of a particular security, but they only trade on it under particular circumstances: anti-mistake traders trade if they see prices move and their investigation suggests that there is no reason for such move; by contrast, price-sensitive fundamental value traders use the information they obtained to establish limits beyond which they do not trade. As a consequence, the impact of these traders on price-accuracy is limited to those occasions where uninformed traders do not trade idiosyncratically (but instead follow an identifiable, if misinformed, trend)—in which case anti-mistake traders contribute to bringing prices back to informed levels—and to those occasions where market prices swing so wildly that they trigger price-sensitive fundamental value traders to step in (with corrective effects). For a discussion, *see* Fox, Glosten and Rauterberg (n 2).

[134] ibid.

information revealed through this type of trading would normally always be reflected into prices quite quickly.[135]

Lastly, derivatively informed traders contribute to price-accuracy both through trade-decoding and price-decoding. Trade-decoding is limited to those (rare) occasions when an informed trader is directly identified and observed; for that reason, its contribution to price-accuracy can be significant, but is generally limited by the fact that there are not many such occasions.[136]

By contrast, price-decoding—through which the presence of informed investors is inferred from order flow pressures—can significantly accelerate price-discovery, working as a self-limiting replacement for a wide initial distribution of information. Specifically, the degree to which price-decoding contributes to price-accuracy depends on how skilled (traditional) informed traders are at disguising their trading, and on how fast the decoded information would otherwise travel into the market; its self-limiting nature comes from the fact that markets cannot support equilibriums where prices are fully accurate.

Indeed, according to Grossman and Stiglitz,[137] traditional informed traders only incur the costs of acquiring information as long as prices remain relatively

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[135] A broader notion than that of 'announcement traders' is that of 'universally informed traders,' which includes not just announcement traders, but also those who trade based on 'old' information. For a discussion of these different categories of traders, *see* Gilson and Kraakman (n 99).

[136] ibid.

[137] *See* Sanford J Grossman and Joseph E Stiglitz, 'On the Impossibility of Informationally Efficient Markets' (1980) 70 The American Economic Review 393. *See*, also, the rational expectations models developed by Robert E Verrecchia, 'Information Acquisition in a Noisy Rational

noisy (or partially coded). The more accurate prices become, the less profitable informed trading becomes, and the smaller the incentive for traders to search for information; to the extent that prices could ever become perfectly accurate, traders would stop looking for information, causing prices to again become uninformed; this, in turn, would eventually encourage informed trading to return to the market and resume its contribution to price-accuracy—ultimately fuelling an oscillating equilibrium between 'enlightenment and ignorance.'[138]

(3) Complementarities and tensions in the relationships between market players

The tensions between derivatively informed traders and (traditional) informed traders illustrate a larger point that is as true in the new EU markets as it has always been: informed traders compete amongst themselves—with the impact of this competition on price-accuracy depending on how it affects, on the one hand, the traders that contribute the most to price-accuracy (like fundamental value traders and, arguably, derivatively informed traders), and, on the other hand, the traders that contribute only marginally to price-accuracy (like insider dealers and announcement traders).[139]

Expectations Economy' (1982) 50 Econometrica 1415; and Anat R Admati, 'A Noisy Rational Expectations Equilibrium for Multi-Asset Securities Markets' (1985) 53 Econometrica 629.

[138] Gilson and Kraakman (n 99), 577.

[139] Fox, Glosten and Rauterberg (n 2).

A parallel rationale can be applied to liquidity providers (traditionally seen as uninformed traders, but often derivatively informed traders).[140] Now as before, the competitive interactions between these traders also influence the cost of trading—with their impact on market quality similarly depending on how the categories of liquidity providers that make the most (and least) significant contributions to liquidity are affected by these interactions.

Beyond these two sets of interactions, there is one other type of interactions that has always had—and continues to have—a key influence over market efficiency: those between (traditional) informed traders and (variously informed) liquidity suppliers.

Before, it was noted that increased market liquidity, which makes all trading cheaper, favours price-accuracy; in turn, markets where prices are more accurate and less volatile also tend to display smaller spreads.[141] In practice,

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[140] Some categories of liquidity providers—particularly professional liquidity suppliers—use announcement information, as well as decodable order flow information to update their quotes. Particularly in the context of limit order book-type markets—with fully democratised liquidity provision—fundamental value traders too can provide (even if they more often take) liquidity. For a discussion, *see* Stanislav Dolgopolov, 'Insider Trading, Informed Trading, and Market Making: Liquidity of Securities Markets in the Zero-Sum Game' (2012) 3 William & Mary Business Law Review.

[141] *See, i.a.,* the models developed by Demsetz, Stoll, and Ho and Stoll—showing that increased market volatility increases the risk of holding assets, contributing to widened bid-ask spreads (Harold Demsetz, 'The Cost of Transacting' (1968) 82 The Quarterly Journal of Economics 33; Hans Stoll, 'The Supply of Dealer Services in Securities Markets' (1978) 33 Journal of Finance 1133); and Thomas Ho and Hans Stoll, 'Optimal Dealer Pricing under Transactions and Return Uncertainty' (1981) 9 Journal of Financial Economics 47). Still, it appears that some degree of volatility is beneficial for liquidity providers, since investors might perceive the absence of any volatility as erasing most profit-making opportunities, and feel less inclined to engage with the market; to the extent that they are less informed than liquidity providers, their retreat from the market increases the costs of providing liquidity and bid-ask spreads (*see* Helios Herrera, 'Sorting in Risk-Aversion and Asset Price Volatility' (2005) 41 Journal of Mathematical Economics 557; Olivier Jeanne and Andrew K Rose, 'Noise Trading and Exchange Rate Regimes' (2002) 117 The Quarterly Journal of Economics 537; and Jakree Koosakul and Ilhyock Shim, 'The Beneficial

however, this depiction of a virtuous cycle of liquidity and price-discovery hides important short-term trade-offs inherent in the relationships established between *(i)* liquidity providers and *(ii)* (traditional) informed traders in relatively (in)efficient markets—and which have long had a decisive influence on their behaviour.

To understand the behaviour of *(i)* liquidity providers in these markets, it is worth noting that, in markets where not all information is instantaneously distributed and plugged into prices, trades on (somewhat) private information only have the effect of creating unusual order flow pressures, at least in the short-term[142]—and that this is a similar effect to that of correlated noise trading.[143] Consequently, liquidity providers who detect such unusual pressures may not know whether they originate in private information or not.[144]

Now, a particular instance of unusual order flow pressure that does originate in informed trading translates an attempt by informed traders to exploit imprecisions in the quotes of liquidity providers: an attempt to buy when ask quotes are too low, or to sell when buy quotes are too high.[145] As a result, liquidity providers typically lose money when they are on the other side of trades with

Aspect of FX Volatility for Market Liquidity' (Bank for International Settlements 2017) BIS Working Papers 629).

142 Foucault, Pagano and Röell (n 26).

143 Armour and others (n 4).

144 Foucault, Pagano and Röell (n 26).

145 ibid.

better informed traders.[146] And because liquidity providers are often unsure whether order flow pressures originate in informed trading or not, they may mitigate the risk that they are being preyed upon by adjusting their quotes.

In the first instance, liquidity providers will seek to adjust their quotes in reaction to any unusual order flow pressures—and, if those unusual pressures do originate in informed trading, these adjustments will accelerate price-discovery. But they will also anticipate them: according to Glosten and Milgrom,[147] liquidity providers will, in fact, set their 'ask' and 'bid' quotes conditional on the next arriving (buy and sell) orders.[148]

Unlike post-trading quote adjustments—which may contribute to price-accuracy—the creation of bid-ask spreads in anticipation of the information asymmetry endured by liquidity providers necessarily makes markets less liquid (and potentially less informed). Just how much depends on the proportion of

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[146] This notion was first introduced by Treynor in 1971 (*see* Jack Treynor, 'The Only Game in Town' (1995) 51 Financial Analysts Journal 81).

[147] Glosten and Milgrom (n 26).

[148] Similarly, their ask price will exceed their bid by a spread wide enough to ensure that they can recover any losses made on their dealings with better informed traders in their dealings with uninformed traders. In the end, both perspectives lead to a similar bid-ask spread. Notably, liquidity providers need to set bid-ask spreads that are also wide enough to cover their other costs (arising, in particular, from their inventory management and order processing risks), allowing them to run a profitable business. Crucially, liquidity providers also need to set up bid-ask spreads that are narrow enough to attract liquidity-takers, as demand for liquidity is not inelastic (*see* Foucault, Pagano and Röell (n 26)).

informed trading, on volatility and on the information available[149] to the liquidity-provider.[150]

Looking now at the *(ii)* behaviour of (traditional) informed traders, it is worth recalling that while liquidity-providers adjusting their quotes in the process of trading against better informed traders can accelerate the process of price-discovery, it also limits the gains of informed traders[151]—discouraging them from acquiring and trading on new information.

Indeed, it was noted earlier that (traditional) informed trading tends to decrease when and to the extent that the profits from such activity start being captured by other players—particularly derivatively informed traders. Informed trading thrives only in markets that are relatively inefficient—so the more accurate prices become (more quickly) and the less profitable informed trading becomes, the less resources will be allocated to acquiring new information, with negative impact on price-accuracy.[152]

[149] So far, liquidity providers have been essentially portrayed as derivatively informed traders (which some would call uninformed) who gain their information from observing and analysing the order flow. In truth, liquidity providers have access, like all other market players, to all information made available to the market (namely via news and announcements)—and nothing prevents liquidity providers from engaging in (traditional) informed trading.

[150] *See* Foucault, Pagano and Röell (n 26). *See,* in particular, the impact of information asymmetry in the context of executing large orders, which typically face increased shortfall implementation costs (Kyle (n 26)).

[151] Or even, in extreme situations, trade in front of them, effectively 'free-riding' on the information obtained by these informed traders (*see* van Kervel and Menkveld (n 27)). The ability to identify informed traders might depends on how well these traders can disguise their activity—in particular by avoiding trading in large quantities or through quick successive orders (*see* Fox, Glosten and Rauterberg (n 2) and Foucault, Pagano and Röell (n 26)).

[152] Grossman and Stiglitz (n 137).

This suggests that, in the short term,[153] the dynamic relationship between liquidity-providers and informed traders involves trade-offs that earlier discussions of a virtuous cycle between liquidity and price-accuracy did not anticipate: from a static perspective, markets that are more liquid encourage more informed trading, and better-informed markets decrease the costs of providing liquidity—but, from a dynamic perspective, the activity of (traditional) informed traders (which is the main market channel for price-accuracy) can also increase the cost of providing liquidity, while the activity of liquidity-providers (which is the main market channel for liquidity) can likewise decrease the profits of (traditional) informed trading.[154]

As a result, evaluating new market conduct, and, in particular, determining the extent to which it contributes to (or undermines) market efficiency, should always take these negative trade-offs into account—namely by considering which categories of market players are negatively affected by that conduct and what is, in turn, their relative contribution to market efficiency. And this is as important in modern EU markets as it was before algo-trading came along.

2.4.1.3 Isolating the change experienced by the new EU markets

This section has argued that the new (automated) EU markets have much in common with the EU markets of thirty years ago, including the functions that they are hoped to play and the identity of the categories of players through which they

[153] Notably, there is always price-discovery in the very long run, as long as the order flow is (even if only slightly) unbalanced—it might just be very slow (*see* Foucault, Pagano and Röell (n 26)).

[154] ibid.

create social value. Now as before, the quality of EU markets is driven by the activity of their players—with their contributions to market quality depending on the mechanisms and strategies they employ, not least because of how these mechanisms and strategies shape the complementarities and trade-offs that have always been inherent in their relationships.

In identifying what has remained the same following the availability of automated-trading technology across EU markets, this thesis has taken important steps towards determining how these markets have in fact changed over the last three decades: and what has changed is precisely the mechanisms and strategies employed by the different players that comprise them.

Steps were also taken towards determining how these new mechanisms and strategies should be evaluated (and eventually regulated). Now as before, regulatory response to new market conduct should depend on whether it makes a positive or negative impact on the contribution of market players to market efficiency and fairness. Put more simply, new market behaviours—namely the market behaviours that have come to dominate the new automated EU markets—must continue to be addressed depending on the specific benefits and risks that they create for market quality.

2.4.2 The change in the new EU markets

The last section closed with the notion that the radical change experienced by EU markets in the age of algo-trading was, more specifically, a change to the mechanisms and strategies employed by their players.

Before evaluating this change in the next chapter—the benefits and risks inherent in these new mechanisms and strategies—two points are worth stressing: first, that such change was more rigorously driven by the availability of automated-trading technology (than by algo-trading *per se*); and, second, that this technology has changed markets through both direct and indirect channels—with impact on precisely which mechanisms and strategies are different in the new EU markets.

2.4.2.1 Automated-trading technology as a driver of change

The main purpose of this thesis is to evaluate the EU algo-trading regime, which has been characterised as the response given by the EU to algo-trading. This is somewhat imprecise: as will be noted, this regime does not just contain the EU response to algo-trading—but rather its response to the broader change resulting from the availability of automated-trading technology across those markets.[155]

And this is the right way to approach algo-trading: not as a driver of change in itself, but as a product of change—to be analysed alongside other products of that change.[156] In truth, change in financial markets is typically driven by three factors—technology, regulation and competition[157]—and algo-trading cannot be accurately characterised as either.

[155] *See* chapter 4.

[156] *See* section 4.4.

[157] *See* Fox *et al,* noting that equity markets are 'very dynamic, with changes driven by innovations in technology, market participants' strategies, and regulation itself' (Fox, Glosten and Rauterberg (n 2)). Crucially, competition is not always seen as an independent driver of change: for instance,

Indeed, algo-trading was defined earlier as a type of trading. Now, in the sense that it was technological development that allowed algorithms to be turned into computer code, algo-trading can also be characterised as a product/use-case of technology—but algo-trading is not, itself, new technology: it is rather the most obvious (and only direct) product of traders incorporating automated-trading technology into the mechanisms of their activity.[158]

At the same time, it will now be argued that the availability of automated-trading technology has done more to change EU markets than just offer traders new mechanisms for their trading.

2.4.2.2 The dual change brought by automated-trading technology

Algo-trading is a use-case of automated-trading technology in financial markets—and discussions about automated-trading technology are often framed as discussions about algo-trading. Indeed, examples of this practice are found in the EU algo-trading regime[159]—but also in this thesis, not least when referring to that regime as the 'EU algo-trading regime.'

Schwartz *et al* see competition instead as a product of technology and regulatory developments (*see* Schwartz, Byrne and Colaninno (n 6)).

[158] Automated-trading technology is a subtype of algorithmic technology. For a discussion of other 'use cases' of algorithmic technology in the financial system *see* Expert Group on Regulatory Obstacles to Financial Innovation (ROFIEG) (n 49).

[159] The EU algo-trading regime actually regulates all (direct and indirect) uses of automated-trading technology—and not just algo-trading. *See*, i.a., article 17 of MiFID II, which regulates a number of indirect products of automated-trading technology—that are not, themselves, algo-trading—under the broad label of 'algo-trading' (*see*, i.a., paragraphs (5)-(6)).

Algo-trading is, in fact, the only *direct* product of automated-trading technology in the context of the financial markets—making it acceptable to refer to the impact of algo-trading when discussing the impact of automated-trading technology, particularly as the label 'algo-trading' grew more popular than the label 'automated-trading technology.'[160] However, the use of this short-cut carries a significant danger: because algo-trading is only a product of automated-trading technology, equating the two can lead to the misconception that the adoption of algo-trading mechanisms is the only change brought about by automated-trading technology to the markets—and EU markets in particular.

This is not true. Algo-trading is indeed the most visible face of the change created by automated-trading technology in EU markets, in the sense that the incorporation of this technology into the mechanisms used by most traders in these markets—this new mechanical way of trading—is the most obvious way in which such technology has changed them. But the widespread availability of automated-trading technology (and the subsequent popularisation of algo-trading) have *indirectly* induced a number of additional changes in the strategies more widely adopted by players in these markets—including algo-traders themselves, but also venues and other intermediaries.

Indeed, it is argued that the availability of automated-trading technology has changed EU markets in two ways: first by *directly* changing the mechanisms adopted by most traders in those markets; and, second, by *indirectly* encouraging

[160] As of 6 November 2020, a Google-search for automated-trading technology produces only 'about 260,000 results,' while a search for algo-trading produces 'about 3,180,000 results.'

further changes in the strategies adopted more broadly by all market players in response to the widespread popularisation of algo-trading across those markets.

Understanding the double-nature of this change is fundamental for determining the full impact of automated-trading technology on EU markets: while certain benefits and risks may be associated with any instance where algo-trading mechanisms are employed (regardless of strategy), others may be specifically linked to particular algo-trading strategies. And others still may be associated with strategies that—despite not being algo-trading—have been created to attract or facilitate algo-trading.

Ultimately, it is also fundamental for designing an effective algo-trading regime—capable of regulating the change brought by automated-trading technology to financial markets with a view to preserving or increasing their efficiency and fairness.[161] While such a regime may need to include rules applicable to all uses of algo-trading mechanisms—in response to risks that may always arise from algo-trading, regardless of strategy—it may also have to include separate rules applicable to algorithmic trading-inspired strategies that may carry specific, additional risks.

2.5 Conclusion

Effective regulatory regimes must reflect a good understanding of their object of regulation—nature, benefits and risks. As such, before beginning its evaluation

[161] For a discussion of the goals of financial regulation, *see* Armour and others (n 4).

of the EU algo-trading regime, this thesis has taken the first steps towards understanding what algo-trading is and how it appears to have impacted EU markets.

In attempting to understand what algo-trading is, this chapter has produced a rigorous method for identifying it—by looking at *who* formulates and implements a trading decision and *how*—but it has also shed light on the nature of algo-trading as a product of automated-trading technology. And, crucially, on the fact that algo-trading is just one—albeit the most *direct*—innovation brought by this technology to financial markets.

An effective algo-trading regime should then reflect the notion that algo-trading is only the most visible face of the change experienced by markets as a result of automated-trading technology—and place it within the broader context of the *indirect* changes caused by this technology to the strategies adopted by market players: most obviously traders, but also venues and other intermediaries.

But this is not enough: an effective algo-trading regime should also be based on accurate knowledge of how this (direct and indirect) change caused by automated-trading technology to the mechanisms and strategies employed by players in modern financial markets have impacted the ability of these players to act as channels for increasing the efficiency and fairness of these markets.

As such, before determining whether the EU regime meets these necessary conditions for an effective algo-trading regime—by revealing an adequate understanding of algo-trading and of the impact of automated-trading technology on EU markets—the next chapter discusses that impact in greater detail.

3. THE CHANGE BROUGHT BY AUTOMATED-TRADING TECHNOLOGY TO EU MARKETS

3.1 Introduction

Financial markets have experienced radical change at the hands of automated-trading technology, and although there is much about modern financial markets—and EU capital markets, in particular—that has remained impervious to the forces of this technology, much is also different.

The previous chapter examined the nature of this change, ultimately arguing that this has been a change to the mechanisms and strategies employed by market players. And, because player conduct is the fundamental channel through which markets become more efficient and fairer, this is also a change that stands to have significant impact on market quality—and, namely, on the quality of EU markets.

This chapter analyses that impact as a pre-condition to evaluating the EU algo-trading regime. As argued, an effective algo-trading regime must reflect an accurate understanding not only of the nature of the change brought by automated-trading technology to the markets, but also of its impact on market quality. Indeed, it is often noted—particularly in the context of financial regulation[162]—that technology is neutral: its mere existence is not sufficient

[162] In the context of EU financial regulation, *see* Expert Group on Regulatory Obstacles to Financial Innovation (ROFIEG) (n 49).

reason to regulate it; the need for regulation depends on how that technology is used, and how those uses affect the quality of financial markets.[163]

Given the dual-natured impact of automated-trading technology on financial markets, this chapter is divided into two parts. The first part—devoted to the direct change brought by automated-trading technology to EU markets—examines the use of algo-trading mechanisms by traders, regardless of strategy (*3.2*). The second part—dedicated to the indirect change brought by automated-trading technology to these markets—analyses the strategies adopted by trading venues, other intermediaries and traders themselves in reaction to the widespread popularisation of algo-trading (*3.3*).

In the end (*3.4*), it is argued that the incorporation of automated-trading technology into the mechanisms used by algo-traders can have a positive impact on liquidity and price-accuracy, but always carries a certain degree of cyber and systemic risk—even if it does not appear to make any significant contribution to increasing the risk of market manipulation.

Finally, it is also argued that the benefits and risks created by algo-trading can be amplified by many of the strategies adopted by venues, intermediaries and traders in response to the popularisation of algo-trading. At the same time, these different strategies also carry special benefits and risks which are unique to their context—and may thus be deserving of special rules.

[163] *See*, i.a., Schwartz, Byrne and Colaninno (n 6).

3.2 New mechanisms for new markets

Although the impact of automated-trading technology on EU markets has been widespread—reaching all categories of market players—the most direct product of this technology has been the change operated in the mechanisms used by most traders in those markets. In other words, the most visible change brought by automated-trading technology to EU markets has been the popularisation of algo-trading.

This section re-introduces algo-trading, expanding on its definition and offering a more complete characterisation of algo-trading mechanisms (*3.2.1*). This serves as a starting point for discussing how their use has impacted EU capital markets—creating both benefits and risks for their quality (*3.2.2*).

3.2.1 Beyond automation: the new algo-trading mechanisms adopted in EU markets

This thesis has introduced the idea that the availability of automated-trading technology has directly changed the mechanisms employed by most traders in EU markets.

This is equivalent to stating that the availability of automated-trading technology is directly responsible for the advent of algo-trading, which involves incorporating automated-trading technology into the mechanisms used by traders to exchange instruments in financial markets—resulting in a type of trading where machines (instead of humans) autonomously formulate and implement decisions by following pre-coded rules.[164]

The notion of 'algo-trading' is then centred around that of 'automation'[165]—understood as the lack of human intervention[166]—which can also be found at the heart of most algo-trading rules, including those in the EU regime.[167] However, a number of additional characteristics have also come to be associated with the use of algo-trading mechanisms, including disintermediation and higher speeds. And while these characteristics may not be as central to defining algo-trading as automation, they are broadly present in all uses of algo-trading mechanisms, and help illustrate their impact on the quality of EU markets.

3.2.1.1 Disintermediation

The association between algo-trading and disintermediation is a natural consequence of the idea that algo-trading is devoid of human interaction. Indeed, the classification of 'algo-trading' should only be given to trading where machines retain full-control over the process of making and implementing decisions—and such level of control can only be achieved through full-disintermediation.

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[164] *See* chapter 2.

[165] In the literature, *see,* i.a., Bhupathi (n 50); Brogaard (n 54); Keller (n 54); and Jones (n 39).

[166] 'Automation' is defined by the Cambridge on-line Dictionary as 'the use of machines and computers that can operate without needing human control.'

[167] Indeed, chapter 4 shows that the EU definition of algo-trading also relies on the notion of 'automation' (noting that human intervention should be 'absent' or 'limited')—with the EU regime then capturing only the categories of algorithms that allow machines the most freedom over decision implementation (*see* MiFID II, article 4(1)(39)).

In truth, commentators often highlight the direct nature of the connection between algo-traders and the platforms where they trade[168]—equating algo-trading with the placement of orders 'via direct market-access channels.'[169] It is then unsurprising that algo-trading mechanisms are also often linked to the use of DEA services,[170] whereby venue members, typically execution intermediaries, offer non-members disintermediated access to those venues.[171]

However, it is worth noting that traders can engage in algo-trading without contracting for DEA services—and vice versa. Indeed, traders who are venue members already enjoy disintermediated access to markets and do not have to enter into additional DEA arrangements before they can undertake algo-trading. And traders willing to contract for DEA services might just be looking for a clearer view of the market, more control over their trades, anonymity, or speed.[172]

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[168] *See*, i.a., Alain Chaboud and others, 'Rise of the Machines: Algorithmic Trading in the Foreign Exchange Market' (2014) 69 The Journal of Finance; and Hendershott and Riordan (n 54).

[169] Domowitz and Yegerman (n 39), 1. DEA includes both direct access through DEA services and direct access through membership of a trading venue (*see* OICV-IOSCO, 'Policies on Direct Electronic Access - Consultation Report' (2009)).

[170]*See* MiFID II, recital (62). *See* also the discussion in section 8.2.1.1.

[171] ESMA, 'Consultation Paper: Guidelines on Systems and Controls in a Highly Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (2011) ESMA/2011/224.

[172] *See,* i.a., OICV-IOSCO, 'Principles for Direct Electronic Access to Markets - Final Report' (2010) FR08/10.

3.2.1.2 Higher speeds

The notion that algo-trading is faster than manual trading is also widely shared in the literature,[173] and algo-trading mechanisms are often credited with having enabled participants 'to dramatically speed up the reception of market data, internal calculation procedures, order submission and reception of execution confirmations'[174]—allowing for very short trader reaction times.[175]

Ultimately, these higher speeds are more often associated with the sub-type of algo-trading 'HFT,' but all algo-trading is broadly faster than manual trading.[176] Indeed, a 2013 study of the Australian equity markets found that many of its algo-traders who claimed to be slower than HFTraders were actually 'also engaged in very fast trading, sometimes at average speeds higher than the high-frequency traders,' with reaction times in 'the range of milliseconds.'[177]

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[173] *See,* i.a., Jonathan Ahlstedt and Johan Villysson, 'High Frequency Trading' (Gothernburg: Chalmers University of Technology 2012); Bhupathi (n 50); and Jones (n 39). It is also shared by the EU: *see,* i.a. recital (62) of MiFID II, noting that 'the use of trading technology has increased the speed…of how investors trade.'

[174] Peter Gomber and others, 'High-Frequency Trading' (Goethe-Universität - Frankfurt Am Main 2011), 7.

[175] *See,* i.a.*,* Chaboud and others (n 168); and Walter Mattli, 'Introduction and Overview: A New Capital Market Reality', *Global Algorithmic Capital Markets - High Frequency Trading, Dark Pools, and Regulatory Challenges* (Walter Mattli, Oxford University Press 2019). *See*, also, O'Hara (n 1), noting that the automation of trading decisions and the optimisation of order execution are often associated with increases in trading speed.

[176] *See* Yesha Yadav, 'Algorithmic Trading and Market Regulation', *Global Algorithmic Capital Markets - High Frequency Trading, Dark Pools, and Regulatory Challenges* (Walter Mattli, Oxford University Press 2019); and O'Hara (n 1).

[177] ASIC (n 85), 90.

3.2.2 The impact of the new algo-trading mechanisms on the quality of EU markets

It has been argued that the use of algo-trading mechanisms makes trading fully automated and disintermediated, as well as typically faster than manual trading. It will now be argued that these characteristics fundamentally change the contribution to efficiency and fairness made by the traders who employ these mechanisms—creating new benefits and risks for the quality of EU markets.

3.2.2.1 The benefits of the use of algo-trading mechanisms

First and foremost, the use of algo-trading mechanisms appears to make trading cheaper:[178] automation reduces the costs of most activities, and trading in financial markets is no different.[179]

Indeed, algo-trading helps traders manage the risks inherent in strategies as diverse as market-making[180] and block-trading[181]—not least because the flexibility and higher speeds inherent in algo-trading reduce the costs of managing portfolios and inventories,[182] bringing traders closer to the ideal of

[178] *See*, i.a., Menkveld (n 7); and James Angel, Lawrence E Harris and Chester S Spatt, 'Equity Trading in the 21st Century: An Update' (2015) 5 Quarterly Journal of Finance (QJF) 1.

[179] Menkveld (n 7).

[180] Yadav (n 176).

[181] Menkveld (n 7).

[182] Ciamac C Moallemi and Mehmet Sağlam, 'The Cost of Latency in High-Frequency Trading' (2013) 61 Operations Research 1070.

'frictionless' optimisation.[183] And the fact is that both static and dynamic measures of liquidity—from effective spread[184] to implementation shortfall[185]—have fallen significantly since algo-trading first started growing in popularity.[186]

There is also reason to believe that algo-trading can make positive contributions to the price-accuracy of modern financial markets.

First, the disintermediation inherent in algo-trading has increased the transparency of the trading process—increasing the amount of data directly accessed by traders.[187] Second, algo-trading has armed traders with data-processing capabilities that often surpass human ability[188]—combatting the negative impact of irrationality and human biases[189] on price-accuracy.[190] Finally, algo-trading provides traders with more sophisticated tools to trade on new

[183] Menkveld (n 7).

[184] Angel, Harris and Spatt (n 178).

[185] Andrea Frazzini, Ronen Israel and Tobias J Moskowitz, 'Trading Costs of Asset Pricing Anomalies' (Chicago Booth - Fama-Miller Center for Research in Finance 2012) Chicago Booth Paper No. 14-05.

[186] Menkveld (n 7). The explicit costs of trading—ie, commissions—have also fallen during this period, benefiting both retail and institutional investors (*see,* respectively, Angel, Harris and Spatt (n 178); and Andre Cappon, 'The Brokerage World Is Changing, Who Will Survive?' *Forbes* (16 April 2014)).

[187] Henry TC Hu, 'Too Complex to Depict? Innovation, "Pure Information," and the SEC Disclosure Paradigm' (2012) 90 Texas Law Review 1601.

[188] Yadav (n 176).

[189] For examples of the impact of irrationality and human biases in trading, *see*, i.a., John M Coates, Mark Gurnell and Aldo Rustichini, 'Second-to-Fourth Digit Ratio Predicts Success among High-Frequency Financial Traders' (2009) 106 Proceedings of the National Academy of Sciences 623; and Brad M Barber and Terrance Odean, 'Trading Is Hazardous to Your Wealth: The Common Stock Investment Performance of Individual Investors' (2000) 55 Journal of Finance).

[190] Menkveld (n 7).

information[191]—which is particularly important when executing large orders, with higher implementation shortfall.[192]

3.2.2.2 The risks inherent in the use of algo-trading mechanisms

Algo-trading also carries certain risks for market quality—in the sense that the use of trading mechanisms that automate, disintermediate and speed up the trading process may also harm the contribution that traders make to the efficiency and fairness of the markets where they engage in algo-trading.

First, algo-trading increases the vulnerability of the trading process to machine-driven errors and biases—creating two categories of risks: operational risks and risks of inherent error[193] (together 'cyber risk').

In the context of algo-trading, operational risks are those that arise from reliance on automated-trading technology. Automated technology is invariably vulnerable to malfunction, and trading algorithms, in particular, can always fall victim of 'software glitches, erroneous source code, or disruptions in connectivity.'[194] As such, operational risks affect all algo-trading to some extent.

In turn, risks of inherent error are those that arise from the disintermediation and higher speeds of algo-trading. The fact that all algo-trading

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[191] Yadav (n 176).

[192] *See* O'Hara (n 1). *See* also chapter 2.

[193] Yadav (n 176), 239.

[194] ibid.

is fully disintermediated and devoid of human intervention means that humans are not often able to intervene in real-time to address malfunctions in automated-trading technology[195]—which is especially problematic when trading also occurs very fast and significant damage can occur before humans can stop it.[196]

These cyber risks are further magnified when trading algorithms—often programmed to 'trade off "smarts" for speed'—are deployed in environments as complex as most modern markets, with their high-volumes of hard-to-process data.[197] In particular, algorithms—namely, investment decision algorithms—have been known to struggle with soft, contextual data.[198]

Notably, the fact that algorithms are especially receptive to certain types of data—and overly prone to ignore others—can encourage different algorithms (from different traders) to respond correlatedly to the same inputs.[199] Therefore, algo-trading can amplify market trends very rapidly—which is fine when algorithms get it right, but can turn disastrous when they all ignore or misinterpret the same piece of information. These errors can then decrease price-accuracy,

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[195] ibid.

[196] In other words, this risk may be compounded in the context of HFT strategies, which could justify differences in regulatory treatment. For a discussion, *see* chapter 9.

[197] *See* Budish, Cramton and Shim (n 27), 1615; and Yadav (n 30).

[198] Sarah Zhang and Ryan Riordan, 'Technology and Market Quality: The Case of High Frequency Trading' (2011) ECIS 2011 Proceedings 95.

[199] Chaboud and others (n 168).

and are particularly consequential in simpler algorithms, which consider less information and are less sensitive to changes in data.[200]

Finally, it is worth noting that, while all instances of algorithm malfunctions can affect the trader that employed the malfunctioning algorithms, their impact is broader—and they can also inflict negative externalities on other market players.[201] Specifically, algorithm malfunctions can cause strain on venue infrastructure, absorb liquidity, and spread quickly to the sphere of other market participants—and, crucially, across markets.[202]

This happens because although most modern markets—and certainly the EU capital markets—are highly fragmented, they are also highly inter-connected, namely by the activity of algo-traders:[203] as a result, the impact of misbehaving algorithms is often compounded by 'speed and interconnectivity,' fuelling cross-

[200] Indeed, simple execution algorithms that do not take price into account may be more likely to cause extreme price movements than those that do (*see* CFTC and SEC, 'Findings Regarding the Market Events of May 6, 2010 - Report of the Staffs of the CFTC and SEC to the Joint Advisory Committee on Emerging Regulatory Issues' (2010), cited *in* ESMA, 'Consultation Paper: Guidelines on Systems and Controls in a Highly Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (n 171)).

[201] *See* Jones (n 39), 40, noting that 'errors [from rogue algorithms] have the potential to impose externalities on others.' *See*, also, James J Angel, 'When Finance Meets Physics: The Impact of the Speed of Light on Financial Markets and Their Regulation' (2014) 49 Financial Review 271, 278—observing that 'freak events can be triggered from programming glitches in which seemingly innocuous minor changes lead to a major catastrophe.' *See*, finally, the excessive investment in low-latency technology denounced *in* Budish, Cramton and Shim (n 27).

[202] For instance, in 2012, US securities trader Knight Capital mistakenly deployed an algorithm that not only caused it losses of around $460 million, but also caused 'significant swings in the share prices of almost 150 stocks' (*see* Kirilenko and Lo (n 29), 65), as well as significant variations in trading activity—not just at NYSE (where the algorithm was originally active), but also, for example, at NASDAQ (*see* Yadav (n 176)). For a discussion, *see* chapter 4.

[203] Notably, algo-traders can trade quickly across multiple markets, strengthening informational and transactional ties (*see* Yadav (n 176)).

market instability,[204] and contributing to the creation of persisting and self-enforcing trends, which can quickly develop into price bubbles.

The most expressive example of this systemic risk[205] created by algo-trading is the extreme 'bad volatility'[206] episodes known as flash crashes.[207]

In particular, algo-trading has been linked to the 2010 Flash Crash,[208] a systemic intraday event that saw the prices of more than 300 different securities traded in US markets suddenly move '60% or more away' from their then-current

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[204] Kern and Loiacono (n 77).

[205] *See* Yadav (n 176); Conac (n 31); and Foresight, 'The Future of Computer Trading in Financial Markets: An International Perspective' (n 7). For a definition of systemic risk, *see* IMF, BIS and FSB, 'Guidance to Assess the Systemic Importance of Financial Institutions, Markets and Instruments: Initial Considerations - Background Paper' (2009) Report to the G-20 Finance Ministers and Central Bank Governors).

[206] In this context, 'bad volatility' is used to describe price variations that do not translate an actual change in the value of the underlying asset (which, in the case of equity securities, corresponds roughly to the value of the stream of discounted future cash flows of a particular firm); by contrast, 'good volatility' is used to describe price fluctuations justified by variations in the value of the underlying asset. For a discussion of the term 'excess volatility' (essentially corresponding to the idea of 'bad volatility'), *see*, i.a., John Y Campbell and Robert J Shiller, 'Stock Prices, Earnings and Expected Dividends' (1988) 43 Journal of Finance 661.

[207] *See*, i.a., OICV-IOSCO, 'Regulatory Issues Raised by the Impact of Technological Changes on Market Integrity and Efficiency - Consultation Report' (2011) CR02/11; and Charlie X Cai and others, 'Informed Trading and Market Structure' (2015) 21 European Financial Management 148, linking algo-trading to greater volatility (and the proliferation of 'flash crash' episodes).

[208] The 2010 Flash Crash is just one of many episodes that have drawn attention to the need to regulate algo-trading. Some of these episodes arose from algorithms reacting too quickly to (often inaccurate) news-reporting (like the crash caused by a hacked Associated Press twitter account reporting on an inexistent attack on the White House in 2013, or the fall experienced by United Airline shares when an erroneous news report announced that the company had filed for a second bankruptcy in 2008), or from algorithms misbehaving as a result of glitches (like the Knight Capital incident discussed in fn 202). Other episodes, still, were caused by failures in venue infrastructure (as exemplified by NASDAQ not being able to handle demand during the Facebook IPO in 2012). Finally, there have also been instances of intentionally programmed market manipulation; for example, Citadel Securities, LLC was fined for quote stuffing in 2014 and Michael Coscia was found guilty of spoofing in 2015.

values and bounce back to those values—all within 30 minutes.[209] And while there may have been more to the 2010 Flash Crash than just the actions of algo-traders,[210] a joint-report by the US Securities and Exchange Commission ('SEC') and the US Commodity Futures Trading Commission ('CFTC') did note that the episode originated in a sell-program implemented via a misbehaving execution algorithm—and was exacerbated by the (in)action of the specialised algo-traders known as HFTraders.[211]

Ultimately, episodes like the 2010 Flash Crash dry up liquidity and cause prices to deviate from their theoretical fundamental values—but their impact may be just temporary, and it is not clear whether it represents a serious threat to long-term market efficiency.[212] Regardless, there can be no question that these episodes 'impair market confidence,'[213] undermining perceptions of fairness—

[209] *See* Andrei A Kirilenko and others, 'The Flash Crash: The Impact of High Frequency Trading in an Electronic Market' (2017) 72 The Journal of Finance. Further analysis of the 2010 Flash Crash can be found, i.a., *in* David Easley, Marcos M López de Prado and Maureen O'Hara, 'The Microstructure of the "Flash Crash": Flow Toxicity, Liquidity Crashes, and the Probability of Informed Trading' (2011) 37 The Journal of Portfolio Management 118; Eric M Aldrich, Joseph Grundfest and Gregory Laughlin, 'The Flash Crash: A New Deconstruction' (2017) <https://papers.ssrn.com/abstract=2721922> accessed 31 July 2020; and Albert J Menkveld and Bart Z Yueshen, 'The Flash Crash: A Cautionary Tale about Highly Fragmented Markets' (2018) 65 Management Science.

[210] There is still some debate over whether algo-traders triggered the events of May 2010, but there is relative consensus that algo-trading at least contributed to the propagation of the extreme volatilities experienced across the E-Mini S&P markets where everything started (*see* Kirilenko and others (n 209)).

[211] CFTC and SEC (n 200).

[212] In this sense, *see* Fox, Glosten and Rauterberg (n 2).

[213] Oxera, 'What Is the Economic Impact of the MiFID Rules Aimed at Regulating High-Frequency Trading? An Economic Impact Assessment.' (Foresight, Government Office for Science 2012), 70.

which is both a pre-condition for efficiency, as well as an independent indicator of market quality.

3.2.2.3 The perceived association between algo-trading and market manipulation

More controversially, the use of algo-trading mechanisms has also been linked to an increased risk of market manipulation.[214]

This idea that the use of algo-trading mechanisms makes a special contribution to the risk of market manipulation is typically based on a combination of three arguments: a substantive argument that algo-trading provides novel ways to manipulate the market;[215] and two pragmatic arguments that algo-trading has increased market manipulation levels[216]—or has, at least, made this type of misbehaviour more difficult to monitor and detect.[217]

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[214] *See,* i.a. Khaldoun Khashanah, Ionut Florescu and Steve Yang, 'On the Impact and Future of HFT' (Stevens Institute of Technology - Financial Engineering Division School of Systems and Enterprises 2014) White Paper.

[215] *See*, i.a., Kiyohiko G Nishimura, 'Electronic Trading and Financial Markets' (International Paris-Europlace Financial Forum, Tokyo, 29 November 2010); Stéphane Daniel, 'New Technologies and Market Abuses: Outdated Legal Frameworks, Short-Falling Reforms and New Proposals' (LLM Dissertation, London School of Economics 2013); and Tom CW Lin, 'The New Market Manipulation' (2017) 66 Emory Law Journal 1253.

[216] *See* the concerns expressed, i.a., *in* Charles R Korsmo, 'High-Frequency Trading: A Regulatory Strategy' (2013) 48 University of Richmond Law Review 523; Austrian Federal Chamber of Labour - Brussels Office, 'Go Ahead for Overhaul of the Markets in Financial Instruments Directive (MiFID/MiFIR 2): Public Hearing in the European Parliament' (2011) News - Consumers; and Daniel (n 215).

[217] *See*, i.a., Joseph E Stiglitz, 'Tapping the Brakes: Are Less Active Markets Safer and Better for the Economy?' (Federal Reserve Bank of Atlanta 2014); Matt Prewitt, 'High-Frequency Trading: Should Regulators Do More?' (2012) 19 Michigan Telecommunications and Technology Law Review 131; Nishimura (n 215); and Mao Ye, Chen Yao and Jiading Gai, 'The Externalities of High Frequency Trading' [2013] SSRN <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2066839> accessed 31 July 2020.

In truth, there is not much theoretical support for the notion that algo-traders engage in types of manipulation that are fundamentally different from traditionally-prohibited forms of market manipulation[218]—nor is there any empirical evidence that algo-trading has increased market manipulation levels.[219] Indeed, the opposite might be true, with a 2015 study revealing that markets dominated by certain algo-trading strategies experience less (of certain types of) manipulation.[220]

The pragmatic argument that algorithmic trading-driven manipulation is harder to monitor and detect is more difficult to evaluate.

In theory, algo-trading is more likely to fall into patterns, and market surveillance systems—which are typically designed to pick up logic sequences, as opposed to one-off trades[221]—may be better equipped to deal with the (relative) predictability of algorithms than with the (relative) randomness of humans. This certainly hinges on the condition that regulators and supervisors

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[218] *See*, i.a., Thomas Clarke, 'High-Frequency Trading and Dark Pools: Sharks Never Sleep' (2014) 8 Law and Financial Markets Review 342; Bhupathi (n 50); and Korsmo (n 216).

[219] *See*, i.a., Frank J Fabozzi, Sergio M Focardi and Caroline Jonas, 'High-Frequency Trading: Methodologies and Market Impact' (2011) 19 Review of Futures Markets 7; and Foresight, 'The Future of Computer Trading in Financial Markets: An International Perspective' (n 7).

[220] *See* Cumming *et al* noting that 'marketplaces with a significant presence of HFT are substantially less likely to experience [end-of-day] manipulation and more severe [end-of-day] manipulation' (Douglas J Cumming, Feng Zhan and Michael J Aitken, 'High Frequency Trading and End-of-Day Price Dislocation' (2015) 59 Journal of Banking & Finance 330, 331). *See*, also, a 2012 Foresight report, speculating that some algo-traders—HFT arbitrageurs—'have powerful means and incentives to keep prices in equilibrium and to inflict losses on manipulators, as they focus on the relative pricing of economically similar securities,' which means that their activity may 'make abuse less likely' (*see* Foresight, 'The Future of Computer Trading in Financial Markets: An International Perspective' (n 7), 94).

[221] *See* Douglas Cumming and Sofia Johan, 'Global Market Surveillance' (2008) 10 American Law and Economics Review 454.

have the technology needed to keep up with algo-traders—which may not always be the case[222]—but the truth is that there is no concluding evidence that algo-trading has made a material contribution to increasing the difficulties of monitoring and detecting market manipulation.[223]

3.2.2.4 The overall impact of algo-trading on the quality of EU markets

Overall, there is relative consensus that the use of algo-trading mechanisms has made trading cheaper and more impermeable to human bias, as well as more immediate and transparent—with positive impact on liquidity and price-accuracy.

Simultaneously, algo-trading is also particularly vulnerable to machine-driven errors and biases, which can travel fast and correlatedly across the markets—with negative impact on market quality. Additionally, algo-trading carries an inherent risk of overloading the existing market infrastructure and is more difficult to keep under control. As a result, the use of algo-trading mechanisms has also been linked to extreme volatility episodes that can spread rapidly across the markets with important systemic consequences.

[222] *See* Douglas W Arner, Jànos Barberis and Ross P Buckley, 'FinTech, RegTech and the Reconceptualization of Financial Regulation' (2017) 37 Northwestern Journal of International Law & Business); and Avgouleas *in* Authority of the House of Lords, 'MiFID II: Getting It Right for the City and EU Financial Services Industry' (EU Committee 2012) 28. There are, however, some hopeful signs that regulators may be able to keep up: *see*, i.a., the case of SEC, who turned to HFTraders for help in developing new market surveillance system 'MIDAS' (*see* Nathaniel Popper and Ben Protess, 'To Regulate Rapid Traders, SEC Turns to One of Them' *The New York Times* (7 October 2012)). For a helpful systematisation of the challenges faced by regulators 'in a FinTech/RegTech-dominated world' *see* Luca Enriques, 'Financial Supervisors and Regtech: Four Roles and Four Challenges' (2017) 53 Revue Trimestrielle de Droit Financier).

[223] Although, if it did, that could also explain the lack of evidence linking algo-trading to increased levels of market manipulation.

These risks are all inherent in the very nature of algo-trading: they arise because (all) algorithmic trading is automated, disintermediated and generally faster than manual trading.

This remains true even if certain types of algorithms might be more prone to these risks than others—and should remain true even as algorithms start embracing machine-learning.[224] And, crucially, it continues to be true even if some of these risks are amplified by the strategies of particular market players—including not just algo-traders, but also trading venues and other intermediaries.

3.3 New strategies for new markets

The change brought by automated-trading technology to EU markets cannot be reduced to its direct incorporation into the mechanisms used by most traders in those markets. A complete evaluation of the change brought by this technology to these markets must also contemplate its wider indirect impact on market strategies.

This section therefore analyses the strategies developed by trading venues (*3.3.1*), other intermediaries (*3.3.2*) and algo-traders themselves (*3.3.3*) in indirect response to the availability of automated-trading technology and the popularisation of algo-trading across EU markets. It then discusses how these different strategies have impacted the quality of these markets (*3.3.4*)—

[224] Indeed, the use of machine-learning algorithms in trading might carry additional risks, in particular from crowded trades: *see*, i.a., Jon Danielsson, Robert Macrae and Andreas Uthemann, 'Artificial Intelligence and Systemic Risk' (2019) Systemic Risk Centre Special Papers SP 16.

particularly, if not exclusively, by amplifying the benefits and risks associated with the general use of algo-trading mechanisms.

3.3.1 The new strategies adopted by trading venues in EU markets

Trading venues help markets function more efficiently and fairly, providing infrastructure that registers the orders conveyed by traders, matches those orders through variable price-formation mechanisms, and assists in the execution of any resulting transactions.[225]

Intuitively, the contribution made by trading venues to market quality depends on the mechanisms and strategies that they adopt—which are, in turn, permeable to the forces of technology, regulation and competition.[226] In particular, the conduct of EU venues has been significantly changed by the advent of automated-trading technology.[227]

Specifically, the widespread availability of automated-trading technology and the subsequent popularisation of algo-trading have indirectly encouraged EU venues to adopt new strategies designed to appeal to algo-traders.[228] Ultimately,

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[225] Armour and others (n 4).

[226] As are all user-connecting platforms (*see* Menkveld (n 7)). *See*, also, Merritt B Fox, Lawrence R Glosten and Gabriel V Rauterberg, 'The New Stock Market: Sense and Nonsense' (2015) 65 Duke Law Journal 191.

[227] The conduct of trading venues has also been (directly) changed by the advent of algorithmic technology more broadly, but the analysis of that change exceeds the scope of this thesis.

[228] O'Hara (n 1).

this has resulted in changes to procedures for matching and market-clearing, in changes to speed and access arrangements, and in changes to fee structures.[229]

3.3.1.1 Procedures for matching and market-clearing

Venues can choose between two types of market design: order-driven, which allows traders to meet by relying on pre-established order precedence and pricing rules; and quote-driven, where trades are arranged by dealers, who also supply liquidity and guarantee order execution.[230] And while quote-driven markets were once the rule, advances in technology—namely automated-trading technology—have encouraged most EU venues to implement order-driven platforms (or hybrid systems) dominated by electronic order books.[231]

Venues opting for order-driven systems must also choose the frequency with which their markets are cleared:[232] under discrete-time designs, orders are processed in batches and cleared through auctions held at regular intervals;[233] in

[229] Arguably, the new automated-trading environment has also encouraged the popularisation of 'dark pools': trading environments with controlled access, which do not publicly display quotes and where slower traders can take cover from faster HFTraders. For a discussion of the role played by dark pools in EU markets, *see* Oxera, 'The Design of Equity Trading Markets in Europe - An Economic Analysis of Price Formation and Market Data Services' (2019) Prepared for Federation of European Securities Exchanges; and Monica Petrescu and Michael Wedow, 'Dark Pools in European Equity Markets: Emergence, Competition and Implications' (ECB 2017) 193.

[230] For a discussion, *see* Armour and others (n 4).

[231] Rama Cont, Sasha Stoikov and Rishi Talreja, 'A Stochastic Model for Order Book Dynamics' (2010) 58 Operations Research 549.

[232] Marlene Haas and Marius Zoican, 'Beyond the Frequency Wall: Speed and Liquidity on Batch Auction Markets' (2016) Post-Print hal-01484805, HAL.

[233] *See* Kenneth D Garbade and William L Silber, 'Structural Organization of Secondary Markets: Clearing Frequency, Dealer Activity and Liquidity Risk' (1979) XXXIV The Journal of Finance. Depending on how long these intervals are, these auctions can be classified as FBAs; for a discussion of FBAs, *see* Budish, Cramton and Shim (n 27).

continuous-time markets, orders generally trade as they match.[234] And, again, while most venues used to operate in discrete-time,[235] most EU venues now operate in continuous-time, with two-sided auctions at the beginning and end of each trading day.[236]

The basic building-blocks of these continuous-time markets are limit orders,[237] which are instructions specifying how much of a particular instrument a trader wants to buy (sell), and for what maximum (minimum) price—and which can be marketable or non-marketable depending on whether they can be immediately fulfilled.[238] As a result, once a limit order is submitted to a venue, it either becomes part of its limited order book ('LOB')—as a bid/ask—or leads to a trade.[239] At each point, the LOB displays all outstanding limit orders, illustrating how liquid that particular venue is.

The functioning of LOBs explains their popularity with modern EU venues:[240] LOBs are less dependent on specialists, dealers and brokers—

[234] Erik Brinkman and Michael P Wellman, 'Empirical Mechanism Design for Optimizing Clearing Interval in Frequent Call Markets' (2017) Proceedings of the 2017 ACM Conference on Economics and Computation.

[235] For example, the NYSE operated as a twice-daily call auction until 1882, when call auctions were formally eliminated for stocks (*see* Garbade and Silber (n 233)).

[236] *See*, i.a., Budish, Cramton and Shim (n 27); Fox, Glosten and Rauterberg (n 226); Menkveld (n 7). These auctions are often complemented by additional auctions, particularly after a venue has been forced to interrupt its activity (for example following a trading halt).

[237] There are other order types in LOB markets, but they are all 'proxy instructions to the exchange for the generation of limit orders' (*see* Budish, Cramton and Shim (n 27)).

[238] Fox, Glosten and Rauterberg (n 226).

[239] ibid.

[240] *See* Oxera (n 229). Examples of EU venues that function as LOBs include Euronext (which combines six local markets into a single order book), the two venues operated by the Deutsche

replacing their services with computer programs capable of autonomously channelling limit orders into the market.[241] This allows venues to operate more cheaply[242]—but also to offer the speed and responsiveness demanded by the algo-traders that currently dominate EU markets.[243]

Finally, it is noteworthy that while LOB markets process orders serially and continuously, under price-time priority rules,[244] order submission is nevertheless subject to minimum price variations, and that these minimum tick sizes have been decreasing in markets—such as EU markets—where venues have been able to use them to compete for algorithmic order-flow.[245]

3.3.1.2 Speed and access arrangements

Modern trading venues, including EU venues,[246] also compete for algo-trading order flow through speed and access arrangements—in particular by allowing

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Börse (which operate as central LOBs with continuous trading interrupted by a mid-day auction), and NASDAQ Nordic (which combines four local markets into a centralised LOB). Interestingly, periodic auction platforms have also experienced a recent surge in popularity—which appears to be related with suspensions of the double volume-cap mechanism applicable to 'dark pools' under MiFIR (*see* ESMA, 'Final Report - Call for Evidence on Periodic Auctions' (2019) ESMA70-156–1035).

[241] Jones (n 39).

[242] Menkveld (n 7).

[243] *See* Fox, Glosten and Rauterberg (n 226); Menkveld (n 7). However, *see* Budish, Cramton and Shim (n 27). for a criticism of continuous-time markets.

[244] *See* Budish, Cramton and Shim (n 27); and Menkveld (n 7).

[245] In EU markets, competition between venues—in particular on tick size—was encouraged by the first version of MiFID. MiFID II crucially imposes a minimum tick size regime (*see* chapter 7).

[246] *See,* i.a. Euronext, which on its website promises 'low latency' trading platforms that host 'faster' trading systems (Euronext, 'Connectivity' available at <https://www.euronext.com/en/connecting>).

access to their platforms via DEA services and by offering co-location capabilities.[247]

Increased venue speed typically allows traders to realise higher gains, particularly in the context of algo-trading. But not all algo-traders trade at the same speed, or value speed equally, turning it into an ideal differentiation factor for venues—who might want to host different types of platforms: some faster and designed to attract speed-seeking algo-traders;[248] and others slower and devised to protect slower traders.[249]

But, for speed-seeking algo-traders, electing to trade on a fast venue is just the first decision of many. Even these traders employ highly heterogeneous strategies[250] and value speed differently[251]—encouraging modern EU venues[252] to offer different connection speeds to their matching engines.[253]

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[247] Oxera (n 229).

[248] Emiliano Pagnotta and Thomas Philippon, 'Competing on Speed' (2018) 86 Econometrica.

[249] Indeed, some traders prefer relatively slower markets. The US-based IEX, for example, competes with other venues by offering an environment free from harmful, speed-fuelled trading practices and maintains an artificial 350-microsecond speed-bump that slows down incoming orders (*see* Daniel Aisen, 'Incentivizing Trading Behavior Through Market Design' (December 2017) <https://iextrading.com/docs/Incentivizing%20Trading%20Behavior.pdf> accessed 31 July 2020). The NYSE too has secured approval to introduce its own speed-bump in its NYSE American market (*see* Matt Turner, 'A War of Words between 2 of America's Stock Exchanges Has Taken a Strange Twist' *Business Insider* (13 March 2017)).

[250] *See* Kirilenko and others (n 209). These strategies are discussed in section 3.3.3.2.

[251] Matthew Baron and others, 'Risk and Return in High-Frequency Trading' (2019) 54 Journal of Financial and Quantitative Analysis 993.

[252] Oxera (n 229).

[253] *See* Menkveld (n 7); and O'Hara (n 1).

3.3.1.3 Fee structures

The advent of automated-trading technology has also influenced venue competition for algo-trading order flow on the basis of market data fees and trading fees.

Indeed, the popularisation of algo-trading has been followed by a slight increase in market data fees,[254] as well as by an increase in the variety of market data products offered by EU venues—appealing to traders with different appetites for detail and speed.[255] At the same time, EU venues have also responded to the fact that many algo-trading strategies rely on the quick submission of large volumes of orders by decreasing their trading fees.[256]

Finally, many EU venues[257] have attempted to employ asymmetric fee models to increase the attractiveness of their platforms in the current (automated) trading environment:[258] with some charging higher fees to liquidity-taking

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[254] According to a 2019 Oxera report on EU markets, ‘there has been a general upward trend in market data consumption,’ which has been ‘driven by a rise in trading strategies that require more data, in particular from the significant growth in electronic trading,’ leading to most exchanges increasing—if only slightly—their data fees (*see* Oxera (n 229)).

[255] *See* ibid.—and also for a discussion of the relationship between market data fees and trading fees.

[256] *See* Pagnotta and Philippon (n 248). A report written by Oxera in 2019 also reveals that EU markets have been featuring ‘lower trading fees and new service propositions to traders and investors’ (*see* Oxera (n 4)); back in 2009, the EC had already noted that ‘fee reductions…by some regulated markets’ had been particularly ‘significant for algorithmic trading’ (*see* CESR, ‘Impact of MiFID on Equity Secondary Markets Functioning’ (2009) Report CESR/09-355.Committee of European Securities Regulators (n 4), 18).

[257] These fee structures were popularised within the EU by multi-lateral trading facilities like Chi-X, BATS and Turquoise (*see* Gomber and others (n 174)).

[258] Hendershott, Jones and Menkveld (n 36).

participants and lower fees to traders engaged in market-making ('maker-taker model'); and others doing the exact opposite ('taker-maker model').[259]

Although these asymmetric models became fairly popular after first being introduced in the 1990s—they have lately been facing increasing competition from alternative models,[260] and closer scrutiny from regulators.[261] Still, the ability to tailor fee structures remains an important tool for venues competing for algorithmic order flow[262]—particularly as many algo-trading strategies rely significantly on volume and large-scale trading.[263]

3.3.2 The new strategies adopted by intermediaries in EU markets

It is not just venues that can contribute to market quality: their role is complemented by agents acting as information, liquidity, execution, and post-

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259 For a discussion of rebates in the context of the EU regime, *see* chapter 7.

260 *See,* for example, the IEX transparent flat fee price arrangement.

261 *See,* i.a., article 48(9) of MiFID II, discussed in chapter 7. Notably, the first 'maker-taker' EU venue—the LSEG Turquoise—has now stopped hosting this type of trading fee arrangement.

262 In its 2019 report on EU markets, Oxera explains the success of EU MTFs following the first version of MiFID by highlighting, in particular, their adoption of 'maker-taker fee structures' (*see* Oxera (n 229)).

263 Marios Panayides, Barbara Rindi and Ingrid M Werner, 'Trading Fees and Intermarket Competition' (BAFFI CAREFIN, Centre for Applied Research on International Markets Banking Finance and Regulation 2017) 1751.

trade intermediaries[264]—whose contribution to liquidity and price-accuracy similarly depends on the mechanisms and strategies that they adopt.[265]

Much like venues, intermediaries too can have their strategies and mechanisms significantly transformed by technology, regulation and competition, and the advent of automated-trading technology, specifically, has also caused significant indirect change in the strategies that these intermediaries employ—particularly execution intermediaries.

Indeed, while the availability of automated-trading technology and the popularisation of algo-trading may also have transformed the strategies of information and liquidity intermediaries,[266] its influence was most felt by execution intermediaries[267]—which have not only incorporated (execution) algorithms into their trading, but have also started offering new services to their clients.[268]

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[264] Notably, individual agents can engage in more than one type of intermediation. Investment banks, for example, often act simultaneously as equity-analysts, brokers and dealers (*see* Armour and others (n 4)).

[265] Information intermediaries search, process and transmit the data that is eventually impounded into prices; liquidity intermediaries—or market-makers—cover order imbalances by standing ready to buy and sell the same instruments during market opening hours; execution intermediaries—or brokers—provide traders with access to the venues where they can meet other traders; and post-trade intermediaries help clear and settle transactions. For a discussion, *see* ibid.

[266] The impact of automated-trading technology on algorithmic market-making, in particular, is discussed in section 3.3.3.2, as most liquidity in modern EU markets is provided by algo-traders, and often HFTraders, instead of formally appointed liquidity-providers.

[267] As such, this thesis discusses only the impact of automated-trading technology on the strategies adopted by execution intermediaries—not least because its scope is essentially limited by the EU algo-trading regime (*see* chapter 1), which only covers specifically the behaviour of these intermediaries (*see* chapter 4).

[268] The algo-trading strategies adopted by execution intermediaries are discussed in the next section—which looks at the different algo-trading strategies adopted across EU markets. This

These are the DEA services discussed earlier as one of the mechanisms for ensuring disintermediated access to markets[269]—and they were partly introduced to facilitate algo-trading,[270] and to respond to the increasing demand of algo-traders for speed, flexibility, transparency and control.[271]

Control, in particular, is especially important in markets—such as EU markets—where (uninformed) traders without disintermediated market access often have their order flow executed against the inventory of their intermediaries (or of those willing to pay their intermediaries for order-flow), instead of being directed to trading venues.[272]

Now, this possibility—known as internalisation—can have significant benefits for (uninformed) traders: knowing that they are dealing with uninformed order flow, internalisers can offer (small) price improvements over the quotes displayed in (lit) venues.[273] However, it is not always true that these traders would not have been able to find better prices in (lit) LOBs, as prices change quickly,

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section discusses only the new services offered by execution intermediaries to facilitate algo-trading.

[269] For a discussion of the different categories of DEA, *see* OICV-IOSCO, 'Policies on Direct Electronic Access - Consultation Report' (n 169).

[270] Goldman Sachs, Morgan Stanley and UBS were among the first execution intermediaries to respond to the demand of algo-traders for DEA channels (*see* Morgan Stanley, 'Goldman Sachs, Morgan Stanley and UBS Agree to Provide Reciprocal Dark Pool Access' (20 May 2008). Current examples of EU-registered brokers that provide DEA services include IG, and iDealing.

[271] Gomber and others (n 174).

[272] Anton Golub, John Keane and Ser Huang Poon, 'The Impact of Internalisation on the Quality of Displayed Liquidity' (Foresight 2012) Economic Impact Assessment EIA10.

[273] *See* ibid. Additionally, the benefits from selling order flow may be passed on by brokers to their clients—although the extent to which they are is rather unclear (*see* Fox, Glosten and Rauterberg (n 2)).

and liquidity is more than what is found at the top of the order book.[274] And there is a real danger that execution intermediaries—who stand to receive payments for order flow[275]—let conflicts of interest cloud their judgement as to where the orders of their clients should be routed.[276]

It is therefore unsurprising that traders in modern EU markets have become particularly appreciative of DEA services—which have come to play an important role in facilitating algo-trading.

3.3.3 The new strategies adopted by algo-traders in EU markets

Finally, and perhaps most obviously, the availability of automated-trading technology and the popularisation of algo-trading have indirectly encouraged those traders with access to algo-trading mechanisms to develop a wide variety of trading strategies—divided, for ease of exposition, into two broad categories: vanilla algo-trading strategies and HFT strategies.[277]

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[274] *See* chapter 2.

[275] For a discussion, *see* Fox, Glosten and Rauterberg (n 2).

[276] Notably, most execution intermediaries—and certainly the execution intermediaries subject to EU financial regulation—are subject to best execution requirements (such as those found in MiFID II, article 27), but compliance with these requirements can be particularly hard to assess, particularly when they are 'defined by a [wide] array of execution characteristics (*see* Matteo Aquilina and Carla Ysusi, 'Are High-Frequency Traders Anticipating the Order Flow? Cross-Venue Evidence from the UK Market' (2016) FCA Occasional Paper 16, 18).

[277] While this distinction can be problematic if taken far enough (in particular by being given regulatory relevance), it helpfully showcases the wide spectrum of algo-trading strategies that dominate the modern EU capital markets and their different impact on market quality—which should be taken into account when designing a regulatory response to algo-trading.

3.3.3.1 Vanilla algo-trading strategies

Vanilla algo-trading strategies are those that can be readily employed by most traders in financial markets and include both automated investment decision-making strategies (relying on investment decision algorithms) and automated execution strategies (relying on execution algorithms).[278]

The accessibility of these strategies—including index arbitrage and simple portfolio-rebalancing—comes from the fact that they typically rely on simpler investment decision algorithms, and structured execution algorithms (like 'TWAP' or 'VWAP') connected to automated order routing systems ('AORs').[279] And these (simpler) execution algorithms and AOR systems, in particular, have come to form the basis of essentially all equity trading in modern EU markets.[280]

This is a reflection of the sheer size, complexity and fragmentation of these markets—where securities are often traded across a large number of competing venues (with different structures and rules), through a wide variety of trade-

[278] For the differences between these two categories of algorithms, *see* chapter 2.

[279] There is a variety of execution algorithms. While (more structured) schedule-driven execution algorithms base trading trajectory on historical data, such as the time-weighted average price ('TWAP'), or the volume-weighted average price ('VWAP') of a particular security, (less structured) opportunistic execution algorithms forego pre-defined execution schedules in favour of incorporating real-time information into their execution-optimisation decisions (*see* Ian Domowitz and Henry Yegerman, 'Measuring and Interpreting the Performance of Broker Algorithms' (2005) ITG Inc Research Report, discussed also *in* Jian Yang and Brett Jiu, 'Algorithmic Selection: A Qualitative Approach' (2006) <https://www.cis.upenn.edu/~mkearns/finread/algosel.pdf> accessed 31 July 2020).

[280] *See* O'Hara (n 1). and the discussion in chapter 2.

supporting tools (including co-location and DEA)—making them very difficult to navigate without the help of execution algorithms.[281]

3.3.3.2 HFT strategies

HFT strategies are a sub-set of algo-trading strategies which are often grouped together[282] either because they are carried out by proprietary traders armed with ultra-low latency infrastructure—under a direct approach to defining HFT—or because they are very fast,[283] involve high message intraday rates, avoid overnight positions, or rely on fleeting orders that are cancelled shortly after being placed—under an indirect approach to defining HFT.[284]

Despite being grouped together under the umbrella-term of 'HFT'—not least by this thesis—this group of strategies is extremely heterogeneous and includes a wide variety of trading postures (both aggressive and passive)[285] that

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[281] *See* ibid. This is especially true for execution intermediaries, who may be subject to trade-through rules and best execution principles (*see* Fox, Glosten and Rauterberg (n 2)).

[282] *See* Easley *et al*, noting that 'speed is not the defining characteristic that sets…HFT apart' and that HFT is rather the product of a new 'trading paradigm' characterised by certain 'strategic decisions' (David Easley, Marcos Lopez de Prado and Maureen O'Hara, 'The Volume Clock: Insights into the High Frequency Paradigm' (2012) 39 The Journal of Portfolio Management 19, 19).

[283] While HFT is often described as a sub-type of algorithmic trading that is particularly fast (*see*, i.a., Menkveld (n 7)), all algo-trading is generally faster than manual trading 'with technological improvements originally attaching to HFTs permeating throughout the marketplace' (*see* O'Hara (n 1)). *See* also the discussion in section 3.2.1.2.

[284] For a discussion of the different approaches to defining HFT, *see* ESMA, 'Economic Report: High-Frequency Trading Activity in EU Equity Markets' (ESMA 2014). For a discussion of how HFT can be distinguished from vanilla algo-trading, *see*, i.a., Anton Golub, 'Overview of High Frequency Trading' (Manchester Business School 2011); Jones (n 39); Keller (n 54); Ye, Yao and Gai (n 217); Bhupathi (n 50); and Jonathan Brogaard and others, 'High-Frequency Trading and Extreme Price Movements' (2018) 128 Journal of Financial Economics 253.

[285] Depending, in particular, on whether the strategy creates liquidity—in which case it is passive—or absorbs liquidity—in which case it is aggressive (*see*, i.a., Fox, Glosten and

feed on very different types of data (both fundamental information and order flow),[286] with very different impact on market quality. This section then looks separately at some of the most common HFT strategies: *(1)* market-making strategies, *(2)* low-latency strategies, and *(3)* information-discovery strategies.[287]

(1) HFT market-making strategies

In markets—like EU markets—where most venues operate as LOBs, the business of market-making has become democratised, and any trader placing (non-marketable) limit orders contributes to liquidity.[288]

Still, not all traders make equally significant contributions to liquidity and even LOBs may have the need for professional liquidity-providers; the difference between LOBs and quote-driven markets is that the professional liquidity-providers in LOBs are typically HFTraders—placing orders in the same instruments on both sides of the book, and making the spread on each round-tip transaction.[289]

Rauterberg (n 2); and Foresight, 'The Future of Computer Trading in Financial Markets: An International Perspective' (n 7)).

[286] *See* Menkveld (n 7).

[287] For a detailed description of these (and other) controversial HFT practices, *see* Fox, Glosten and Rauterberg (n 2).

[288] *See* section 3.3.1.1.

[289] Menkveld (n 27).

The reason why HFTraders dominate the business of liquidity-provision in electronic LOBs is that ultra-low latency infrastructure is particularly effective for managing the various risks inherent in market-making.[290]

In regard to information-asymmetry risks, ultra-low latency infrastructure allows HFTraders to both acquire and react to new information very quickly—regardless of whether that information comes from observational data, announcements, or the order-flow.[291] The result is that HFTraders are typically better informed than traditional professional liquidity-providers[292]—and better able to avoid predatory informed trading, namely by quickly updating their quotes.[293]

As for inventory-management risks, ultra-low latency technology helps HFTraders finetune their inventories—allowing them to buy and sell financial instruments faster, and end the trading day on a neutral position.[294] Finally, ultra-low latency technology also helps HFTraders manage their order-processing

[290] For a discussion of these risks, *see* chapter 2.

[291] *See,* i.a. Fox, Glosten and Rauterberg (n 2); and Menkveld (n 7). Particularly in regard to announcement data, *see* Grace Xing Hu, Jun Pan and Jiang Wang, 'Early Peek Advantage? Efficient Price Discovery with Tiered Information Disclosure' (2017) 12 Journal of Financial Economics 399.

[292] For a summary of the different ways in which HFTraders are better informed, *see* Menkveld (n 7).

[293] *See*, i.a. Boyan Jovanovic and Albert J Menkveld, 'Middlemen in Limit Order Markets' (Society for Economic Dynamics 2010) 2010 Meeting Papers 955; and Joel Hasbrouck and Gideon Saar, 'Low-Latency Trading' (2013) 16 Journal of Financial Markets 646.

[294] *See,* i.a., Brown (n 52); and Menkveld (n 7).

risks—namely by helping them trade on a cross-market basis and select the most inviting trading environments.[295]

Indeed, one of the main differences between HFT market-makers and traditional, institutionally-designated market-makers is that HFT market-making is typically 'implemented across and within markets'—and it is not unusual for HFTraders to have positions on just one side of the book in a particular market.[296] Another important difference is that HFTraders are not often subject to continuous market-making requirements.[297]

(2) HFT low-latency strategies: in particular, low-latency arbitrage

The infrastructure at the disposal of HFTraders also puts them in an ideal position to engage in a variety of low-latency strategies[298]—namely, low-latency arbitrage.[299]

Arbitrage has traders looking for 'pricing discrepancies between securities and markets' and 'exploiting these discrepancies.'[300] Typically, the ability to identify these discrepancies is the prerogative of (traditional) informed traders—

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[295] Menkveld (n 27).

[296] O'Hara (n 1), 3.

[297] This stands in contrast with the specialists and dealers employed by venues (*see* Fox, Glosten and Rauterberg (n 2); and O'Hara (n 1)). *See,* however, the new market-making requirements introduced by MiFID II and discussed in chapter 9.

[298] Low-latency strategies are defined as the HFT strategies that depend on ultra-low latency technology.

[299] Fox, Glosten and Rauterberg (n 2).

[300] Armour and others (n 4), 143.

as opposed to liquidity-providers—but HFTraders are better informed than traditional liquidity-providers.[301]

Indeed, the ultra-low latency infrastructure employed by HFTraders is especially advantageous for retrieving information—particularly from announcements and variations in the order flow.[302] And when that information reveals unjustified differences between prices, HFTraders can quickly correct them—bringing prices closer to fundamental values.[303]

Although arbitrage is thus typically regarded as a valuable activity,[304] HFTraders have been accused of engaging in a less-valuable type of arbitrage: a low-latency arbitrage whereby they leverage their infrastructure to 'predict when orders are going to arrive at different trading venues and trade in advance of slower traders'—intermediating 'trades that would have taken place without their involvement,'[305] and making a riskless profit in the process.[306]

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[301] Menkveld (n 7).

[302] *See*, i.a., Hu, Pan and Wang (n 291). Simple algorithms deal better with structured, hard data than with unstructured, soft data (*see* Zhang and Riordan (n 198))—although this might change with the advances of machine-learning (*see* chapter 2).

[303] In particular, HFTraders might engage in pure arbitrage (whereby they detect and correct the differences in prices between the same security trading in different venues), in linked arbitrage (whereby they detect and adjust the differences in prices between securities that exhibit a definitive price relationship), or in statistical arbitrage (whereby they detect and adjust the differences in prices between securities whose values are, or have been, correlated: *see* Oxera (n 213).

[304] Fox, Glosten and Rauterberg (n 226).

[305] Aquilina and Ysusi (n 276), 3.

[306] *See* Fox, Glosten and Rauterberg (n 2). In particular, HFTraders have been noted for using technology to learn that the best available bid or ask are going to change in time for trading against stale midpoint limit orders sitting inside the bid-ask spread, or in 'dark pools.'

(3) HFT information-discovery strategies: in particular, electronic front-running

The final set of HFT strategies considered in this section are those where HFTraders use both their raw speed advantages and superior ability to uncover and process information to compete with slower traders—typically over longer timeframes than those found in low-latency strategies.[307]

These information-discovery strategies can include the use of (investment decision) algorithms to dissect observational data and announcements with the purpose of devising trading strategies that are either more sophisticated than those of other traders, or that take faster advantage of new information.[308]

But HFTraders do not just extract information from observational data and announcements: it has been noted that in (relatively) inefficient markets, the order flow is also an important source of information,[309] and ultra-low latency technology is especially well-suited for taking advantage of unusual trading

[307] Aquilina and Ysusi (n 276).

[308] Typically, HFTraders trade accuracy for speed and may not engage in in-depth fundamental analysis. As for news and announcements, they will cause intense run games (and near-instantaneous quote adjustments), as passive HFTraders run to update 'stale' quotes before they are preyed upon by any aggressive HFTraders looking to 'snipe' those quotes (*see* Budish, Cramton and Shim (n 27))—two strategies discussed previously as 'market-making' and 'low-latency arbitrage.'

[309] *See* chapter 2.

pressures[310]—through a practice that has become known as 'electronic front-running.'[311]

This practice sees HFTraders search the order-flow for signs of child orders: slices of a larger parent order that is currently making its way through the markets, and which has been split across a period of time, and often across venues to decrease implementation shortfall.[312] Once HFTraders learn of this parent order—and can safely predict that more child orders will follow—they start 'running in front of them,' ie, changing quotes ahead of the new child orders ('trading against the wind'), or even trading alongside parent orders perceived as being the most informed ('trading with the wind').[313]

[310] Even when the sources of these trading pressures are hidden in the order-book. Indeed, HFTraders have been known to increase their knowledge of the order-book by engaging in 'pinging,' ie, by placing small orders in dark venues (or inside the bid-ask spread of lit venues) to uncover hidden limit orders and gain a better sense of how the order book is evolving (*see* Fabozzi, Focardi and Jonas (n 219)). Notably, aggressive pinging has led to discussions about whether this practice can amount to market manipulation (*see,* i.a. Lin (n 215); and Gary Shorter and Rena S Miller, 'High-Frequency Trading: Background, Concerns, and Regulatory Developments' (Congressional Research Service 2014) Report Prepared for Members and Committees of Congress 7–5700).

[311] The expression is controversial and has been criticised, in particular, for being too similar to 'frontrunning', which refers to a decidedly illegal practice (for a discussion, *see* Fox, Glosten and Rauterberg (n 2).—who propose that 'electronic frontrunning' be called 'anticipatory order cancelation' instead).

[312] ibid.

[313] *See,* i.a., Robert A Korajczyk and Dermot Murphy, 'High-Frequency Market Making to Large Institutional Trades' (2019) 32 The Review of Financial Studies 1034; and van Kervel and Menkveld (n 27).

3.3.4 The impact of the new algo-trading inspired strategies on market quality

Earlier in this chapter, it was noted that the generalised use of algo-trading mechanisms across EU markets has had a mixed impact on their quality—creating both benefits and risks.

It was also noted that these benefits and risks are inherent in the—automated, disintermediated and fast—nature of algo-trading and are always present in this type of trading, regardless of how the use of algo-trading mechanisms translates into actual trading strategies. However, this does not mean that the extent of these benefits and risks is entirely independent from the strategies specifically adopted by algo-traders—or, crucially, from the strategies adopted by venues and other intermediaries in response to algo-trading.

Indeed, the strategies developed in response to the availability of automated-trading technology and the increasing adoption of algo-trading mechanisms can often amplify the benefits and risks from the use of algo-trading mechanisms. And—although perhaps less obviously—they have also created new benefits and risks that only arise in the particular context of those strategies.

This section examines the benefits and risks created by the different strategies developed by market players in indirect response to the availability of automated-trading technology across EU markets—looking separately at the impact of the strategies developed by venues, intermediaries and traders.

3.3.4.1 The impact of the new strategies adopted by trading venues on EU markets

Overall, the strategies adopted by trading venues in response to algo-trading have had a mixed impact on market quality.

The fact that most venues now operate as continuous LOBs makes trading cheaper and faster[314]—magnifying the increases in efficiency broadly associated with the use of algo-trading mechanisms by traders.[315] Additionally, the fact that venues can offer varying tick size regimes has fuelled competition between platforms, encouraging them to allow traders to 'trade in ever smaller increments'[316]—and thus putting pressure on bid-ask spreads.[317]

At the same time, fast continuous LOBs—that work with ever-decreasing tick size regimes—can also add fuel to the extreme volatility episodes that sometimes plague modern markets,[318] particularly when venue trading systems

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[314] Marco Pagano, 'The Changing Microstructure of European Equity Markets', *European Securities Markets, The Investment Services Directive and Beyond* (Guido Ferrarini, Kluwer Law International 1998).

[315] *See*, i.a., Brogaard *et al* noting that algo-trading activity—and HFT speed—tends to increase when venues also increase their speed (Jonathan Brogaard and others, 'High-Frequency Trading and the Execution Costs of Institutional Investors' (2014) 49 Financial Review 345). *See*, also, Menkveld and Zoican noting that speeding up a venue enables high-frequency market-makers to update their quotes faster, which could have a positive impact on liquidity, depending on how other (predatory) traders behave (Albert J Menkveld and Marius Zoican, 'Need for Speed? Exchange Latency and Liquidity' (2017) 30 Review of Financial Studies 1188).

[316] James J Angel, 'Tick Size Regulation: Costs, Benefits, and Risks' (2012) Economic Impact Assessment EIA7.

[317] *See* Fox, Glosten and Rauterberg (n 2), noting the link between smaller tick size regimes and narrower spreads.

[318] *See* MiFID II, recital (62). *See,* also Goldstein and others (n 80); and Gaia Balp and Giovanni Strampelli, 'Preserving Capital Markets Efficiency in the High-Frequency Trading Era' (2018) 2

are unable to keep up with the continuous order-flow generated by algo-trading, the significant order volumes associated with many algo-trading strategies, or the glitches that are always a risk with this trading.[319]

And even when the systems of these modern LOBs work as intended, some would argue that the continuous-trading model is flawed by design, invariably creating low-latency arbitrage opportunities for which algo-traders compete in ‘run games’ that can only be won by the fastest among them—pushing them into a wasteful technological arms race to the bottom, which often includes overinvestment in co-location and DEA services.[320]

In terms of market data fees, the different data products currently sold by most venues generally facilitate the use of algo-trading mechanisms,[321] amplifying their impact on market quality. At the same time, the offer of these differentiated products—along with the offer of different co-location

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Journal of Law, Technology & Policy 349. Specifically in regard to tick size regimes, *see* Angel (n 316).

[319] In particular, it is worth recalling the 2012 Facebook IPO, when NASDAQ—which had been selected by Facebook as the best place to list its shares for being a ‘technology-savvy exchange’—experienced an ‘unforeseen glitch’ in its system for IPOs, which ‘interacted unexpectedly with trading behaviour’ and ended up delaying the Facebook IPO by 30 minutes (*see* Kirilenko and Lo (n 29)).

[320] *See,* i.a., Budish, Cramton and Shim (n 27); and Menkveld and Zoican (n 315).

[321] *See* Oxera (n 229). For the US, *see*, i.a., SEC, ‘Staff Report on Algorithmic Trading in U.S. Capital Markets’ (2020).

arrangements—may encourage the creation of two-tiered markets where retail traders are systematically disadvantaged in their market interactions.[322]

When it comes to trading fees, the asymmetric structures popularised in the last two decades—but recently discouraged by MiFID II[323]—have an ambiguous impact on market quality:[324] while traders might benefit from having more options, this increased choice also makes it harder to monitor the activity of execution intermediaries, who may struggle with the increased conflicts of interest created by these structures.[325]

Finally, the fact that most EU venues have been slightly increasing their market data fees while significantly decreasing their trading fees, could indicate a transition into markets that are more liquid and enjoy higher price-accuracy—but only to the extent that any increases in fees do not discourage agents from trading in these markets (with negative impact on their quality).[326]

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[322] *See,* i.a., Steven R McNamara, 'The Law and Ethics of High-Frequency Trading' (2016) 17 Minnesota Journal of Law, Science & Technology 71.

[323] MiFID II, article 48.

[324] In perfectly efficient markets, the use of asymmetric 'maker-taker' and 'taker-maker' models should not matter at all: the cheaper liquidity created in 'maker-taker' markets should off-set the higher fees paid by liquidity takers (and vice-versa). However, these asymmetric fee models become important in real-world markets, where there is a need for execution intermediaries—and most retail trading is actually intermediated (*see* Fox, Glosten and Rauterberg (n 2)).

[325] For a discussion of the advantages and disadvantages of different asymmetric fee structures, *see* ibid.

[326] This trade-off and the conditions for an optimal mix of market data and trading fees are discussed in more detail *in* Oxera (n 229).

3.3.4.2 The impact of the new strategies adopted by intermediaries on EU markets

Intermediaries—and, particularly, execution intermediaries—have responded to the widespread availability of automated-trading technology and the popularisation of algo-trading by beginning to offer DEA services catering to algo-traders and their appetite for disintermediation.[327]

The supply of DEA services has three main effects. First, it facilitates algo-trading, allowing for full disintermediation and increasing the speed with which orders are transmitted[328]—and consequently exacerbating the benefits and risks associated with the general use of algo-trading mechanisms.

Second, the supply of DEA services increases the transparency of the trading process, as well as trader control over that process,[329] which should help protect investors against abuses from execution intermediaries and re-direct trading into lit venues, with positive impact on liquidity and price-accuracy.[330] At the same time, the use of DEA services also limits the role played by these

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[327] Another important change in the strategy of execution intermediaries has been the overwhelming adoption of execution algorithms. However—because execution algorithms have become the building block for virtually all financial markets trading (*see* O'Hara (n 1))—their impact on market quality is discussed together with the impact of vanilla algo-trading strategies, below.

[328] OICV-IOSCO, 'Policies on Direct Electronic Access - Consultation Report' (n 169).

[329] *See* Busch (n 31); and OICV-IOSCO, 'Policies on Direct Electronic Access - Consultation Report' (n 169).

[330] For a discussion about the role played by dark-pools in modern financial markets and potential abuses by execution intermediaries, *see* Fox, Glosten and Rauterberg (n 2).

intermediaries in preventing or curtailing the effects of the extreme volatility episodes that have been linked to the use of algo-trading mechanisms.[331]

Finally, the supply of DEA services raises fairness concerns,[332] to the extent that the availability of DEA services puts their users at a relative advantage when compared to other traders[333]—particularly since execution intermediaries do not always offer these arrangements to retail traders.[334]

3.3.4.3 The impact of the new strategies adopted by algo-traders on EU markets

The impact of *(1)* vanilla algo-trading and *(2)* HFT on the quality of EU markets varies significantly across strategies.

(1) Vanilla algo-trading strategies

The impact of automated investment decision-making strategies on market quality essentially depends on the extent to which the investment decision algorithms employed in these strategies are vulnerable to the cyber risk inherent in all algo-trading. They can make a positive contribution to price-accuracy to the extent that 'machines' have greater processing power and are less prone to

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331 *See*, i.a., Busch (n 31); and OICV-IOSCO, 'Policies on Direct Electronic Access - Consultation Report' (n 169).

332 Particularly under a broader notion of fairness whereby all market participants are required to enjoy equivalent processing capabilities and bargaining power (*see* Shefrin and Statman (n 114)). For a discussion, *see* chapter 2.

333 OICV-IOSCO, 'Policies on Direct Electronic Access - Consultation Report' (n 169).

334 *See* chapter 4.

biases than humans—but they can also harm market quality when they give rise to systemically-relevant operational and inherent errors.[335]

The impact of automated execution strategies on market quality deserves closer analysis, particularly when they are used to support the implementation of large—often informed—orders.[336]

In this context, automated execution strategies may have a positive impact on long-term price-discovery,[337] to the extent that execution algorithms help informed traders profit from their information-gathering efforts[338]—as well as on liquidity, to the extent that slicing parent orders into multiple child orders smooths out the trading process, preventing liquidity shortages and volatility spikes.[339]

At the same time, these strategies can also have a negative impact on liquidity, to the extent that they increase the information asymmetry risk inherent in market-making[340]—and, consequently, on price-accuracy, to the extent that all

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335 *See*, i.a., John Paul Broussard and Andrei L Nikiforov, 'Human Bias in Algorithmic Trading' (2013) <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2375739> accessed 31 July 2020; James Schmitz, 'Algorithmic Trading in the Iowa Electronic Markets' (2012) 1 Algorithmic Finance 157; and Yadav (n 176).

336 Although these strategies are also vulnerable to cyber risk, with important systemic consequences (note, in particular, the Knight Capital incident discussed in section 3.2.2.2; and chapter 4).

337 In the short-term, execution algorithms help informed traders hide their trading, curtailing the activity of price-decoders and the speed at which information is plugged into prices.

338 *See,* i.a., van Kervel and Menkveld (n 27).

339 CFTC and SEC (n 200).

340 They might also have a negative impact on liquidity when correlated algorithms pursue the same illiquid assets (*see*, i.a., Riccardo Cesari, Massimiliano Marzo and Paolo Zagaglia, 'Effective Trade Execution' (Rimini Centre for Economic Analysis 2012) Quaderni DSE Working Paper No. 836).

trading, including informed trading, is more expensive in less liquid environments.[341]

Ultimately, evaluating the overall market impact of automated execution strategies on the quality of EU markets then depends on which categories of informed traders and liquidity-providers—with their different contributions to the liquidity and price-accuracy of these markets—are the most benefited (or harmed) by these strategies.[342]

(2) HFT strategies

HFT strategies stand to have significant impact on EU capital markets—with HFT currently accounting for 30%-49% of all trades, and 58%-76% of all orders in these markets.[343] However, it is worth recalling that the category of 'HFT strategies' includes very different behaviours, which influence the quality of EU markets in markedly distinct ways.

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[341] From a fairness perspective, execution algorithms are valuable tools for retail traders investing in the markets through large institutional investors (like pension funds); at the same time adjustments to the bid-ask spread reflecting the increase in information asymmetry risk coming from the use of (more sophisticated) execution algorithms affect all traders (including large institutional investors)—and smaller retail investors, who are typically most reliant on top-of-the-book liquidity (*see,* i.a., van Kervel and Menkveld (n 27)).

[342] For a discussion, *see* the evaluation of electronic front-running below.

[343] *See* ESMA, 'Economic Report: High-Frequency Trading Activity in EU Equity Markets' (n 284). In a 2016 study, ESMA re-affirmed its reliance on these numbers and acknowledged that 'HFT provides for a large part of activity in equity…markets' (*see* ESMA, 'Order Duplication and Liquidity Measurement in EU Equity Markets' (2016) ESMA Economic Report 1, 2016).

HFT-driven market-making is generally thought to have a positive impact on liquidity[344]—even if HFT-provided liquidity may have a tendency to leave the market when it is needed the most, and, particularly, during the recurring episodes of 'bad' volatility that have come to be associated with algo-trading.[345] Indeed, the fact that HFT-driven market-making makes a positive contribution to liquidity—while also decreasing on-going levels of 'bad' volatility—might be sufficient compensation for the 'mini flash-crashes' that have become the new normal in modern financial markets.[346]

At the same time, the role played by fleeting HFT orders during extreme volatility episodes such as the 2010 Flash Crash is more concerning—particularly given the impact that these events may have on less sophisticated traders,[347] their systemic significance,[348] and their perceived (un)fairness.[349]

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[344] *See*, i.a. Joel Hasbrouck, 'High-Frequency Quoting: Short-Term Volatility in Bids and Offers' (2018) 53 Journal of Financial and Quantitative Analysis 613; and Jonathan Brogaard and Corey Garriott, 'High-Frequency Trading Competition' (2019) 54 Journal of Financial and Quantitative Analysis 1469. This contribution might be particularly significant when bid-ask spreads are wide, namely due to minimum tick sizes (*see* the evidence discussed *in* Menkveld (n 7)). However, it is worth noting that the contribution of HFT market-making to liquidity also appears to depend on the level of competition amongst HFTraders (*see,* i.a., Budish, Cramton and Shim (n 27); and Menkveld (n 27)). Overall, it nonetheless appears that HFTraders make a positive contribution to liquidity (*see* Menkveld (n 7)).

[345] It can also have a positive impact on price accuracy, to the extent that HFT market-makers are quick to update their quotes and changes to quoted prices eventually translate into changes to trading prices (*see,* i.a., Joshua Mitts, 'A Legal Perspective on Technology and the Capital Markets: Social Media, Short Activism and the Algorithmic Revolution' (Observatoire Européen du Droit Financier 2020)).

[346] Fox, Glosten and Rauterberg (n 2).

[347] ibid.

[348] Kirilenko and others (n 209).

[349] *See* Oxera (n 229). *See*, also, Michael Lewis, *Flash Boys: A Wall Street Revolt* (First Edition, W W Norton & Company 2014).

The impact of HFT-led electronic front-running on the quality of EU markets is more ambiguous still.[350]

If execution algorithms are the tool used by vanilla algo-traders to escape the radar of derivatively informed traders, electronic front-running is the tool used by these derivatively informed traders to locate vanilla algo-traders. For that reason, electronic front-running will generally have a positive short-term impact on price-accuracy, but might discourage informed investors from searching for new information (making prices less informed in the long term);[351] at the same time, electronic front-running helps HFT market-makers provide cheaper liquidity—benefiting all traders in the market (both informed and uninformed).

Ultimately, the overall impact of electronic front-running on market efficiency might then be positive if it is found that this practice mostly harms the categories of informed traders that contribute the least to price-accuracy—like insiders and announcement traders[352]—and mostly helps the categories of market-makers that contribute the most to liquidity.[353] This might be the case in

[350] Electronic front-running is just one of the information-discovery strategies that fall under the category of 'HFT.' These strategies also include augmented versions of the vanilla automated investment decision-making strategies discussed previously. The fact that these information discovery strategies generally rely more on speed than on accuracy means that they might contribute very little to price-accuracy; by contrast, they fuel the dangerous 'run games' discussed earlier—which can have a negative impact on liquidity, while creating negative externalities for excessive investment in low-latency technology (*see* Budish, Cramton and Shim (n 27)).

[351] *See,* i.a., Yadav (n 30); Markus Baldauf and Joshua Mollner, 'High-Frequency Trade and Market Performance' (Stanford University 2014); and Brian Weller, 'Does Algorithmic Trading Reduce Information Acquisition?' (Northwestern University 2016) Working paper.

[352] Fox, Glosten and Rauterberg (n 2).

[353] *See* chapter 2.

EU markets, where limited empirical research has shown that better-informed investors may be better able to evade HFT liquidity-providers than less-informed investors, with their hurried trading.[354]

In fact, a recent paper covering a sample of trading in Swedish index stocks reported that 'the information content[355] in institutional orders [was]…larger for those where [HFTraders] trade[d] with-wind' and that the private information in these orders [was] revealed more slowly—with institutions trading 'very carefully on this information.' In this sample, half of the information motivating these more informed orders was only 'revealed after about three hours'—and HFTraders needed a total of 'seven hours to detect the…order and trade with-wind on it'—in contrast to the less informed 'against wind orders,' whose price impact came from 'public information.'[356] Indeed, a different paper has noted that HFTraders can decode aggressive order flow in as little as 30 seconds.[357]

[354] From a fairness point of view, the impact of electronic front-running on retail investors is less straightforward: while smaller retail investors stand to benefit the most from small bid-ask spreads, the truth is that retail traders often invest in the markets through larger institutional traders (like pension funds), whose large orders might be easy prey for HFTraders (*see,* i.a., van Kervel and Menkveld (n 27)).

[355] Under a 'spread decomposition approach', the information component of orders is measured as the 'mid-quote five minutes later minus the pre-trade mid-quote'—which is meant to reflect the permanent impact of the order on market price, as opposed to its transitory impact, which is thought to disappear within 5 minutes (*see* ibid, 24).

[356] *See* ibid, 3, 32. Note, however, that this paper concludes by speculating that the actions of HFTraders may have a negative impact on market quality if research by institutional investors becomes unprofitable.

[357] Nicholas Hirschey, 'Do High-Frequency Traders Anticipate Buying and Selling Pressure?' (2020) Forthcoming Management Science.

As for the set of HFT strategies that rely on low-latency technology to exploit small speed advantages—namely, low-latency arbitrage—it would appear that their impact on market quality is unambiguously negative.[358] However, it also seems that this type of strategies may not be especially popular in EU markets[359]—where the relative geographical proximity between venues, the lack of a regulatory-relevant consolidated audit trail, and the less predictable way in which orders are re-routed across markets in obedience to best execution requirements are all factors that contribute to decreasing their profitability.[360]

3.4 Conclusion

There is no question that modern EU markets have been profoundly changed by the advent of automated-trading technology and the subsequent popularisation of algo-trading—but evaluating this change is far from straightforward.

First, this change has been wide-reaching, comprising both direct impact on the mechanisms employed by algo-traders and indirect impact on the strategies adopted by most market players—including not just algo-traders, but

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[358] S*ee*, in particular, Fox, Glosten and Rauterberg (n 2); and Budish, Cramton and Shim (n 27).

[359] Crucially, a recent study reported by the FCA (from former MS UK) has noted that 'there is no evidence…that [high frequency traders] can "see the market" and trade in front of other participants at a millisecond frequency' (*see* Aquilina and Ysusi (n 276)), and the Dutch AFM has also denied any evidence of HFTraders using their ultra-low latency infrastructure to predict where liquidity will occur (*see* AFM, 'AFM Investigates a Couple of High Frequency Trading Strategies'). *See,* however, more recently, Aquilina *et al*, who use exchange message data (as opposed to LOB data) to show evidence of low-latency arbitrage races happening in the LSEG (Matteo Aquilina, Eric Budish and Peter O'Neill, 'Quantifying the High-Frequency Trading "Arms Race": A Simple New Methodology and Estimates' (2020) FCA Occasional Paper 50).

[360] At least in comparison to the US, where these issues were first identified. For a discussion, *see,* i.a., Aquilina and Ysusi (n 276).

also venues and other intermediaries. Second, these new mechanisms and strategies have changed the contributions made by different categories of players to market quality in markedly different ways—warranting separate analysis.

The separate analysis of these mechanisms and strategies has then made three things clear: first, that the use of algo-trading mechanisms always carries certain benefits and risks—regardless of the strategies implemented by algo-traders; second, that those benefits and risks can be amplified by the presence of particular strategies—regardless of whether those strategies come from algo-traders themselves, from venues, or from other intermediaries; and, third, that certain benefits and risks only arise in the context of particular algorithmic trading-inspired strategies—and are often unique to that context.

This means that, in addition to being well-informed about the nature of the change brought by automated-trading technology to financial markets (as prescribed in *chapter 2*), an effective algo-trading regime must also respond appropriately to the varying impacts of that change. Namely, such a regime should include both rules that regulate the generalised use of algo-trading mechanisms—to the extent that all algo-trading creates certain benefits and risks—as well as rules that apply to particular algorithmic trading-inspired strategies—to the extent that they either amplify the benefits and risks inherent in algo-trading, or create benefits and risks unique to their context.

The next chapter examines the extent to which the EU algo-trading regime embodies these recommendations, beginning with an analysis of its basic building blocks: concerns, purposes, scope and structure.

4. MAN VS MACHINE: THE NEW EU ALGORITHMIC TRADING REGIME

4.1 Introduction

Financial markets are eminently social: they provide platforms where traders with complementary interests in financial instruments can meet; they are hoped to create social value by working efficiently and fairly; and their efficiency and fairness depends on the conduct of their participants.[361]

The fact that the conduct of participants in these markets—including in modern EU markets—has been drastically impacted by the advent of automated-trading technology has not changed the fact that markets are still made by, and for, humans: in these markets, automated-trading technology is, above all, a tool that humans use to improve the mechanisms of their activity.[362]

But automated-trading technology is not just any tool: it has *directly* birthed a type of trading—algo-trading—that is defined by the absence of human intervention. This gives algo-trading a certain air of autonomy: it creates a story of 'us versus them,' where humans fear that these new trading machines may eventually turn against their creators.

[361] *See*, i.a., Armour and others (n 4); and Fox, Glosten and Rauterberg (n 2).

[362] Automated-trading technology has also caused *indirect* change in the strategies adopted by everyone else in the market (in addition to algo-traders themselves): *see* chapters 2-3.

Throughout history, this 'fear that a person's or humanity's technological creations…will ultimately cause them harm'[363]—has encouraged humans to regulate the most varied products of technology, and algo-trading has been no exception.

Indeed, it has been noted that the EU responded to the availability of automated-trading technology by approving what has been described as the 'toughest package'[364] of algorithmic trading-related measures in the world. And this may have been the right course of action: this thesis has argued that the change brought by this technology to EU markets creates significant threats to their quality. Still—if it is true that algo-trading should be regulated—it is harder to determine what an effective algo-trading regime should look like.

Now, at this point, this thesis has already established that an effective algo-trading regime must at least reflect an accurate understanding of both the nature and impact of the change brought by automated-trading technology to financial markets—and include both rules that regulate the use of algo-trading mechanisms, as well as rules that regulate particular strategies inspired by the popularisation of algo-trading across the markets.

Therefore, this chapter begins the evaluation of the EU algo-trading regime by determining if the EU got the basics rights—namely, whether it properly understood: first, what algo-trading is; second, how automated-trading

[363] Jeff Prucher, *Brave New Words: The Oxford Dictionary of Science Fiction* (Oxford University Press 2007).

[364] EC, cited by Martin Wheatley (*see* Wheatley (n 14).

technology has changed its markets; and, third, how that change should be regulated.

This exercise is undertaken by looking at the basic building blocks of the EU regime: concerns and purposes (*4.2*), scope (*4.3*) and structure (*4.4*). Ultimately (*4.5*), it is argued that certain aspects of the EU algo-trading regime—its purposes and structure—do reveal a good understanding of the channels through which automated-trading technology has changed the modern EU markets, as well as of the goals that should guide the regulation of that change.

However, other aspects of the EU regime—its underlying concerns and scope—reveal three fundamental misconceptions about algo-trading: first, that simple execution algorithms carry less risk than other algorithms; second, that the use of algo-trading mechanisms has meaningfully contributed to an increased risk of market manipulation; and, third, that the impact of HFT on market quality can be assessed as if HFT were a monolithic subtype of algo-trading.

Such misconceptions go against the conclusions reached in previous chapters[365]—and stand to threaten the effectiveness of the EU regime.[366]

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[365] *See*, in particular, chapter 3.

[366] *See* chapters 4, 6 and 9 for an analysis of the three main negative consequences caused by these misconceptions—and for a discussion of their impact on the effectiveness of the EU regime.

4.2 The 'toughest' algo-trading regime in the world

The discussion of how the change brought by automated-trading technology to EU markets should be regulated—and whether the EU algo-trading regime adequately regulates that change—starts with an analysis of the building blocks of this 'toughest' of algo-trading regimes. [367]

In particular, it is worth reflecting on how the EU came to approve such regime—on the concerns (*4.2.1*) and purposes (*4.2.2*) that inspired it—as a first step towards evaluating its understanding of the technology-driven phenomenon that it attempted to regulate (*4.2.3*).

4.2.1 The concerns behind the EU regime

The notion that technology can outpace financial regulation has long preoccupied the EU,[368] and concerns about automated-trading technology date from as early as 2009[369]—almost a decade before its algo-trading regime came into force.[370]

[367] EC, cited by Martin Wheatley (*see* Wheatley (n 14)).

[368] EU Council, 'Press Release 3313th Council Meeting - General Affairs' (2014) 9545/14 PRESSE 271 PR CO 25.

[369] CESR, 'Impact of MiFID on Equity Secondary Markets Functioning' (n 256).

[370] This concern has been shared by a number of EU institutions: *see*, for instance, the EESC (*in* EESC, 'Opinion of the EESC on the "Proposal for a [MiFID] (Recast)"' (2012) COM(2011) 656 final — 2011/0298 (COD).—and the ECB (*in* ECB, 'Opinion of the European Central Bank of 22 March 2012 on (i) a Proposal for [MiFID II], (ii) a Proposal for a Regulation on Markets in Financial Instruments and Amending Regulation [EMIR] on OTC Derivatives, Central Counterparties and Trade Repositories, (iii) a Proposal for [MAD] and (Iv) a Proposal for [MAR]' (2012) CON/2012/21).

Indeed, already in 2010 the Committee of European Securities Regulators ('CESR') had noted[371] that 'technological advance ha[d]…facilitate[d]…strong growth in algorithmic and high frequency trading'[372]—calling for rules[373] to address the impact of algo-trading on large order execution,[374] the increasing use of HFT,[375] and internal crossing systems.[376]

An action plan was later put together by the European Securities and Markets Authority ('ESMA'), culminating in the approval of guidelines[377] for

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371 Following a call for evidence issued in 2010 (*see* CESR, 'Micro-Structural Issues of the European Equity Markets' (2010) Call for evidence CESR/10-142).

372 CESR, 'Technical Advice to the European Commission in the Context of the MiFID Review - Equity Markets' (2010) CESR/10-802, 12.

373 ESMA, 'Press Release - ESMA Consults on Systems and Controls for Highly Automated Trading' (2011) ESMA/2011/223.

374 Beyond highlighting that algo-trading had 'rendered the execution of large orders more complex,' CESR also noted the role played by market fragmentation in increasing this complexity (*see* CESR, 'Technical Advice to the European Commission in the Context of the MiFID Review - Equity Markets' (n 372)). Indeed, market fragmentation might be a better explanation for this increased complexity—particularly as trading algos actually play an important role in optimising large order execution in these fragmented markets (*see* chapter 3).

375 At the time, CESR described HFT as an emerging phenomenon that already accounted for 40% of total trading within EU markets and which should be brought under the scope of MiFID (*see* ibid).

376 Internal crossing systems were then viewed by the CESR as systems that—although to some extent, functionally equivalent to venues—were subject to much lower levels of transparency than those required of RMs and MTFs (*see* ibid).

377 The consultation paper that preceded these guidelines sheds more light into the EU concerns with algo-trading, noting that 'trading in financial instruments [had] come to rely increasingly on the use of electronic trading systems'—and pointing to two factors driving the change experienced by EU markets: the popularisation of 'screen-based' markets accessed electronically by their participants; and the growing use of trading algorithms by those participants (*see* ESMA, 'Consultation Paper: Guidelines on Systems and Controls in a Highly Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (n 171)).

organisational arrangements applicable to algo-traders and venues hosting algo-trading—as well as principles to govern DEA services facilitating algo-trading.[378]

As ESMA was finalising its guidelines, the EU was also in the process of adapting its financial regulation framework to algo-trading[379]—and the first proposals for a reformed MiFID ('MiFID II') and a new MiFIR, issued in 2011, were partly, and self-confessedly, a response to the 'growth of automated trading and high frequency trading.'[380]

Additionally, the EU feared that 'automated and high frequency trading (HFT) ha[d] raised issues about how regulators monitor[ed] such trading and whether [the EU market abuse framework] adequately capture[d] specific strategies that may be abusive practices'[381]—resulting in one further proposal for a new MAR where the EU definition of market manipulation would be amended to include an express mention to algo-trading and HFT.[382]

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[378] At that point, ESMA chose not to focus on co-location, fee structures and tick sizes—sensing that such topics 'did not relate directly to the challenges for systems and controls of trading platforms and investment firms caused by a highly automated trading environment' and acknowledging its limitations 'under the existing legislative framework' (*see* ESMA, 'Press Release - ESMA Consults on Systems and Controls for Highly Automated Trading' (n 373)).

[379] EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MiFID Recast] and the Proposal for a [MiFIR]' (2011) Commission Staff Working Paper SEC(2011) 1227 final.

[380] EC, 'Commission Staff Working Document - Impact Assessment Accompanying the Document Proposal for [MiFID and MiFIR]' (2011) SEC(2011) 1226 final, 11.

[381] EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (2011) Commission Staff Working Paper SEC(2011) 1218 final, 2.

[382] MAR came into force on 2 July 2014; MiFID II and MiFIR came into force on the same day, but only started applying from 3 January 2018. This framework has since been complemented by a series of delegated regulations. More recently, the ESMA guidelines that kick-started the process of regulating algo-trading within the EU were officially withdrawn, following their

Ultimately, it appears that the new EU algo-trading regime was thus motivated by three key concerns: a general concern with the use of algo-trading mechanisms and the strategies that facilitate that use; and two specific concerns with the group of algo-trading strategies known as 'HFT,' and with the use of algo-trading mechanisms in the context of market manipulation.

4.2.2 The purposes guiding the EU regime

Underlying the concerns that motivated the EU algo-trading regime is the notion that markets should be made 'better, safer and more open' following such transformative 'technological developments…as high frequency trading'[383]—as well as a desire[384] to improve their efficiency[385] and fairness.[386]

Indeed, already in 2011 ESMA had noted that its algo-trading guidelines were meant to 'ensure fair and orderly trading,…promote market integrity [and] strengthen financial stability.'[387] And, in 2014, the EU Council would also argue

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incorporation into the MiFID/MiFIR framework (*see* ESMA, 'ESMA Withdraws MiFID Automated Trading Guidelines Following Their Incorporation into MiFID II').

[383] EC, 'New Rules for More Efficient, Resilient and Transparent Financial Markets in Europe' (2011) Press Release.

[384] *See* ibid. The EU also expressed the desire to preserve market 'resilience'—ie, the ability of EU markets to 'deal with peak order and message volumes,' while ensuring orderly trading, particularly under stressful market conditions, or upon system failure (*see* MiFID II*,* article 48 (1))—which has both efficiency and fairness implications.

[385] Under EU financial regulation, 'efficiency' is measured as 'the extent to which prices in a market fully reflect all the information available to investors' (*see* EC, 'Glossary of Useful Terms Linked to Markets in Financial Instruments' (n 42)).

[386] The EU definition of 'fairness' is particularly hard to pin down, but ESMA appears to equate it with a certain 'parity' between market players (*see* Steven Maijoor, 'Market Transparency – Does It Prevent Crisis?' (2011) ESMA/2011/322).

[387] *See* ESMA, 'Consultation Paper: Guidelines on Systems and Controls in a Highly Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (n 171),

that the EU algo-trading regime should promote the 'efficiency of EU financial markets'—ensuring, in particular, that 'all organised trading [was] conducted on regulated trading venues,' that 'strengthened requirements [were] introduced in relation to organisation, transparency and market surveillance in all…types of venues' and that the use of HFT techniques was 'limited.'[388]

Currently, these efficiency and fairness goals are expressly found in MiFID II—the central piece of the EU algo-trading regime—which notes the importance of creating markets 'in which investors are effectively protected and the efficiency and integrity of the overall market are safeguarded.'[389]

4.2.3 A step in the right direction?

Looking at the concerns and purposes underlying the EU algo-trading regime, it appears that the first step taken by the EU with its algo-trading regime has been a step in the right direction: the advent of automated-trading technology and the popularisation of algo-trading have certainly created risks for the quality of EU markets—and it is right for those risks to be regulated with the goal of increasing the efficiency and fairness of those markets.

11; in the context of EU law, 'integrity' refers to the 'safe operation of markets, without misleading information or inside trades, so that investors can have confidence and be sufficiently protected' (*see* EC, 'Glossary of Useful Terms Linked to Markets in Financial Instruments' (n 42)).

[388] EU Council, 'Markets in Financial Instruments: Council Adopts New Rules' (2014) 9769/14 PRESSE 288.

[389] MiFID II, recital (62).

At the same time, close examination of the concerns expressed by the EU before approving its algo-trading regime reveals two worrying signs: first, that the EU looks at HFT—and is worried about HFT—as a whole, while seemingly ignoring the significant variety of strategies included under the misnomer of 'HFT;' and, second, that the EU makes a clear association between algo-trading and market manipulation—even though the arguments used to support that association are extremely debatable.[390]

To the extent that these misconceptions have an impact on the content of the EU algo-trading regime, they may be cause for concern—but before assessing that impact, it is worth determining whether the scope and structure of the EU regime reveal any other misconceptions held by the EU about algo-trading.[391]

4.3 The scope of the EU algo-trading regime

Previously, this thesis noted that all algo-trading carries at least some cyber and systemic risk.[392] As such, an effective algo-trading regime should in principle strive to capture all algo-trading—with any exceptions requiring careful justification.

[390] *See* chapter 3.

[391] *See* chapters 6 and 9.

[392] *See* chapter 3.

This section continues the task of determining whether the EU algo-trading regime conveys a correct understanding of the change brought by automated-trading technology to EU markets—namely by capturing all (or most) instances of algo-trading. This is done by examining both the objective scope (*4.3.1*) and the subjective scope (*4.3.2*) of that regime—and assessing whether they reveal any additional misconceptions held by the EU about algo-trading (*4.3.3*).

4.3.1 The objective scope of the EU regime

Although all uses of algo-trading mechanisms carry at least a certain degree of risk, the EU algo-trading regime does not actually capture all algo-trading.

This section takes the EU definition of algo-trading—enshrined in MiFID II—as a starting point for determining which algorithms are indeed captured by the EU regime. Ultimately, it is argued that such regime leaves unregulated simple execution algorithms—and that those algorithms carry the same (if not more) risk than the algorithms that fall under its scope. Additionally, the distinction introduced by the EU regime between different types of algo-trading, with different regulatory importance, is functionally ineffective and difficult to apply.

4.3.1.1 Picking apart the EU definition of algo-trading

The EU definition of algo-trading—found in article 4(1)(39) of MiFID II—is relevant across the entire EU algo-trading regime, effectively determining its objective scope.[393]

As will be noted, this definition is in many ways similar to the definition of algo-trading put forth earlier in this thesis, but there are some crucial differences between the two. These differences are revealed by dividing the EU definition into two parts, intermediated by the expression 'and does not include:'[394] the first part reflecting how the EU understands algo-trading conceptually; and the second part working as a qualifying statement—suggesting that there is a certain sub-type of algo-trading that would normally be deemed as 'algo-trading' for the purposes of the EU regime, but which is actually not.[395]

This illustrates the fact that the EU does not think that all algo-trading[396] creates the same risk[397]—and, crucially, that the EU thinks that there is a sub-set of algo-trading that does not require regulation.[398] But before determining

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[393] Even though the EU regime extends beyond MiFID II, most references made by the EU to algo-trading refer to the MiFID II regime. *See*, for example, MAR, recital (18).

[394] MiFID II, article 4(1)(39).

[395] MiFID II, article 4(1)(39).

[396] CDR 2017/565, recital (22).

[397] ESMA, 'Consultation Paper: Guidelines on Systems and Controls in a Highly Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (n 171).

[398] The EU also excludes the use of systems for the 'confirmation of orders' and the 'post-trade processing of executed transactions' from its definition of algo-trading, but, as the expressions 'confirmation' and 'post-trade' imply, such systems are only relevant in the aftermath of trading: only a particularly broad conception of trading—or over-carefulness—justify their apparent

whether the EU was right to exclude some algorithms from the scope of its regime, this thesis looks at both parts of its algo-trading definition to determine what that scope is.

(1) A conceptual starting point to defining algo-trading

The first half of the EU definition of algo-trading characterises it as:

> '[T]rading in financial instruments where a computer algorithm automatically determines individual parameters of orders such as whether to initiate the order, the timing, price or quantity of the order or how to manage the order after its submission, with limited or no human intervention…'[399]

According to the EU, all algo-trading then features a computer following rules that pre-determine the individual parameters of orders—which is entirely aligned with the conceptual definition of algo-trading introduced by this thesis.[400]

However—and contrary to that definition—the EU definition also notes that all trading carried through computer algorithms is 'algorithmic,' even when there is actual (if 'limited') human intervention in the trading process.[401] The EU then defines systems that have only 'limited human intervention' as those where:

inclusion in the first half of the EU definition of algo-trading (followed by their subsequent exclusion in the second half of that definition).

[399] MiFID II, article 4 (1) (39).

[400] *See* chapter 2. The definition in that chapter falls in line with most academic and regulatory definitions of algo-trading—which also fail to contemplate any form of human intervention in algo-trading (*see*, i.a., Jones (n 39); Kannan (n 39); and Domowitz and Yegerman (n 39)). *See*, however, the CFTC Regulation Automated Trading proposal (which has since been shelved): CFTC, 'Regulation Automated Trading - Notice of Proposed Rulemaking' (n 39).

[401] MiFID II, article 4 (1) (39). *See* also CDR 2017/565, recital (21).

> 'for any order or quote generation process or any process to optimise order-execution, an automated system makes decisions at any of the stages of initiating, generating, routing or executing orders or quotes according to pre-determined parameters.'[402]

It seems, then, that any scenario where not 'every parameter or attribute is manually entered into a front-end system by a natural person, with no further discretion by any computer system or algorithm,'[403] or, indeed, any scenario where a computer makes decisions 'at any'[404] stage of the trading process falls under the category of '[trading with] limited human intervention' under MiFID II—and, hence, under the conceptual definition of algo-trading endorsed by the EU.

This interpretation leaves the EU with an exceptionally broad conceptual starting point to defining algo-trading—which is notably wider than the definition of algo-trading discussed earlier in this thesis.[405] But this starting point only tells half the story: it might be a fair representation of how the EU perceives algo-trading—but it says very little about the types of algo-trading that the EU believes should be regulated.

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[402] CDR 2017/565, article 18.

[403] *See* the definition of algo-trading in the latest iteration of the ill-fated CFTC proposal 'Regulation AT'—which may offer a tool for interpreting what 'limited human intervention' means in this context. Indeed, the EU and the US have signed a joint-statement whereby their representatives (including CFTC staff) have agreed to 'continue cooperation on the regulation of algorithmic trading—and the CFTC has since acknowledged that 'its [own] definition of algorithmic trading is similar to the definition of algorithmic trading adopted by the European Commission under MiFID II' (*see* CFTC, 'Regulation Automated Trading - Notice of Proposed Rulemaking' (n 39), 64).

[404] CDR 2017/565, article 18.

[405] *See* chapter 2.

The subset of algo-trading that ultimately falls under the EU regime is determined through a qualifying statement that explicitly excludes certain (simpler) algorithms from its scope.

(2) From qualifying statement to regulatory definition

The second half of the EU definition of algo-trading notes that algo-trading:

> '…does not include any system that is only used for the purpose of routing orders to one or more trading venues or for the processing of orders involving no determination of any trading parameters or for the confirmation of orders or the post-trade processing of executed transactions.'[406]

This qualifying statement suggests that not all sub-types of algo-trading are equally deserving of regulatory treatment. The decision of what to regulate is then made by the EU with the help of two concepts: 'investment decision algorithm' and 'execution algorithm.'

These are essentially the two categories of algorithms used earlier in this thesis to explain how algo-trading works[407]—although the EU gives them a slightly different meaning. Specifically, the EU defines 'investment decision algorithms' as those that 'make automated trading decisions by determining which financial instrument should be purchased or sold,'[408] while this thesis sees

[406] MiFID II, article 4 (1) (39).

[407] *See* chapter 2.

[408] By contrast, 'order execution algorithms' are those that can be used to 'optimise order-execution processes by automatic generation and submission of orders or quotes, to one or several trading venues once the investment decision has been taken' (*see* CDR 2017/589, recital (5)).

them as those that govern not just the making, but also the implementing of investment decisions—by contrast with 'execution algorithms,' which make (and implement) decisions regarding the optimisation of the execution of previously-formulated investment decisions. This is because 'investment decision algorithms' is a sub-set of the category 'trading algorithms,' which implies more than just making decisions.[409]

The EU then goes on to suggest that these two categories of algorithms 'should be differentiated' due to having different potential impact 'on the overall fair and orderly functioning of the market'[410]—as well as to find further sub-categories within them.

Specifically, the EU isolates the sub-category 'pure investment decision algorithms'[411] within the notion of 'investment decision algorithms'—and uses it to refer to algorithms which 'generate orders that are only to be executed by non-automated means and with [more than limited] human intervention.'[412]

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[409] Rather, it implies the implementation of those decisions (ie, the actual 'trading'). Still, this difference is not relevant in practice, since the EU ends up excluding 'pure investment decision algorithms' from its definition of algo-trading *(as noted below).*

[410] CDR 2017/589, recital (5).

[411] CDR 2017/589, recital (7).

[412] In practice, a 'pure investment decision algorithm' would then be a type of investment decision algorithm that is incapable of actually initiating orders, and which 'does not necessarily pre-determine the timing, price and quantity of such orders' (*see* FCA, 'Algorithmic Trading Compliance in Wholesale Markets' (n 51)). By contrast, 'non-pure' investment decision algorithms would be algorithms capable of implementing investment decisions they would have previously made.

It also draws a distinction within the category of ‘execution algorithms’—differentiating between algorithms used to optimise order execution and which, in that optimisation, do more than just select the venues for order submission (‘smart execution algorithms’) and algorithms that, while also seeking to optimise order execution, merely determine the venues ‘where the order should be submitted without changing any other parameter of the order’ (‘basic execution algorithms’).[413] For example, algorithms used to slice parent orders into child orders[414] with the goal of decreasing the implementation short-fall of large orders[415] are often smart execution algorithms, employed through smart order routers (‘SOR’): typically, those algorithms make autonomous decisions about the timing and size of orders, in addition to determining where to send them.

In regard to investment decision algorithms, the EU then clarifies that—to the extent that the EU algo-trading regime mandates the testing of algorithms—‘pure investment decision algorithms which generate orders that are only to be executed by non-automated means and with human intervention should be excluded from the testing requirements [in the EU regime].’[416]

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[413] CDR 2017/565, recital (22).

[414] ESMA, ‘Questions and Answers on MiFID II and MiFIR Market Structures Topics’ (2020) ESMA70-872942901–38.

[415] *See* chapters 2-3.

[416] CDR 2017/589, recital (6).

In regard to execution algorithms, the EU states that its definition of algo-trading 'should…encompass [SORs]'[417]—but not systems that only determine the venues to which orders should be submitted 'without changing any other parameters.'[418] In other words, the EU regulatory definition of algo-trading—as it stands at the centre of the EU regime—includes smart execution algorithms, but not basic execution algorithms employed through AORs.[419]

4.3.1.2 Evaluating the objective scope of the EU regime

Earlier in this thesis, algo-trading was defined as the trading whereby a machine formulates and implements trading decisions by following pre-coded rules. The regulatory definition of algo-trading put forth by MiFID II appears, in first instance, to be both broader and narrower than that earlier definition: broader in that it tolerates some (if limited) human intervention; and narrower in that it excludes particular sub-types of algo-trading—namely those carried out through pure investment decision and basic execution algorithms.

[417] *See* CDR 2017/565, recital (22). The same idea was already present in the 2012 ESMA Guidelines on algo-rading—which stated that such SORs were covered by ESMA in attention to the 'risks involved in order entry' (*see* ESMA, 'Final Report: Guidelines on Systems and Controls in an Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (2011) Guidelines and Recommendations 2011/456).

[418] CDR 2017/565, recital (22).

[419] It could be argued that these limits flow from Level 2, as opposed to Level 1, instruments and that, as such, there could be a residual sub-category of algo-trading (including basic execution algorithms) that—in light of the hierarchy of sources—would complement the categories of algo-trading described in those Level 2 instruments. However—and even though the exact content of these limits can only be determined by looking at Level 2 instruments—their existence flows clearly from MiFID II, which explicitly excludes from its definition of algo-trading 'any system that is only used for the purpose of routing orders to one or more trading venues' (*see* article 4(1)(39)).

Now, in practice, there should not be many instances where the algorithms included in the EU definition of algo-trading will be used in strategies that involve any form of human intervention, even if limited: investment decision algorithms implemented through automated means are essentially self-sufficient—and execution optimisation through SORs is virtually incompatible with the slowness and inferior processing power of human action: once the appropriate trade-off between certainty of order execution and certainty of price has been selected, execution may be better left to the machines.[420]

Realistically, it seems then that the EU definition of algo-trading is actually just narrower than the conceptual definition proposed by this thesis—leaving only the question of whether excluding pure investment decision algorithms and basic execution algorithms from the scope of the EU regime is cause for concern.

The exclusion of pure investment decision algorithms from (part of) the EU regime does very little in terms of actually restricting its scope: it just brings it more in line with most conceptual definitions of algo-trading—including the definition proposed in this thesis. Indeed, such definition suggested that algo-trading is characterised by a computer formulating and implementing trading strategies that follow pre-coded rules—and it would appear that the use of a pure investment decision algorithm making a decision without being able to implement it could never be classified as algo-trading.

[420] O'Hara (n 1).

As such, it is argued that the only meaningful way[421] in which the EU regulatory definition of algo-trading is actually different from the conceptual definition introduced earlier in this thesis is by excluding simple execution algorithms implemented through AORs.[422] As a result, the key question for assessing the appropriateness of the objective scope of the EU algo-trading regime is whether the exclusion of these algorithms reveals any key misunderstandings about algo-trading, or hurts the effectiveness of that regime.

This question is answered by examining *(1)* the risks inherent in basic execution algorithms and by evaluating *(2)* the extent to which the exclusion of these algorithms from the scope of the EU regime has created any practical difficulties to its application.

(1) The risks in basic execution algorithms

Determining whether basic execution algorithms should have been included in the EU algo-trading regime depends on whether their use carries the same risks generally inherent in all uses of algo-trading mechanisms—or whether there is

[421] The small conceptual differences between the two definitions are also unproblematic: if it is true that a conceptual definition should provide a faithful translation of the object it tries to capture—and if it is true that the conceptual starting point used by the EU to define algo-trading is too broad by including trading with 'limited human interference,' that would only be cause for concern if it meant that the EU had fundamentally misunderstood algo-trading as a phenomenon, which is clearly not the case. The reference to 'limited human interference' is certainly an unnecessary add-on to the EU definition, but it does not take away from the fact that such definition includes the two elements that characterise this type of trading: pre-coded rules and a machine decision-maker.

[422] CDR 2017/565, recital (22).

something about these algorithms that significantly decreases their risk, rendering their inclusion in the EU regime either unnecessary or disproportionate.

Indeed, although the EU has never been clear about why it decided to leave these algorithms unregulated, it has noted that different algorithms should be regulated differently according to their impact 'on the overall fair and orderly functioning of the market'[423]—or, in other words, according to their risk.

Now, when discussing the risks arising from the use of algo-trading mechanisms, this thesis noted that any instance where these mechanisms are employed can give rise to machine-driven errors and biases. It was also noted that, because these errors are able to travel fast across markets—and because algorithms tend to respond to the same inputs in correlated ways—any single algorithm-driven error can have systemic consequences.

Additionally, because all algo-trading is disintermediated and generally faster than manual trading, all uses of algo-trading mechanisms carry the risk of overloading trading venue infrastructure. As a result, all algo-trading can

[423] *See* CDR 2017/589, recital (5). In particular, there is no evidence that the exclusion of these algorithms from the EU regime resulted from pressure by market participants—even if stakeholders consulted on MiFID II noted the 'need for a clear differentiation between the activities of automated order routing (AOR) [and] smart order routing (SOR),' at least in the context of determining which activities should be covered by the definition of DEA (*see* ESMA, 'Final Report – ESMA's Technical Advice to the Commission on MiFID II and MiFIR' (2014) ESMA /2014/1569). However, it is worth noting that, in the US, the CFTC reported that some commentators to proposed Regulation AT reported that regulating simple execution algorithms would result in algo-traders numbering 'in the thousands' and that those algorithms should, as such, be excluded from those rules (*see* CFTC, 'Regulation Automated Trading - Notice of Proposed Rulemaking' (n 39)). Ultimately, the CFTC decided against excluding simple execution algorithms from its proposed regulation (which then ended up being shelved), but it seems plausible that the EU received similar feedback—and was more sensitive to these concerns.

ultimately contribute to ‘flash crashes’ and other such episodes of extreme bad volatility, which can quickly spread across securities and across markets.

This is certainly not the same as saying that every instance where algo-trading mechanisms are employed carries the same risks: it was also noted that the impact of these mechanisms changes greatly depending on the algorithms and strategies actually employed by the traders who make use of these tools (and even, in fact, on the strategies employed by non-algorithmic traders hosting or facilitating this trading). Still, it seems that any instance where algorithms are used comes with at least some degree of cyber and systemic risk.

For that reason, the decision made by the EU to exclude basic execution algorithms used in AORs from the scope of its regime can be (and has been) subject to criticism. Namely, the CFTC has noted that:

> ‘In contrast to MiFID II…the [CFTC] intends that [its] definition of Algorithmic Trading includes systems that make determinations regarding any aspect of the routing of an order, i.e., systems that only make decisions as to the routing of orders to one or more trading venues. The [CFTC] believes that automated order routers have the potential to disrupt the market to a similar extent as other types of automated systems, and therefore should not be treated differently under the proposed regulations.’[424]

This position was then partly justified by reference to the infamous Knight Capital trading glitch, whereby ‘errors related to the coding and testing of an

[424] CFTC, ‘Regulation Automated Trading - Notice of Proposed Rulemaking’ (n 39), 65.

automated equity router' caused a trader to sustain losses of more than $460 million, 'in addition to causing substantial market disruption.'[425]

The story goes as follows: in 2005, former Knight Capital Group ('Knight Capital')[426] made a change to the code sequence in one of its AORs, rendering one of its functions—the ability to recognise when orders had been filled—defective. And although this (now defective) function was not meant to be used following the change to the code sequence, it was left in the algorithm.[427]

When, in late July 2012, Knight Capital deployed new code in the same algorithm, it had the effect of allowing new orders to trigger the defective function that had mistakenly been left in the code.[428] The defective Knight Capital algorithm was then triggered when the markets opened on 1 August 2012, resulting in Knight Capital sending a large volume of erroneous orders to the market in rapid succession—and ultimately leading to the trading of 397 million shares in 45 minutes.[429] Due to the defect in its code, the basic execution algorithm used by Knight Capital entirely ignored the executions received from

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425 ibid, 65.

426 Knight Capital has singe merged with Getco, with the resulting KCG Holdings eventually being acquired by Virtu Financial Inc, a known HFTrader.

427 SEC, 'Press Release - SEC Charges Knight Capital With Violations of Market Access Rule' (2016) 2013–222.

428 ibid.

429 Kirilenko and Lo (n 29).

venues and sent 4 million orders to the same trading centres, while attempting to fill just 212 orders.[430]

Later, the SEC came to the conclusion that 'Knight's system of risk management controls and supervisory procedures was not reasonably designed to manage the risk of its market access,…its reviews were inadequate…and its written description of its risk management controls was insufficient.'[431] In the end, the effects of this episode rippled across the markets, causing significant abnormal movements in the prices of almost 150 stocks[432] and substantial variations in trading activity (not just at NYSE, where the orders were initially routed, but also, for instance, at NASDAQ).[433]

Ultimately, it is not entirely clear that the Knight Capital AOR would indeed be classified as a basic execution algorithm under the EU regime—even if the CFTC appears certain that it would.[434] Regardless, the lessons from this episode hold true: the use of a single execution algorithm can have disastrous (and systemically relevant) consequences—and it does not look like relying on less sophisticated algorithms is helpful. As the CFTC also noted, on a different occasion, there is 'no persuasive evidence establishing that the operation of

[430] *US Securities and Exchange Commission against Knight Capital Americas LLC* [2013] File No 3-15570. ('*SEC v Knight Capital* (2013)').

[431] *SEC v Knight Capital* (2013), 3-4.

[432] Kirilenko and Lo (n 29).

[433] Yadav (n 176).

[434] CFTC, 'Regulation Automated Trading - Notice of Proposed Rulemaking' (n 39).

[AORs] presents less risk to the market than other types of automated or algorithmic systems.'[435]

By contrast, there is some support for the idea that 'under stressed market conditions, the automated execution of a large sell order can trigger extreme price movements, especially if the automated execution algorithm does not take prices into account.'[436] This is because—unlike smart execution algorithms and SORs—basic execution algorithms and AORs make only limited attempts to smooth out the impact of large orders in markets, suggesting that the former might pose less of a threat to market stability than the latter.[437]

It could nevertheless be argued that the exclusion of basic execution algorithms from the EU regime is justified by reasons of proportionality. However, it does not appear that the EU was thinking about proportionality as such—but only strictly about risk—when it excluded these algorithms.[438] And while it should now be clear that the use of basic execution algorithms carries significant risk—there is nothing to suggest that the players using them are less able to bear the

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[435] CFTC, 'Regulation Automated Trading – A Proposed Rule by the Commodity Futures Trading Commission on 11/25/2016' (2016) 81 FR 85334, 85340.

[436] *See* CFTC and SEC (n 200), cited by ESMA in its 2011 Consultation paper regarding 'Guidelines on systems and controls in a highly automated trading environment for trading platforms, investment firms and competent authorities' (*see* ESMA, 'Consultation Paper: Guidelines on Systems and Controls in a Highly Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (n 171), 11).

[437] Another question is whether the use of these smart execution algorithms can have a negative impact on price efficiency in the context of particular algo-trading strategies—especially to the extent that such strategies increase the information asymmetry risk that hurts the activity of market-makers (and which, in the modern markets, are essentially HFTraders).

[438] ESMA, 'Consultation Paper: Guidelines on Systems and Controls in a Highly Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (n 171).

regulatory burden inherent in the EU regime: at the time that Knight Capital fell victim to one of its basic execution algorithms, it was one of the largest equity traders in the US. Finally, it is worth noting that the EU regime uses other (better) mechanisms to deal with proportionality concerns—in particular by excluding retail investors engaged in algo-trading from the bulk of its regime.[439]

In the end, it seems then that the EU algo-trading regime should not have excluded basic execution algorithms used in AORs from its scope with the argument that they carry less risk than other types of algorithms. Such decision was based on a fundamental misconception about the risk inherent in different types of trading algorithms and future iterations of MiFID II should ensure that their definition of 'algo-trading' re-captures these unregulated algorithms.

(2) The practical difficulties in distinguishing between types of algorithms

Beyond the fact that basic execution algorithms can be as dangerous as (if not more dangerous than) smart execution algorithms, there is a second reason why the EU should not have excluded them from its regime: the fact that the distinctions between algorithms made by the EU are not functional.

The discussion in this section has already illustrated the difficulties of distinguishing between 'pure investment decision algorithms,' 'non-pure investment decision algorithms/ 'implemented through automated means,' 'basic execution algorithms' and 'smart execution algorithms': first, some of these

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[439] *See* section 4.3.2.2.

categories are not clearly defined in the EU regime; and, second, these algorithms are often used in complex multi-algorithm trading strategies—increasing the difficulties of identifying and characterising them.[440]

Such difficulties are exemplified by the long list of ‘frequently asked questions/FAQs’ that ESMA has had to address in respect to the EU algo-trading definition—and which include inquiries as to whether the ‘use of a simple algorithm qualif[ies] as algorithmic trading,’ or whether the transmission of an order ‘for execution to another investment firm…who uses algorithmic trading’ is algo-trading, or whether an AOR submitting ‘the same order to several trading venues’ qualifies as algo-trading.[441]

This uncertainty has caused MS authorities to adopt a careful approach when advising market participants on how to identify algo-trading. While the United Kingdom (‘UK’) has now exited the EU, it is worth noticing that its Financial Conduct Authority (‘FCA’) has noted that identifying algo-trading under MiFID/MiFIR ‘can present significant challenges, particularly for larger firms,’ as ‘the exact definition and scope of algorithmic trading can vary depending on the type of firms and strategies deployed.’ Ultimately, this has resulted in the FCA advising players to apply ‘the same systems and controls as for algorithmic

[440] For instance, it appears that traders using algorithms to support decision-making—in particular by alerting them to particular market conditions—are not engaging in algo-trading; similarly, the use of electronic systems to support the execution of orders submitted manually to trading platforms does not appear to be algo-trading. But what is, for example, the position of the EU on the application of post-trade controls, like risk filters? For a discussion, *see* CFTC, ‘Regulation Automated Trading - Notice of Proposed Rulemaking’ (n 39).

[441] ESMA, ‘Questions and Answers on MiFID II and MiFIR Market Structures Topics’ (n 414), 16-17.

trading' to pure investment decision algorithms—even if they do not strictly fit into the EU definition of algo-trading.[442]

As a consequence, many traders might end up erring on the side of caution and identifying as 'algo-trading' all of their trading that is supported by algorithms—regardless of whether it actually falls under the scope of the EU regime.[443] And this can be problematic, particularly as that regime includes a series of self-assumedly 'tough' rules:[444] traders wishing to 'err on the side of caution' will be adopting expensive preventative measures—the costs of which might discourage them from investing in unproblematic supporting algorithms that the EU never wanted to regulate in the first place.

Ultimately, this overly cautious interpretation of the scope of the EU regime has a silver lining—in that it might lead, in practice, to the inclusion of basic execution algorithms under its scope. Still, a regulatory regime should strive for internal coherence: a system that is, at once, too restrictive in scope and too broadly applied might work well enough in practice, but should nevertheless be amended as a matter of analytical rigour and legal certainty.

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[442] FCA, 'Algorithmic Trading Compliance in Wholesale Markets' (n 51), 9.

[443] It has been pointed out that the EU definition of algo-trading might, in practice, be 'unhelpful, in that it applies a label that appears to be narrow but is *in fact* very broad,' essentially applying to 'anybody who uses computers to assist their trading [which is] pretty much everybody' (*see* Authority of the House of Lords (n 222),23).

[444] *See* EC, cited by Martin Wheatley (Wheatley (n 14)).

4.3.2 The subjective scope of the EU regime

In addition to being limited to a particular sub-set of algo-trading—as determined by the EU definition of algo-trading—the scope of the EU regime is also limited to particular categories of market players.[445]

But while the objective scope of the EU regime is established by reference to the single concept of 'algo-trading'—which is uniformly used to determine the focus of most rules in that regime—its subjective scope can only be ascertained through individual analysis of each of its rules, as different rules in that regime apply differently to different categories of market players.

As such, this section does not discuss the subjective scope of the EU algo-trading regime in depth: the categories of market players subject to the different rules in that regime are introduced as those rules are discussed in the remaining chapters of this thesis.

However, there are two general aspects of the subjective scope of the EU regime that are transversal to that regime: first, the extension of (all or some of) MiFID II requirements to certain investment firms when they engage in algo-trading (or HFT); and, second, the exclusion of retail traders from that directive. Both aspects refer to MiFID II—which is the centrepiece of the EU algo-trading regime—and both are particularly illuminating for understanding how the EU perceives algo-trading.

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[445] MiFID II, recital (63).

4.3.2.1 Extending MiFID II to investment firms engaging in algo-trading

One of the most noteworthy aspects of the EU regime is the extension of (at least some provisions in) MiFID II to (certain) investment firms, who are typically excluded from the directive—but who are brought back under its scope for engaging in algo-trading, or HFT.

To start, it should be recalled that (professional) investment firms generally fall under the scope of MiFID II, but not when they benefit from the exceptions listed in its articles 2-3. However, the EU algo-trading regime establishes that some of these exempt firms—namely credit institutions[446] authorised under the EU capital requirements framework,[447] insurance and reinsurance undertakings,[448] operators with compliance requirements under the directive[449] on greenhouse gas emission allowance trading,[450] and collective investment undertakings ('UCITS') and pension funds—are now subject to the reporting and

[446] When providing investment services or performing investment activities (*see* MiFID II, article 1(3)(a)).

[447] The EU capital requirements framework includes the Capital Requirements Directive ('CRD IV') and the Capital Requirements Regulation ('CRR'). Recently, this framework has been complemented by a new directive and regulation on prudential requirements specifically applicable to investment firms ('Directive (EU) 2019/2034' and 'Regulation 2019/2033')—both of which will only fully apply from 26 June 2021.

[448] When carrying out the activities listed in Solvency II (*see* MiFID II, article 2(1)(a)).

[449] Directive 2003/87/EC.

[450] When dealing in emission allowances without executing client orders or providing any investment services/ investment activities beyond dealing on own account, and provided that they do not engage in HFT (*see* MiFID II, article 2(1)(e)).

organisational requirements applicable to algo-traders under article 17 of the directive.[451]

Additionally, the EU regime also establishes that investment firms dealing solely on own account ('proprietary investment firms')—who are typically also exempt from MiFID II[452]—are now subject to the directive when, in particular, they enjoy DEA[453] to a venue,[454] or when they engage in HFT (as defined by the EU).[455] Significantly, these firms do not just become subject to article 17 of MiFID II, but to the entirety of the directive, with all the implications that 'MiFID investment firm status' carries—including becoming subject to prudential capital

[451] *See* MiFID II, articles 1(3)(a) and 1(5). Notably, article 1(5) of MiFID II only applies when these firms are members of RMs or MTFs.

[452] *See* MiFID II, article 2(1)(d). Under MiFID II, persons dealing on own account are generally excluded from MiFID due to the fact that 'the scope of prudential regulation should be limited to those entities which…represent a source of a counterparty risk to other market participants' (*see* MiFID II, recital (50)). Notably, MiFID II also applies to instances where 'this [proprietary trading] is structured in such a way as to avoid the execution taking place on own account, such as through the transmission of orders between entities within the same group' (*see* Busch (n 31), 4).

[453] Here—as elsewhere in the thesis—DEA includes both access as venue members and access through DEA services offered by intermediaries (*see* OICV-IOSCO, 'Policies on Direct Electronic Access - Consultation Report' (n 169)). *See,* however, the narrower definition of DEA endorsed by the EU in MiFID II, article 4(1)(41).

[454] There is an exception to this exception: MiFID II does not apply to non-financial entities with disintermediated access to markets 'who execute transactions on a trading venue which are objectively measurable as reducing risks directly relating to the commercial activity or treasury financing activity of those non-financial entities or their groups' (*see* MiFID II, article 2 (1) (d) (ii)).

[455] HFT is defined by article 4(1)(40) of MiFID II. For a discussion, *see* chapter 9.

requirements,[456] as well as to a series of general organisational and reporting requirements.[457]

These extensions are naturally important for ensuring that most (professional) algo-traders are subject to at least the most important provisions in the EU algo-trading regime—and the truth is that the risks inherent in algo-trading remain present regardless of the identity of the trader that engages in algo-trading. However, while the extension of article 17 of MiFID II to certain non-MiFID undertakings is a targeted response to those risks—the extension of the whole of MiFID II, in particular, to proprietary investment firms engaging in HFT can be criticised for a number of reasons.

First, HFT is notoriously unsuitable as a regulatory category, both because it refers to a variety of different market practices—with variably positive and negative effects on market quality[458]—and because it is difficult to rigorously distinguish from vanilla algo-trading.[459] Therefore, while HFT can be a useful

[456] *See* MiFID II, article 15. *See,* in particular, the opinion issued by EBA in the context of preventing the Dutch DNB from subjecting local proprietary traders to softer capital requirements (*see* the notice released by EBA at <https://eba.europa.eu/-/eba-closes-breach-of-union-law-investigation-against-dnb-and-will-monitor-transitional-measures-adopted-to-redress-the-case> and the press release published by DNB at <https://www.dnb.nl/en/news/news-and-archive/persberichten-2017/dnb365628.jsp>); notably, the EBA decision affected various HFT firms, including Flow Traders and Optiver (*see* Reuters staff, 'Dutch Central Bank Adopts European Rules for Proprietary Traders' (14 November 2017)).

[457] John Armour, Martin Bengtzen and Luca Enriques, 'Investor Choice in Global Securities Markets' (ECGI 2017) Law Working Paper N° 371/2017.

[458] *See* chapter 3.

[459] Indeed, there is no common aspect to all HFT—like automation, speed, or disintermediation—that is entirely absent from all other instances where algo-trading mechanisms are used, making HFT difficult to distinguish from algo-trading in abstract—ie, without looking at the strategies actually employed by traders. For a discussion of the difficulties in defining HFT, *see*, i.a., ESMA,

doctrinal category for re-arranging and studying the variety of algo-trading strategies employed in modern EU markets, it should not serve any regulatory purpose: neither that of extending the subjective scope of MiFID II, nor, as will be noted, that of determining the application of special rules only to HFTraders.[460]

Second, there are good reasons why proprietary investment firms are generally excluded from MiFID II—in that they do not 'represent a source of a counterparty risk to other market participants.'[461] As such, any extensions in the applicability of the directive should have been limited to those provisions that are necessary to address the new risks created by their engagement in algo-trading.

In particular, bluntly extending the whole of MiFID II—and all the rules that come with 'MiFID investment firm status'—to HFTraders means subjecting them to strict capital requirements, and taking away some of the flexibility essential to beneficial HFT strategies like market-making.[462] This has led some commentators to speculate that the consequences of applying capital requirements to HFTraders following their regulation as MiFID investment firms

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'Economic Report: High-Frequency Trading Activity in EU Equity Markets' (n 284); and chapter 9.

[460] *See* chapter 9.

[461] MiFID II, recital (50).

[462] Importantly, these rules are set to change with the approval of the new capital requirements framework for investment firms comprised by Directive 2019/2034 and Regulation 2019/2033—which notably make capital requirements depend on the classification of HFTraders (into classes 1, 2 or 3) and on 'k-factors' measuring the risks inherent to their activity. This added flexibility may be important to constrain the impact of capital requirements on the (beneficial) activity of HFTraders; still it is worth noting that proprietary investment firms may nonetheless remain subject to the harsher capital requirements applicable to credit institutions under CRD IV and CRR even under this new framework (*see* Directive (EU) 2019/2034, recital (7) and article 5(1)).

may not have been 'fully realised by the European legislator'[463]—with tight 'capital rules for high-frequency traders' being 'the last thing Europe's already liquidity-constrained financial markets need.'[464]

As such, it is argued that it would be preferable for the EU to only extend the specific provisions in MiFID II that are required to address the risks inherent in algo-trading to proprietary investment firms engaged in HFT—much like it did in regard to insurance and collective investment undertakings.[465] And although the full consequences of using HFT as a regulatory category are not discussed until later in this thesis,[466] it can already be argued that it would be even better if the EU were just to extend the select MiFID II provisions needed to regulate algo-trading—particularly its article 17—to all proprietary investment firms with

[463] Conac (n 31), 17.45.

[464] *See* Stafford, 'Tighter HFT Capital Rules Will Only Harm Eurozone Market Trading' (n 17). At the same time, Biais and Foucault have noted that 'capital buffers would reduce the likelihood that HFT firms would be destabilised by liquidity shocks and would in turn destabilise their counterparties'—and that 'capital requirements could increase the "skin in the game" of the manager owners of HFT firms, and reduce the moral hazard problem associated with limited liability' (*see* Bruno Biais and Thierry Foucault, 'HFT and Market Quality' [2014] Bankers, Markets & Investors 5, 16).

[465] MiFID II, article 1(5).

[466] *See* chapter 9.

disintermediated access[467] to EU markets, instead of specifically targeting HFTraders.[468]

4.3.2.2 Excluding retail traders from the scope of MiFID II

Another noteworthy aspect of the EU-algo trading regime is the exclusion of retail traders from most of its subjective scope.[469]

Indeed, while both professional and retail traders are technically able to employ algo-trading mechanisms in their activity—and the EU regime has extended the scope of (at least some of) MiFID II to professional traders previously exempt from the directive on account of their algo-trading—retail traders remain fully exempt from MiFID II.[470]

This is essentially justified for proportionality reasons: retail traders are typically less capable of bearing the regulatory burden inherent in financial

[467] The expression 'disintermediated access' would allow the regulator to avoid the expression 'DEA'—from which the EU has mistakenly excluded instances where markets provide 'direct access to non-intermediaries (ie, parties other than registered brokerage firms), as market-members and in that capacity connecting directly to the market, without going through an intermediary' (*see* OICV-IOSCO, 'Policies on Direct Electronic Access - Consultation Report' (n 169), 7)—and would be sufficient to encompass all proprietary investment firms engaged in algo-trading, as all algo-trading is, by definition, disintermediated (*see* chapter 3).

[468] This could require the introduction of special licensing requirements for investment firms by reason of their engaging in algo-trading. For a discussion, *see* chapter 5.

[469] Crucially, retail traders fall under the scope of the rules in the EU algo-trading regime included in MAD/MAR. For a discussion, *see* chapter 6.

[470] *See,* MiFID II, article 4(1)(1), which defines 'investment firms' as 'legal person[s] whose regular occupation or business is the provision of one or more investment services to third parties and/or the performance of one or more investment activities on a professional basis;' at the same time, a retail investor is defined by the EU as a 'person investing his own money on a non-professional basis' (*see* EC, 'Glossary of Useful Terms Linked to Markets in Financial Instruments' (n 42)). MiFID II then applies only to (professional) investment firms, market operators, data reporting services providers and, in certain circumstances, third-country firms with branches established within the EU (*see* MiFID II, article 1(1)).

regulation—and they should be exempt from most requirements applicable to professional traders under EU law.[471]

Additionally, retail traders are less likely to engage in algo-trading than professional traders—as they are not often venue members,[472] nor DEA service users[473]—and if they do engage in algo-trading, they might do it at a smaller scale than professional traders. Also, some of the most controversial strategies associated with algo-trading—like HFT low-latency arbitrage—are not usually available to retail investors, who will not have the expensive technology and infrastructure required to pursue them.

Finally, it is worth noting that although the retail traders who do engage in algo-trading are exempt from MiFID II, any venues and intermediaries that host or facilitate their activity fall under the directive—with the result that even the risks

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[471] *See* MiFID II, recitals (12) and (164). Recital (12) notes that '[t]he purpose of [MiFID II] is to cover undertakings the regular occupation or business of which is to provide investment services and/or perform investment activities on a professional basis' and that the scope of MiFID II 'should therefore not cover any person with a different professional activity.' Simultaneously, recital (164) establishes that '[i]n accordance with the principle of proportionality, as set out in [Article 5 of the Treaty of the European Union], [MiFID II] does not go beyond what is necessary in order to achieve [the objective of creating an integrated financial market in which investors are effectively protected and the efficiency and integrity of the overall market are safeguarded],' particularly when the 'establishment of common regulatory requirements relating to investment firms' is concerned.

[472] Most retail trading is carried out by execution intermediaries and often internalised (*see* chapter 3).

[473] *See* ESMA noting that 'direct market access/sponsored access clients are more likely to be professional clients' (ESMA, 'Consultation Paper: Guidelines on Systems and Controls in a Highly Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (n 171)).

arising from retail algo-trading will be somewhat, if only indirectly, mitigated by MiFID II.[474]

4.3.3 A few more misconceptions

All things considered, the analysis of the scope of the EU algo-trading regime has revealed that the EU enjoys a solid conceptual understanding of this trading, endorsing the idea—shared by this thesis—that all algo-trading is conducted by machines autonomously making and implementing trading decisions.

However, closer inspection of the scope of the EU algo-trading regime also reveals two fundamental misconceptions about automated-trading technology and its impact on EU markets: first that algo-trading carried through basic execution algorithms carries less risk than other types of algo-trading; and, second that engagement in HFT should be regulated as such, regardless of the significant variety of algo-trading strategies included in this highly heterogeneous category of trading. Indeed, this chapter had already noted that the EU regime was partly (and mistakenly) motivated by concerns with HFT as a whole.[475]

These misconceptions carry significant consequences for how algo-trading and algorithmic trading-inspired strategies are regulated under the EU regime—including the exclusion of basic execution algorithms from its scope and the extension of 'MiFID investment firm status' to all proprietary investment firms

[474] *See* chapters 7-8.

[475] *See* section 4.2.1.

engaged in HFT. But before expanding on the impact of these misconceptions on the various rules that comprise the EU regime, it is worth looking at the structure of that regime for one final clue as to how the EU perceives the change brought by automated-trading technology to its markets.

4.4 The structure of the EU algo-trading regime

Analysing the basic building blocks of the EU algo-trading regime has revealed the influence of certain misconceptions in the concerns and scope that guide the application of that regime. However, these isolated misconceptions do not take away from the fact that the EU regime shows a fairly nuanced understanding of automated-trading technology and its role in changing EU markets—in particular by being structured into different sets of rules that apply differently to different categories of market players, on account of the different mechanisms and strategies that they employ.[476]

Indeed, the EU regime is divided into two sets of rules: those that apply to every instance where the algo-traders included under its subjective scope employ the algo-trading mechanisms included in its objective scope; and those that apply to particular strategies developed in response to the popularisation of those mechanisms across EU markets.

The first set of rules is then split between two regulatory frameworks: MiFID/MiFIR, which include reporting and organisational requirements that

[476] MiFID II, recital (63).

govern all uses of algo-trading mechanisms; and MAD/MAR, which now explicitly target algorithmic trading-induced market manipulation. As for the second set of rules, it is essentially included in MiFID II and contains provisions that apply to the strategies adopted by venues in response to algo-trading, provisions that govern the strategies adopted by intermediaries to facilitate algo-trading, and, finally, provisions that specifically regulate the use of HFT strategies.

In truth, the way in which the EU has structured its algo-trading regime also reflects some of the misconceptions inferred from analysing the concerns and scope of that regime—in particular, the notion that there is a clear relationship between algo-trading and market manipulation, or the idea that HFT can be regulated as a whole—but it also shows a notable understanding of the dual-natured change brought by automated-trading technology to EU markets.

In particular, the structure of the EU algo-trading regime shows that the EU was able to follow one of the key prescriptions for an effective algo-trading regime made by this thesis—containing both rules that regulate the generalised use of algo-trading mechanisms, and, additionally, rules that apply to particular algorithmic trading-inspired strategies.[477]

4.5 Conclusion

The analysis of the basic building blocks of the EU algo-trading regime has revealed some solid foundations: the EU has fundamentally understood what

[477] *See* chapter 3.

algo-trading is, and why its popularisation can represent a threat to the efficiency and fairness of its capital markets. The structure of the EU regime, in particular, reveals a good grasp of the dual-natured change brought by automated-trading technology to EU markets: because the various mechanisms and strategies changed by this technology have very different impact on market quality, using separate sets of rules for their regulation is key to an effective regime.

Nevertheless, this initial analysis of the EU regime has also revealed three key misconceptions set to have a negative impact on its effectiveness: that not all trading algorithms are worth regulating; that the use of algo-trading mechanisms makes a material contribution to market manipulation; and that HFT raises concerns, and should be regulated, as a whole.

Indeed, some of these negative consequences already became apparent from just looking at the scope of the EU regime: the exclusion of basic execution algorithms from its scope and the extension of MiFID II to all proprietary investment firms engaged in HFT. And already in this chapter some measures were proposed to combat these consequences: the amendment of the EU definition of algo-trading and the extension of only the MiFID II rules needed to govern algo-trading to proprietary HFTraders—or, rather, to proprietary investment firms with disintermediated access to EU markets.

But the misconceptions held by the EU about algo-trading may have shaped more than just the basic building blocks of its algo-trading regime—with its influence also extending to the content of its rules. As such, the next chapters set out to examine that influence and the degree to which it negatively affects the effectiveness of the EU regime.

Ultimately, it will be argued that the rules in MAD/MAR that specifically regulate algorithmic manipulation are based on a wrongly perceived association between algo-trading and market abuse and should as such be amended (*chapter 6*); likewise, the rules in MiFID/MiFIR applicable only to HFT reflect the misconception that (all) HFT can be regulated as a monolithic category of trading and should thus be discarded (*chapter 9*). On a more positive note, it will be argued that the rules in MiFID/MiFIR that govern the general use of algo-trading mechanisms (*chapter 5*) and the strategies employed by venues and other intermediaries in hosting and facilitating algo-trading (*chapters 7-8*) reveal a fairly accurate understanding of the extent to which automated-trading technology has changed EU markets—and should contribute to preserving or improving their quality.

5. NEW RULES FOR NEW MECHANISMS: THE REGULATION OF ALGO-TRADING UNDER MIFID/MIFIR

5.1 Introduction

The EU algo-trading regime is nothing if not ambitious—impressively regulating not just the use of algo-trading mechanisms by traders, but also a myriad of strategies developed by market players in response to the popularisation of these mechanisms across the EU.[478]

Less impressively, the EU regime also suffers from a few key misconceptions about the change brought by automated-trading technology to EU markets. Such misconceptions were apparent even from a superficial analysis of the basic building blocks of that regime—and stand to have a negative impact on its effectiveness. However, the extent of that impact can only be measured after examining the actual content of the different rules in the EU regime.

This chapter begins that examination, starting with the provisions that regulate the use of algo-trading mechanisms—regardless of strategy—and leaving the rules that regulate the strategies inspired by algo-trading for later.[479]

[478] MiFID II, recital (63).

[479] *See* chapters 7-9.

Crucially, the rules in the EU regime that govern the use of algo-trading mechanisms are split into two sets of acts: MiFID/MiFIR, and MAD/MAR. For ease of exposition, they are then analysed in two chapters,[480] with this chapter examining only the rules in MiFID/MiFIR—specifically, the licensing (*5.2*), reporting (*5.3*), and organisational requirements (*5.4*) that may regulate the use of algo-trading mechanisms.

In the end (*5.5*), it is argued that the reporting and organisational requirements applicable to algo-traders under the EU regime are comprehensive, but proportionate—reflecting a solid understanding of the risks inherent in all instances of algo-trading and making a cost-effective contribution to defending the integrity of EU markets against those risks. It is also argued that the absence of special licensing requirements applicable to traders by reason of their algo-trading should be largely unproblematic.[481]

Ultimately, the misconception—endorsed by the EU—that different trading algorithms carry significantly different levels of risk and should thus be regulated differently is somewhat reflected in the distinction made by some of these rules between (non-pure) investment decision algorithms and (smart) execution algorithms. However—and even if it would have been preferable to eliminate those distinctions—their impact is limited and causes no need for immediate reform.

[480] *See* chapters 5-6.

[481] At least under the current configuration of the EU regime: *see* fn 468.

5.2 Licensing requirements

The logical starting point for analysing the rules in the EU regime that govern the general use of algo-trading mechanisms—irrespective of strategy—is the discussion of the licencing requirements that may apply to algo-traders.

Broadly, licensing requirements contain the criteria that must be met before an agent can engage in a regulated activity.[482] In that sense, licensing requirements are often seen as 'entry regulation,' preventing players from accessing activities that entail particular risks unless they abide by certain rules.[483] They are also a means of ensuring obedience to any applicable reporting, organisational and conduct requirements, as licences are often conditional upon continued compliance with those rules.[484]

This section addresses two questions. The first is whether the EU imposes any special conditions before traders are allowed to engage in algo-trading (*5.2.1*). And, since the answer is negative, the second question is whether the EU regime should have included licensing requirements specifically applicable to algo-traders (*5.2.2*).

[482] Armour and others (n 4).

[483] MiFID II, recital (37).

[484] *See* Armour and others (n 4). *See* also, in the context of the EU regime, MiFID II, recital (42) and article 8(c).

5.2.1 Licensing requirements in MiFID II

The best place to begin looking for answers as to whether the EU imposes licensing requirements on algo-traders is MiFID II,[485] which stands as the centrepiece of the EU algo-trading regime.

But before engaging in this exercise, it is worth recalling that such regime extends beyond MiFID II and applies to agents that do not generally fall under the directive. Some of these agents are subject to the algo-trading requirements in article 17 of MiFID II—and discussed later in this chapter—but not to other requirements in the directive,[486] and others, including retail investors, do not fall under MiFID II at all.[487] As such, this section looks separately at MiFID firms, at non-MiFID undertakings that are nevertheless subject to the algo-trading requirements in article 17 of MiFID II,[488] and at non-MiFID investors that are wholly exempt from the directive (but are nevertheless subject to other provisions in the EU algo-trading regime).[489]

Under MiFID II, all MiFID firms are subject to authorisation conditions[490] to ensure the '[protection of] investors and the stability of the financial

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[485] MiFID II should be read in conjunction with MiFIR—but it is MiFID II that contains the provisions governing the authorisation of the activities that fall under its scope (*see* MiFID II, recital (7)).

[486] *See* MiFID II, article 1(3)(a) and (5) and the discussion in chapter 4.

[487] *See* chapter 4.

[488] MiFID II, article 1(3)(a) and (5).

[489] *See*, in particular, the rules discussed in chapter 6.

[490] MiFID II, article 1(2)(a).

system.'[491] These are listed in article 5 and require MS to subject the 'provision of investment services and/or the performance of investment activities as a regular occupation or business on a professional basis…to prior authorisation.'[492]

However, MiFID II imposes no additional licensing requirements on MiFID firms just because they engage in algo-trading. And while it is true that certain undertakings that used to be exempt from MiFID II now fall under its scope (and are subject to its licensing requirements) because they engage in particular algo-trading strategies—namely HFT[493]—that is not the same as having special licensing requirements apply to certain firms solely because they use algo-trading mechanisms.[494]

As for the non-MiFID undertakings that are nevertheless subject to its article 17, these are clearly exempt from the general licensing requirements in the directive. Indeed, MiFID II itself stresses that 'entities which are…supervised under Union law regulating the financial sector and are exempt from this Directive, but which engage in algorithmic trading or high-

[491] MiFID II, recital (37).

[492] MiFID II, article 5.

[493] *See* chapter 4.

[494] Something more is required—in this example, engagement in HFT. The licensing requirements applicable to HFTraders are discussed in chapter 9.

frequency algorithmic trading techniques, should not be required to obtain an authorisation under this Directive.'[495]

Instead, these undertakings are often subject to licensing requirements outside MiFID II. For instance, insurance and re-insurance undertakings are subject to prior authorisation under Solvency II;[496] likewise, companies looking to manage UCITS must apply for a licence under the UCITS Directive.[497] However, the licensing requirements that govern these non-MiFID undertakings too fail to include any rules specifically applicable to algo-traders solely on account of their algo-trading.

Finally, the non-MiFID investors that are fully excluded from the scope of the directive, are also exempt from any licensing requirements under MiFID II—and, indeed, under the wider EU framework. In particular, none of the non-MiFID components of the EU algo-trading regime—such as MAD/MAR—impose special algo-trading licensing requirements.

In conclusion, the EU algo-trading regime—defined earlier as the set of rules that specifically pertain to the use of algo-trading mechanisms and

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[495] MiFID II, recital (63).

[496] EU Directive on the taking-up and pursuit of the business of Insurance and Reinsurance ('Solvency II'), article 14.

[497] EU Directive on the coordination of laws, regulations and administrative provisions relating to undertakings for collective investment in transferable securities ('UCITS Directive'), article 6.

algorithmic trading-related strategies within the EU[498]—does not associate special licensing requirements with the use of algo-trading mechanisms.

In time, it will be noted that certain market players engaged in algo-trading are subject to a duty to inform MS authorities that they carry out this type of trading.[499] However, this is not a licensing requirement, as it does not entail asking for permission to undertake an activity.

5.2.2 Assessing the lack of special licensing requirements in the EU regime

The importance of licensing requirements comes from their role in preventing certain players from accessing particularly risky activities, and bringing them to the attention of the authorities responsible for ensuring compliance with any applicable reporting, organisational and conduct requirements.

Despite their importance, the absence of licensing requirements specifically applicable to (all) agents engaged in algo-trading within the EU is not currently cause for concern. Indeed, even the fact that only certain algo-traders are subject to licensing requirements under wider EU Law is mostly unproblematic.

[498] *See* chapter 1.

[499] *See* MiFID II, article 17(2), discussed in section 5.3.1.

In fact, it is not unusual for financial regulation to distinguish between categories of investors.[500] And here the differences in treatment find justification in two notions: first, the notion that most algo-traders are MiFID firms (or, in any case, regulated entities); and, second, the notion that it could be disproportionate to require non-MiFID undertakings to apply for a broad licence under MiFID II—or, in the case of non-MiFID retail investors, to apply for any licence at all—just by reason of their (vanilla) algo-trading.

Both notions were discussed in *chapter 4*. True algo-trading is disintermediated,[501] and algo-traders can only enjoy disintermediated access to markets by either becoming venue members, or purchasing DEA services. As both alternatives are more easily embraced by persons 'whose regular occupation or business' is facilitating, or engaging in investment activities 'on a professional basis'—ie, by investment firms[502]—most algo-traders will be (professional) investors and, often, MiFID firms.[503]

The second notion—that it would be disproportionate to ask non-MiFID entities to apply for a licence under MiFID II, or to ask non-MiFID retail investors to apply for any licence at all—rests on two ideas. First, it is worth noting that investors excluded from MiFID II often have been so excluded because their

[500] For example, between professional investors, institutional investors, and retail investors (*see*, i.a., Armour and others (n 4)).

[501] *See* MiFID II, article 4(1)(39). It is only this type of (automated, fast and disintermediated) trading that gives rise to the 'cyber' and systemic risks described in chapter 3.

[502] MiFID II, article 4(1)(1).

[503] *See* chapter 4.

activity is less likely to pose a threat to market integrity than that of MiFID firms[504]—and the role of licensing requirements is to control access to activities because of their inherent riskiness.[505]

Second, most non-MiFID investors—and, in particular, retail investors—would be less able to support the stringent regulatory burden imposed by licensing requirements—and, in particular, by MiFID—than professional MiFID firms.[506] This is especially so to the extent that authorisation under MiFID II, specifically, is conditional upon compliance with initial capital requirements,[507] and entails wide-ranging[508] organisational and risk-management obligations, 'fit and proper' requirements for managers and qualifying shareholders, as well as a series of reporting requirements.[509]

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[504] MiFID II, recitals (27)-(50).

[505] The application of special licensing requirements to HFTraders may reflect this idea, as the EU perceives (all) HFT as being especially risky. For a discussion, *see* chapter 9.

[506] MiFID II, recitals (12) and (164).

[507] Indeed, article 15 of MiFID II establishes that MS must 'ensure that the competent authorities do not grant authorisation unless the investment firm has sufficient initial capital in accordance with the requirements of Regulation (EU) No 575/2013 having regard to the nature of the investment service or activity in question.' From 26 June 2021, the reference to 'Regulation (EU) No 575/2013' will be replaced by a reference to 'Directive (EU) 2019/2034,' which establishes new capital requirements for investment firms.

[508] Armour, Bengtzen and Enriques (n 457).

[509] *See*, i.a., MiFID II, articles 5(3), 9, 10 and 16. Consider also Directive (EU) 2019/2034, which must be transposed by 26 June 2021, and which regulates the possibility of investment firms dealing on own account being required to 'remain subject to the same prudential treatment as credit institutions that fall within the scope of Regulation (EU) No 575/2013 and to compliance with prudential supervision under Directive 2013/36/EU' (*see* Directive (EU) 2019/2034, recital (7) and article 5(1)).

Additionally, many of these non-MiFID investors are already sufficiently regulated in other ways:[510] some, as noted, are subject to licensing requirements stemming from other EU acts,[511] and most are subject to a myriad of other regulatory requirements under the EU algo-trading regime.[512]

Ultimately, any single instance of algo-trading carries risk and can thus threaten the integrity of EU markets[513]—which could indeed justify the imposition of special licensing requirements on algo-traders.[514] However, it is argued that, as the current EU regime stands, there are good reasons for the absence of special authorisation requirements applicable to all algo-traders by reason of their algo-trading.[515]

Furthermore, it is worth noting that licensing requirements are not the only regulatory tool available to the EU—and the risks arising from algo-trading

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[510] MiFID II, recital (34).

[511] *See,* i.a., article 8 of CRD IV (for credit institutions); article 14 of Solvency II (for insurance and re-insurance undertakings); and article 5 of the UCITS directive (for undertakings for collective investment in transferable securities).

[512] *See* section 5.3 (in regard to reporting requirements); section 5.4 (in regard to organisational requirements); and chapter 6 (in regard to conduct requirements).

[513] Indeed, 'the potential risks arising from algorithmic trading can be present in any trading model supported by electronic means' (*see* chapter 3 and ESMA, 'Cost Benefit Analysis – Annex II - Draft Regulatory and Implementing Technical Standards MiFID II/MiFIR' (2015) ESMA/2015/1464).

[514] In fact, there has been support for the idea that 'all participants with direct access to a venue [should] be authorised' (*see*, i.a., Christian Krohn noting existing support for this idea *in* Authority of the House of Lords (n 222)). *See* also the ECB noting that 'the regulatory framework should clarify that all entities engaged in AT on a professional basis should be considered within the definition of investment firms and thus fall under the scope of the MiFID and be subject to supervision and monitoring of their activities by competent authorities,' as '[e]nsuring a comprehensive coverage of all entities professionally involved in HFT and AT would limit potential circumvention of the proposed rules' (*see* ECB (n 370)).

[515] This could change if the proposal in this thesis to eliminate the regulatory category of 'HFT' were to be followed; *see* fn 468.

are competently addressed by a number of other EU rules, which are applicable to venues and intermediaries and which should ensure that no algo-trading (as defined by the EU) goes completely unmonitored.[516]

5.3 Reporting requirements

Financial regulation frequently extends beyond prescribing the conditions that limit access to particular activities: market agents wishing to partake in regulated activities are often bound by reporting requirements.

Reporting requirements are rules that impose the obligation to disclose information—either just to regulators, or to the market more widely. The idea is that information is a public good, which can be underproduced; as such, it is not unusual for regulators to require or subsidise the production of information.[517] The EU algo-trading regime accordingly contains rules that mandate the disclosure of information pertaining to the use of algo-trading mechanisms.[518]

Crucially, the reporting requirements included in the EU regime all entail disclosure of information to MS authorities connected to the activity of the algo-trader—rather than to the wider financial markets. It seems then that they are meant to facilitate the monitoring of algo-traders with a view to protecting

[516] *See* chapters 7-8.

[517] Armour and others (n 4).

[518] Additional reporting requirements still govern the use of particular algorithmic trading-inspired strategies, but those are not discussed until chapters 7-9.

market integrity[519]—rather than (directly) increasing their informational efficiency.[520]

For ease of exposition, this thesis divides the reporting requirements applicable to algo-traders into two sub-categories—initial (*5.3.1*) and on-going reporting requirements (*5.3.2*)—prior to evaluating them (*5.3.3*). But before discussing these requirements, it is worth noting one other rule in the EU regime that algo-traders must keep in mind on all reporting occasions: the clock-sync rule in article 50 of MiFID II—which is neither a reporting requirement, nor a requirement that applies exclusively to algo-trading.

Article 50 of MiFID II is not technically a reporting requirement because it does not require the disclosure of information; still, it influences the way in which traders 'record the date and time of any reportable event,' shaping compliance with the requirements discussed below. Additionally, article 50 applies to 'any reportable event,'[521] but is especially important in an algo-trading environment where 'increased accuracy' is particularly 'relevant.'[522]

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[519] As noted by the EC, 'transparency towards regulators' should allow for a 'more extensive monitoring of markets by regulators leading to reinforced market integrity' (*see* EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MiFID Recast] and the Proposal for a [MiFIR]' (n 379)).

[520] Indeed, 'trade data helps investors to find the right price when looking to buy or sell, and to check whether they got the best price by comparing the price that they got with other market prices' (*see* EC, 'Review of the Markets in Financial Instruments Directive (MiFID): Frequently Asked Questions' (2011) MEMO/11/716). As noted below, most algo-traders are also subject to a number of obligations to disclose information to the wider financial markets (including the transparency requirements in MiFIR). However, these requirements are not specific to algo-trading and cannot, for that reason, be included in the EU algo-trading regime.

[521] MiFID II, article 50.

[522] *See, a contrario,* recital (4) of CDR 2017/574.

Briefly, article 50 of MiFID II requires traders to 'synchronise the business clocks they use to record the date and time of any reportable event' with the business clocks of the venues in which they participate, with a particular level of accuracy.[523] Algo-traders, specifically, are allowed to diverge from Coordinated Universal Time ('UTC')[524] by a maximum of 1 millisecond, with time-stamps of 1 millisecond granularity (if they only engage in vanilla algo-trading),[525] or by a maximum of 100 microseconds, with time-stamps of 1 microsecond granularity (if they also engage in HFT). By contrast, non-algorithmic traders can diverge from UTC by as much as 1 second, with timestamps of 1 second granularity.[526]

This differentiation between traders appears motivated by proportionality concerns—and exempts vanilla algo-traders from the harsh clock-sync and time granularity requirements that apply to HFTraders (and which are discussed later in this thesis).[527]

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[523] CDR 2017/574, article 3.

[524] UTC is the reference time for market participants under article 50 of MiFID II (*see* CDR 2017/574, article 1)).

[525] *See* answer 13 (topic 3) *in* ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414).

[526] CDR 2017/574, article 3 and table 2 of its Annex.

[527] *See* chapter 9.

5.3.1 Initial reporting requirements

Most traders engaging in algo-trading in the EU must comply with a myriad of reporting requirements before they can start their activity.

Some of these requirements are found in MiFID II and apply, in particular, to MiFID firms[528]—but others flow from wider EU law. For instance, insurance and reinsurance undertakings are subject to initial reporting requirements under Solvency II,[529] and companies managing UCITS are likewise required to comply with initial reporting obligations under the UCITS directive.[530]

Most of these reporting requirements apply regardless of whether these undertakings engage in algo-trading or not. There are, however, certain requirements in MiFID II that apply just to algo-traders—and which can therefore be said to belong to the EU algo-trading regime.

5.3.1.1 Scope

The initial reporting requirements applicable to algo-traders under the EU regime are found in article 17(2) of MiFID II, and apply both to MiFID firms and to non-MiFID undertakings that are subject to its article 17.[531]

[528] *See*, for instance, articles 5(3) and 7(2) of MiFID II.

[529] *See*, i.a., article 18 of Solvency II.

[530] *See*, i.a., articles 8(1) and 19 of the UCITS Directive.

[531] MiFID II, article 1(3)(a) and (5), and recital (63).

By contrast, retail investors that engage in algo-trading while being excluded from MiFID II are also exempt from the initial reporting requirements in its article 17(2).

5.3.1.2 Purpose and content

The initial reporting requirements in article 17(2) of MiFID II contain a double obligation: a trader engaging in algo-trading in the EU (while falling under the scope of this provision) shall notify that fact to the competent authorities of both its home MS[532] and the MS of the venue where it engages in algo-trading, 'as a member or participant.'[533]

Because these initial reporting requirements are owed to MS authorities, they have the purpose of ensuring that these authorities have enough information to assess whether the information-provider has 'the necessary arrangements' to meet its obligations under the EU regime.[534]

Content-wise, these requirements are straightforward, with one exception: the fact that the specific requirement to disclose engagement in algo-trading activity to the competent authorities of the MS of the venue where their trading takes place applies only to venue members/participants.[535] Under

[532] 'Home MS' is defined in MiFID II, article 4(1)(55).

[533] MiFID II, article 17(2).

[534] The expression is taken from article 7(2) of MiFID II—which applies to initial reporting requirements more broadly—but the idea that it conveys about the function of initial reporting requirements holds true also for the initial reporting requirements included in the EU algo-trading regime.

[535] MiFID II, article 17(2).

MiFID II, the concepts ‘member’/‘participant’ are used interchangeably—and exclude agents that only interact with venues through DEA services.[536] As such, these agents are excused from disclosing their algo-trading to the MS authorities responsible for those venues.

Finally, it is noteworthy that these initial reporting requirements come coupled with a record-keeping obligation to preserve evidence of the information disclosed for a period of five years,[537] which must be ‘sufficient to enable’ the relevant authorities to monitor compliance with MiFID II.[538]

5.3.2 On-going reporting requirements

There are two types of on-going reporting requirements that may apply to algo-traders under the EU regime: specific requirements to disclose information under article 17 of MiFID II; and general requirements to disclose transaction information under MiFIR, which apply broadly to all MiFID firms—but which have some specificities for algo-traders.

Much like the previous section, this section too is limited to analysing the reporting requirements that apply specifically to algo-traders under the EU

[536] Indeed, recital (16) of MiFID II notes that the terms ‘members’ and ‘participants’ ‘do not include users who only access the trading venues via direct electronic access.’ Notably, this limitation does not impact the non-MiFID undertakings that are required to comply with article 17 of MiFID II under its article 1(5), as this list includes only ‘members or participants of regulated markets and MTFs.’

[537] *See* MiFID II, article 17(2) and MiFIR, article 25(1).

[538] MiFID II, article 17(2).

regime—disregarding the many other on-going reporting requirements that apply to traders under wider EU Law.[539]

5.3.2.1 Special on-going reporting requirements under MiFID II

Like the initial reporting requirements discussed previously, the special on-going reporting requirements applicable to algo-traders under MiFID II are also found in article 17(2)[540]—and apply both to MiFID firms and non-MiFID undertakings that are nevertheless subject to this article.[541]

There are, however, two differences between these requirements. The first is that the on-going reporting obligations owed by algo-traders are only ever owed to the competent authorities of their home MS—while the initial algo-trading reporting obligations may, in addition, be owed to the competent authorities of the MS of the venues where the algo-trading takes place.[542]

[539] *See,* i.a., articles 5(3), 9(5) and 22 of MiFID II. *See* also, for example, article 7 of the UCITS directive (for firms managing UCITS); and article 35 of Solvency II (for insurance and reinsurance firms).

[540] These reporting requirements may be complemented by a requirement to flag all orders generated by algo-trading to venues, so that they can report them to the relevant MS authority (*see* MiFID II, article 48(10)), as well as by a requirement to specifically flag all market-making orders (*see* CDR 2017/580, article 3(2)(a))—at least in the case of MiFID firms. These flagging requirements are discussed in chapters 7 and 9—as the first requirement is solely meant to help venues comply with their own reporting requirements and the second requirement only applies in the context of a specific HFT strategy.

[541] MiFID II, article 1(3)(a) and (5).

[542] *See* MiFID II, article 17(2). Notably, however, 'the competent authority of the home [MS] of the investment firm shall, on the request of a competent authority of a trading venue at which the investment firm as a member or participant of the trading venue is engaged in algorithmic trading and without undue delay, communicate the information…that it receives from the investment firm that engages in algorithmic trading [in compliance with the ongoing reporting requirements in article 17(2) of the directive].'

The second difference is that the on-going algo-trading reporting requirements under MiFID II only apply if and to the extent that the competent authority of the home MS of the algo-trader requires them to provide additional information—either 'on a regular, or ad-hoc basis.'[543] Such information typically includes a description of algo-trading strategies, details of the parameters and limits of algo-trading systems, information about mechanisms for compliance with MiFID II,[544] and details on the testing of their algo-trading systems[545]—but MS authorities can request other types of information.[546]

Much like the information disclosed under initial reporting requirements, the information conveyed through on-going reporting obligations must be kept in records 'sufficient to enable' monitoring of compliance with the directive.[547]

5.3.2.2 General on-going reporting requirements under MiFIR

Beyond the on-going reporting requirements in MiFID II, some algo-traders must also comply with on-going reporting requirements under MiFIR.[548]

[543] MiFID II, article 17(2).

[544] *See,* more specifically, MiFID II, article 17(1).

[545] The purpose of these requirements is to have the trader explain the 'design, purpose and functioning of the computer algorithm(s) they employ' (*see* EC, 'Review of the Markets in Financial Instruments Directive (MiFID): Frequently Asked Questions' (n 520)).

[546] MiFID II, article 17(2).

[547] ibid.

[548] The purpose of including these requirements in a regulation (rather than in a directive) was to prevent them from diverging between MS—which was seen as '[adding] costs for firms and [limiting] the use of trade reports for trade authorities'—as well as to ensure the harmonisation of 'the information that identifies who is trading and for whom a trade is being executed' (*see* EC, 'Review of the Markets in Financial Instruments Directive (MiFID): Frequently Asked Questions' (n 520)).

It is worth making two points about the scope of these requirements. First, it is significant that they apply only to MiFID firms and credit institutions authorised under CRD IV when providing investment services and/or performing investment activities[549]—and not to other non-MIFID undertakings that are nevertheless subject to article 17 of the directive.[550] Second, it is worth recalling that the reporting requirements in MiFIR apply regardless of whether a trader engages in algo-trading—and it is just because some of their aspects are only relevant for algo-traders that they can be thought of as a part of the EU algo-trading regime.[551]

Moving on to content, the on-going reporting requirements specifically applicable to algo-traders under MiFIR should be seen as part of a larger MiFID/MiFIR reporting framework, which includes both trade reporting and transaction reporting rules.

Trade reporting aims to enhance price accuracy, in particular by increasing available information about the trading activity that goes on in financial markets.[552] By contrast, transaction reporting is a form of information

[549] *See* MiFIR, article 1(2). Some of the reporting requirements in MiFIR also apply to the operators of trading venues and other intermediaries (*see,* for instance MiFIR, Title II ('Transparency for Trading Venues') and Title III ('Transparency for Systematic Internalisers and Investment Firms Trading OTC')).

[550] As listed in article 1(5) of MiFID II.

[551] For reasons discussed previously, this section only elaborates on these aspects.

[552] *See* Armour and others (n 4); and EC, 'Review of the Markets in Financial Instruments Directive (MiFID): Frequently Asked Questions' (n 520). Arguably, trade transparency is also motivated by fairness concerns, with venues required to make both pre-trade and post-trade information available to the public on a reasonable commercial basis, as well as to ensure non-discriminatory access to that information (*see*, i.a., MiFIR, article 13).

disclosure that 'is not public,'[553] but serves instead to help monitor the activity of market players.[554]

While market players engaging in algo-trading under MiFIR are not subject to any specific trade transparency requirements due to engaging in this type of trading—they are subject to special transaction reporting requirements. As such, it would appear that these requirements are again meant to facilitate the monitoring of algo-traders and preserve the integrity of the markets—rather than to (directly) increase their informational efficiency.[555]

The special transaction reporting requirements applicable to algo-traders under MiFIR are imposed in the context of the general reporting requirements included in article 26 of MiFIR—whereby agents 'which execute transactions in financial instruments' must disclose 'complete and accurate details' of those transactions to the competent authorities 'as quickly as possible, and no later than the close of the following working day.'[556] Any reports under article 26(1) of MiFIR must include designations identifying the persons 'responsible for the investment decision and the execution of the

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[553] EC, 'Glossary of Useful Terms Linked to Markets in Financial Instruments' (n 42).

[554] *See* MiFIR, article 24. *See,* also, CDR 2017/590, recitals (9)-(10). *See,* finally, EC, 'Review of the Markets in Financial Instruments Directive (MiFID): Frequently Asked Questions' (n 520), noting that the 'system of transaction reporting enables supervisors to monitor the activities of investment firms, which helps them to ensure compliance with MiFID, and to monitor for abuses under the Market Abuse Directive (MAD),' and that 'market supervision is the main reason for transaction reporting.'

[555] *See* ibid. Preserving the integrity of the financial markets should contribute to increasing market efficiency. However, the concern with market efficiency surfaces more clearly in other parts of the EU algo-trading regime—and, more specifically, in the rules that apply to particular algorithmic trading-related strategies (as discussed in chapter 9).

[556] MiFIR, article 26(1).

transaction'—and, if that responsibility does not fall on a person but on an algorithm, that algorithm must be identified instead.[557]

The identification of algorithms in the context of transaction reporting obeys two special sets of rules laid down not in MiFIR, but in CDR 2017/590: one applicable to the algorithms responsible for formulating investment decisions, and another applicable to the algorithms responsible for making execution decisions.[558]

The first set of rules—applicable to any algorithm responsible for making investment decisions—states that its designation must comply with three conditions: be 'unique for each set of code or trading strategy that constitutes the algorithm, regardless of the financial instruments or markets that the algorithm applies to;' be used 'consistently when referring to the algorithm or version of the algorithm once assigned to it;' and be 'unique over time.'[559]

The second set of rules—applicable to the algorithms responsible for making execution decisions—subjects their designation to the same rules that apply to the algorithms responsible for making investment decisions,[560] and to

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[557] MiFIR, article 26(3).

[558] This echoes the distinction between 'investment decision algorithms' and 'execution algorithms' discussed *in* chapters 2 and 4. Specifically, the algorithms responsible for making investment decisions 'to acquire or dispose of a specific financial instrument' (as described in CDR 2017/590, article 8(1)) are essentially 'investment decision algorithms,' and the algorithms responsible for determining 'which trading venue, systematic internaliser or organised trading platform located outside the Union to access, which firms to transmit orders to or any conditions related to the execution of an order' (as per CDR 2017/590, article 9(1)) are 'execution algorithms.'

[559] CDR 2017/590, article 8(3).

[560] CDR 2017/590, article 9(3).

one additional rule that governs situations 'where a person and computer algorithm are both involved in execution of the transaction, or more than one…algorithm [is] involved.'[561] Here, it is for the trader to 'determine which person or computer algorithm…is primarily responsible for the execution of the transaction,' in accordance with 'pre-determined criteria established by the investment firm.'[562] Presumably, only the (person or) algorithm 'taking the primary responsibility for the decision should [then] be identified in the report'—although CDR 2017/590 is not entirely clear on that point.[563]

5.3.3 Evaluating the reporting requirements applicable to algo-traders

Reporting requirements mandate the production of information that economic agents would otherwise underproduce; and when a set of reporting requirements mandates the disclosure of information to supervisory authorities (as opposed to the broader market), they have the more specific function of facilitating the monitoring of the information-provider. Finally—because financial regulation is a response to risk, or, rather, to the market failures that

[561] CDR 2017/590, article 9(4).

[562] ibid.

[563] The assumption that only the (person or) algorithm primarily responsible for the execution decision will be identified in the report comes from recital (9) of CDR 2017/590, which—in regard to 'investment decisions'—establishes that 'where more than one person in an investment firm makes the investment decision, the person taking the primary responsibility for the decision should be identified in the report.' Naturally, this is only a recital—and one that only refers to investment decisions made by persons—but the same logic should apply to execution decisions made by algorithms, given the parallels between the two regimes.

arise from risk[564]—reporting requirements apply only to activities that are deemed to be particularly risky.[565]

Such is the case with the reporting requirements in the EU algo-trading regime, which require traders to disclose information to the authorities responsible for ensuring market integrity by reason of their engagement in an activity that gives rise to important risks.[566]

This focus on market integrity is understandable: while the particulars of how a certain investor uses algorithms to trade may not need to be disclosed to the wider market—as that would have little impact on price accuracy,[567] in addition to raising intellectual property concerns[568]—they might be crucial information for supervisors assessing the risk of that activity.

At the same time, and while all algo-trading poses a degree of threat to market integrity, previous sections have made evident that the reporting requirements in the EU regime do not apply to all algo-trading—nor do they apply to all algo-traders, nor to all algorithms in the same way. The question

564 Armour and others (n 4).

565 'Particularly,' because no regulatory intervention is costless.

566 Regardless of strategy employed: *see* chapter 3.

567 Such particulars might be important in the context of corporate disclosure, for investors looking to determine the value of a particular algo-trader, but they contribute very little to the valuation of the securities traded by the algo-trader.

568 *See* Sheridan, noting that 'algo-trading may often include potentially unique strategies.' Disclosure only to MS authorities also carries the risk of this information being 'leaked to competitors,' but this risk is mitigated by the duty of professional secrecy applicable to competent authorities under MiFID II, article 76(1) (Iain Sheridan, 'MiFID II in the Context of Financial Technology and Regulatory Technology' (2017) 12 Capital Markets Law Journal 417, 420).

that this section answers is whether these differences in treatment are justified—or whether they are instead a negative consequence of the EU misconceptions about algo-trading, namely the misconception that certain algorithms are not worth regulating at all.[569]

5.3.3.1 Initial reporting requirements

In order to determine if the initial reporting requirements in the EU regime contribute to market integrity, this section looks at their scope and content.

Scope-wise, these requirements apply to all MiFID firms and non-MiFID undertakings that are nevertheless subject to article 17(2) of the directive. By contrast, algo-traders that are fully exempt from MiFID II are also exempt from these requirements.

The reasons why certain algo-traders—namely those who fall wholly outside the scope of MiFID II—are exempt from the initial reporting requirements in the EU regime are similar to the reasons why they are also exempt from licensing requirements under the directive. Again, most algo-traders fall under the scope of article 17(2) of MiFID II[570]—and the few that do not are excluded by reasons of proportionality: their activity is usually less risky,

[569] *See* chapter 4.

[570] In fact, these considerations are even more resonant in this context, as it will be noted that the only traders that are wholly exempt from the reporting requirements in the EU regime are those that are wholly excluded from MiFID II.

and they are often less capable of bearing the regulatory burden inherent in these requirements.[571]

The scope of the initial reporting requirements applicable to algo-traders under the EU regime has one more limit: traders who only engage in algo-trading through DEA services are exempt from disclosing information to the MS authorities responsible for the venues where they develop their activity. This too appears motivated by proportionality concerns; additionally, the role that could be played by these initial reporting requirements is instead played by the reporting requirements applicable to the intermediaries that facilitate this DEA,[572] which should appease concerns over this limitation.

Content-wise, there is not much to note about the initial reporting requirements imposed on algo-traders under the EU regime: the only specification in MiFID II is that the information reported needs to be 'sufficient' to enable their monitoring.[573] This specification is fully in line with the purpose of these requirements—ie, to facilitate the monitorisation of algo-trading[574]—

[571] For a discussion of these concerns, *see* section 5.2.2.

[572] *See* MiFID II, article 17(5) *in fine. See* also chapter 8.

[573] MiFID II, article 17(2).

[574] EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MiFID Recast] and the Proposal for a [MiFIR]' (n 379).

and the lack of further guidance is also unproblematic: this is a mere 'notification'[575] that a particular entity started engaging in algo-trading.[576]

5.3.3.2 On-going reporting requirements

(1) The on-going reporting requirements in MiFID II

The on-going reporting requirements in MiFID II apply both to MiFID firms and to non-MiFID undertakings that are nevertheless subject to its article 17—but not to other algo-traders. Their scope is therefore similar to that of the initial reporting requirements discussed earlier—and the same arguments as to why that is a fair and proportionate solution also apply here.[577]

At the same time, it is worth recalling that the content of the initial and on-going reporting requirements applicable to algo-traders under MiFID II differ in two important ways.

The first difference is that the on-going reporting obligations under MiFID II only require algo-traders to disclose information to authorities in their home MS—and not to the authorities in the MS of any venues of which they are members. This is fine: while it might be desirable that the authorities in the MS of the venues where traders engage in algo-trading know who those traders are, that concern is addressed by article 17(2) of the directive—which entitles

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[575] EC, 'Review of the Markets in Financial Instruments Directive (MiFID): Frequently Asked Questions' (n 520).

[576] MiFID II, article 17(2).

[577] *See* section 5.3.1.

them to ask the authorities of the home MS of the algo-trader to communicate any information disclosed by that trader under MiFID II.[578]

The second difference has to do with the frequency and content of these requirements: unlike initial reporting requirements—which always apply when an entity first engages in algo-trading—the on-going reporting requirements in MiFID II only apply if and to the extent that the authorities of the home MS of the algo-trader decide that they need more information about their activity. This is again unproblematic: the purpose of these requirements is to help regulators monitor algo-trading and protect market integrity—as opposed to directly increasing the informational efficiency of those markets.[579] As such, it might be enough to just allow regulators to demand more information as and when it is needed.[580]

Indeed, this solution might be preferable. First, it gives different MS the opportunity to adopt different postures on algo-trading: the overall impact of algo-trading on market quality might be positive—even if it also carries important risks for market quality[581]—and MS should enjoy some autonomy to

[578] MiFID II, article 17(2).

[579] EC, 'Review of the Markets in Financial Instruments Directive (MiFID): Frequently Asked Questions' (n 520).

[580] Although this could create a problem of regulatory capture.

[581] S*ee* chapter 3.

adapt national rules to how much they want to encourage their markets to embrace the benefits of automated-trading technology.[582]

Second, allowing regulators to choose when and whether to ask for more information from algo-traders allows them to determine how much and what kind of data they want, based on how much and what kind of data they can analyse given their needs and resources. Since most algo-traders must abide by the initial reporting requirements described in the previous section, it would appear that MS authorities may be in a good place to know if and whether more information is needed in regard to a particular trader.[583]

Finally, limiting these on-going reporting requirements to instances where MS authorities decide that they need more information also addresses proportionality concerns, particularly since some of the entities potentially subject to these requirements are otherwise exempt from most provisions in MiFID II—arguably for good reason.[584]

(2) MiFIR on-going reporting requirements

Contrary to the MiFID on-going reporting requirements, the MiFIR on-going reporting requirements apply only to MiFID firms and credit institutions authorised under CRD IV (when they provide investment services and/or

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[582] Although this could create a problem of lack of uniformity and regulatory competition.

[583] Still, this is an empirical question—which falls outside the scope of this thesis—and the ability of MS authorities to identify the information that they need may vary widely across the EU.

[584] Either because their activities are less risky, or because they are sufficiently covered by other regulatory frameworks (*see* MiFID II, recitals (27)-(50)).

perform investment activities). All other non-MiFID entities that are nevertheless subject to (initial and on-going) reporting requirements under the directive are exempt from the reporting requirements described in MiFIR.

This limitation in scope finds an explanation in the same proportionality reasons that permeate other aspects of the EU regime. In fact, the MiFIR on-going reporting requirements are much more demanding on the time and resources of traders than the MiFID II requirements.

Indeed, the MiFID II requirements entail only a 'notification' that a firm has begun to engage in algo-trading (in the case of initial reporting requirements), or compliance with additional requests for information that may never actually be filed (in the case of on-going reporting requirements). By contrast, the MiFIR on-going reporting requirements always apply—and require undertakings to file complete, accurate and detailed reports of all executed transactions 'as quickly as possible, and no later than the close of the [working day following the transaction].'[585]

As such, necessary compliance with the MiFIR on-going reporting requirements is significantly more burdensome than the single-instance communication owed when an agent starts engaging in algo-trading, or the possible compliance with additional information requests that may—but also may not—be submitted by MS authorities.

[585] MiFIR, article 26(1).

It seems, then, that excluding certain non-MiFID investors from the scope of the MiFIR on-going reporting requirements may be justified. In this regard, the ECB has noted that 'to facilitate cross-market surveillance and to prevent and detect market abuse,' trade reporting should extend to the 'trades generated by any [professional algorithmic traders] within and across trading platforms.'[586] However, it is unclear that such thorough reporting is required when the few professional algo-traders excluded from MiFIR are nevertheless subject to initial and on-going reporting requirements under MiFID II.[587]

Looking now at the content of the on-going reporting requirements applicable to algo-traders under MiFIR, two points warrant further analysis: first the fact that they cover only executed transactions (as opposed to quotes or intentions to trade); and, second, the fact that they apply differently depending on whether transactions are a product of investment decision algorithms, or execution algorithms[588]—potentially reflecting the EU misconception that certain (simpler) algorithms are not worth regulating.[589]

The fact that these requirements cover only executed transactions is easily explained: all transaction reporting under MiFIR is limited to executed

[586] *See* EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MiFID Recast] and the Proposal for a [MiFIR]' (n 379). This view falls in line with the broader ECB view that 'all entities engaged in AT on a professional basis should be considered within the definition of investment firms and thus fall under the scope of the MiFID' (*see* ECB (n 370)).

[587] This is particularly so as the MiFID II on-going reporting requirements allow regulators to ask, at any time, for as much (additional) information as they wish—including information on any transactions generated by algo-trading (*see* MiFID II, article 17(2)).

[588] CDR 2017/590, recitals (9)-(10) and articles 8-9.

[589] *See* chapter 4.

transactions.[590] And if it is true that the use of algorithms in the placing (and cancellation) of orders can also have an impact on market integrity, that information can always be requested by MS authorities under article 17(2) of MiFID II. What is more: the directive expressly requires traders engaging in particular algo-trading strategies—notably, HFT strategies—to store this information and make it available upon request.[591]

The fact that the content of the MiFIR on-going reporting requirements varies depending on the type of algorithms used by traders is more surprising.[592]

It should be recalled that identifying algorithms in the context of MiFIR transaction reporting follows two special sets of rules: one for algorithms responsible for investment decisions and another for algorithms responsible for execution decisions. The main difference between these rules is that a special rule applies when 'a person and computer algorithm are both involved in execution of the transaction, or more than one…algorithm [is] involved,' in which case 'the person or computer algorithm taking primary responsibility for

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[590] Transaction reporting requirements primarily serve 'purposes of supervision' (*see* EC, 'Review of the Markets in Financial Instruments Directive (MiFID): Frequently Asked Questions' (n 520)), unlike trade transparency requirements, which are essentially concerned with market transparency—and which include 'the disclosure of information related to prices quoted' (*see* EC, 'Glossary of Useful Terms Linked to Markets in Financial Instruments' (n 42)).

[591] *See* MiFID II, article 17(2) *in fine*; and chapter 9. These requirements apply in addition to the pre-trade transparency requirements applicable under MiFIR, which mandate the disclosure of quote information to the entire market with the purpose of '[providing] users with information about current trading opportunities,' therefore '[facilitating] price formation and [assisting] firms to provide best execution to their clients' (*see* EC, 'Glossary of Useful Terms Linked to Markets in Financial Instruments' (n 42)).

[592] CDR 2017/590, recitals (9)-(10) and articles 8-9.

the execution shall be determined in accordance with pre-determined criteria established by the investment firm.'[593]

There are a number of problems with this: first, it is unclear whether only the algorithm (or person) primarily responsible for the execution of the transaction should be identified[594]—and, if so, why that should be so. Many algo-trading strategies are complex (involving a combination of different algorithms),[595] and looking only at the algorithm 'primarily' responsible for a transaction might not give a complete view of those strategies.

The difference in treatment between investment decision and execution algorithms is even harder to understand, as it is not justified by differences in the level of risk inherent in both types of algorithms.[596] Indeed, this distinction is likely a product of wider EU misconceptions about the riskiness of different algorithms[597] and should as such be eliminated from the EU regime.

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[593] CDR 2017/590, article 9(4).

[594] Looking at MiFID II, recital (9), it would appear that only the person or algorithm primarily responsible for the execution of the transaction needs to be identified, but the recital refers only to persons making investment decisions, as opposed to algorithms, in general, and execution algorithms, in particular.

[595] *See,* i.a., the FCA, noting that 'some firms combine investment decision and execution algorithms into a single algorithmic trading strategy' (FCA, 'Algorithmic Trading Compliance in Wholesale Markets' (n 51), 9).

[596] For a discussion of how investment decision and execution algorithms both create cyber and systemic risk—even if certain algorithms (and certain algo-trading strategies) carry more risk than others—*see* chapter 3. At the same time, the EU has noted that 'trading algorithms that are investment decision algorithms should be differentiated from order execution algorithms having regard to their potential impact on the overall fair and orderly functioning of the market' (*see* CDR 2017/589, recital (5))—although the EU defines 'investment decision algorithms' and 'execution algorithms' differently than this thesis (*see* chapter 4).

[597] *See* chapter 4.

5.4 Organisational requirements

The EU regime makes full use of the tools available under the European financial regulation framework: in addition to reporting requirements—and the conduct requirement analysed in the next chapter—the EU also subjects most algo-traders to a complex web of organisational requirements.[598]

Organisational requirements are rules that address the 'organisational deficiencies and excessive risk taking or lack of control' of particular agents through 'the reinforcement of [their] corporate governance' and the imposition of 'stricter requirements' for how they organise particular activities.[599]

These requirements are not an exclusive of the EU algo-trading regime. Most players engaging in (or responding to) algo-trading within EU markets have long been subject to organisational requirements outside that regime—and would still be subject to such requirements even if the EU had not approved organisational rules for algo-traders.[600]

Indeed, it was only during the process of reviewing the first version of MiFID that the EC—faced with the growing popularisation of algo-trading—

[598] *See*, i.a., Conac noting that that the rules applicable to investment firms under the EU regime 'include mostly organisational requirements' (Conac (n 31), 17.18). *See* also the requirements applicable to venues (hosting algo-trading) and other trading intermediaries (facilitating algo-trading), as discussed in chapters 7-8.

[599] EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MiFID Recast] and the Proposal for a [MiFIR]' (n 379).

[600] MiFID firms have long been subject to 'expanded organisational requirements' under EU law (*see* Kern and Loiacono (n 77))—as have insurance and re-insurance undertakings,[600] or firms managing UCITS (*see*, respectively, chapter IV of Solvency II; and chapter II of the UCITS directive).

thought it necessary to introduce 'new specific organisational requirements' to govern 'authorised firms involved in automated trading.'[601] As a result, MiFID II now includes a series of special, 'enhanced'[602] organisational requirements that apply exclusively to traders engaging in algo-trading.

These 'enhanced' organisational requirements are designed to address any 'potential threats for the orderly functioning of markets' arising from algo-trading[603]—ie, to defend the integrity of EU markets against the 'potential trading system errors'[604] associated with the use of algo-trading mechanisms.[605] However—and although all algo-trading carries at least some risk[606]—not all algo-traders are subject to the special organisational requirements in the EU regime.

[601] EC, 'Public Consultation - Review of the Markets in Financial Instruments Directive (MiFID)' (2010).

[602] EC, 'Proposal for a Directive of the European Parliament and of the Council on Markets in Financial Instruments Repealing Directive 2004/39/EC of the European Parliament and of the Council (Recast)' (2011) COM(2011) 656 final 2011/0298 (COD).

[603] *See* ibid. Notably, MiFID II also includes 'enhanced' organisational requirements applicable to venues (hosting algo-trading) and other trading intermediaries (facilitating algo-trading). More broadly, these requirements serve to safeguard market quality.

[604] EC, 'Public Consultation - Review of the Markets in Financial Instruments Directive (MiFID)' (n 601).

[605] *See,* recital (2) of CDR 2017/589 noting that 'an investment firm should address all risks that may affect the core elements of an algorithmic trading system, including risks related to the hardware, software and associated communication lines used by that firm to perform its trading activities.' For a discussion, *see* chapter 3.

[606] *See,* i.a., ESMA noting that 'the potential risks arising from algorithmic trading can be present in any trading model supported by electronic means' (*see* ESMA, 'Cost Benefit Analysis – Annex II - Draft Regulatory and Implementing Technical Standards MiFID II/MiFIR' (n 513)).

This section has two aims: first, to identify the organisational requirements that can apply to algo-traders under the EU regime (*5.4.1*) and, second, to assess whether such requirements help defend EU markets against the risks inherent in all algo-trading activity, or are instead plagued by any of the misconceptions held by the EU about algo-trading (*5.4.2*).

5.4.1 A complex web of organisational requirements

The organisational requirements that can apply to algo-traders under the EU regime are found in article 17(1) of MiFID II,[607] and were originally conceived as an enhanced set of special organisational requirements.

The fact that these requirements are included in MiFID II means that they apply only to certain algo-traders: namely, MiFID firms and non-MiFID entities that are nevertheless subject to its article 17(1);[608] by contrast, all retail algo-traders who are wholly excluded from MiFID II are also exempt from these requirements. The fact that these requirements are seen as an 'enhanced' set of 'special' requirements means that they apply in addition to other organisational requirements found elsewhere in EU law.

For example, MiFID firms and credit institutions authorised under CRD IV (when providing investment services or performing investment activities)[609] are also subject to the organisational requirements in article 16 of the directive.

[607] However, the detail of these organisational requirements is only found in CDR 2017/565.

[608] MiFID II, article 1(3)(a) and (5).

[609] MiFID II, article 1(3)(a).

Indeed, MiFID II specifically mandates home MS to require compliance with both 'the organisational requirements laid down in paragraphs 2 to 10 of [article 16] and in [a]rticle 17.'[610]

It seems then that different categories of algo-traders are subject to different organisational requirements under EU law: MiFID firms and relevant credit institutions are subject both to the general organisational requirements in article 16 and to the special organisational requirements in article 17(1) of the directive; other non-MiFID firms that are nevertheless required to abide by its article 17 are exempt from the organisational requirements in article 16,[611] but are still subject to the special organisational requirements in article 17(1) (along with any other organisational requirements that might apply to them under wider EU law);[612] and non-MiFID investors exempt from the directive may not be subject to any organisational requirements at all.

Although different categories of algo-traders are subject to different organisational requirements under EU law, only the rules that constitute a special response to the perceived risks in algo-trading can be said to form a

[610] MiFID II, article 16(1)

[611] Although some of the provisions in CDR 2017/589—which adds detail to article 17 of MiFID II—appear to pre-suppose compliance with certain provisions in article 16 of MiFID II (and in CDR 2017/565); *see* the discussion below.

[612] *See*, i.a., chapter IV of Solvency II (applicable to insurance and reinsurance undertakings); and chapter III of the UCITS directive (applicable to collective investment undertakings and pension funds, and their depositaries and managers).

part of the EU algo-trading regime. As such, the next section analyses only the organisational requirements in article 17(1) of MiFID II.[613]

5.4.1.1 <u>The special organisational requirements applicable to algo-traders</u>

The special organisational requirements applicable to algo-traders under article 17(1) of MIFID II can be divided into three categories: requirements to apply effective and suitable[614] systems and risk controls to algo-trading systems;[615] requirements to have effective business continuity arrangements;[616] and requirements to put in place appropriate testing and monitoring systems.[617]

Beyond describing the categories of organisational requirements applicable to algo-traders—and their goals—article 17(1) of MiFID II offers little detail in terms of what is required for compliance. This is not accidental: such

[613] This does not mean that the organisational requirements in article 16 of MiFID II apply in the exact same way to both manual traders and algo-traders: in particular, article 16(6) contains a series of record-keeping obligations that have a slightly different content when these traders engage in algo-trading—in which case their records must include designations to identify the algorithms responsible for the relevant decisions (*see*, respectively, CDR 2017/565, article 72 and Annex I, and CDR 2017/565, article 74 and Annex IV).

[614] In this context, 'suitable' requires traders to have regard to the business that they operate—'to the nature, scale and complexity of [their] business model' (*see* CDR 2017/589, recital (1))—when designing their systems and risk controls (*see* MiFID II, article 17(1)).

[615] The goal of these requirements is to ensure that those systems are resilient and have sufficient capacity, are subject to appropriate trading thresholds and limits, are embedded with mechanisms that prevent erroneous orders from being sent, do not create or contribute to a disorderly market, cannot be used for purposes contrary to MAR, and cannot be used for purposes contrary to the rules of the venues to which that system is connected (*see* MiFID II, article 17(1)).

[616] The purpose of these requirements is to help algo-traders deal with any failures of their trading systems (*see* MiFID II, article 17(1)).

[617] The goal of these requirements is to ensure that both the systems and risk controls, and the business continuity arrangements required of algo-traders have indeed been implemented and are suitably effective (*see* MiFID II, article 17(1)).

detail is found in CDR 2017/589,[618] and can be changed 'where necessary to deal with further innovation and developments' in [this] area'[619]—which is important when regulating a technology-driven phenomenon like algo-trading.[620]

CDR 2017/589 divides the organisational requirements in article 17(1) of MiFID II into two categories: general, governance-type organisational requirements;[621] and specific organisational requirements to ensure the resilience of algo-trading systems.[622]

5.4.1.2 The general organisational requirements in CDR 2017/589

The general organisational requirements in CDR 2017/589 are a series of governance, decision-making and staffing requirements that belong to the first category of requirements in article 17(1) of MiFID II, requiring the application of systems and risk controls to algo-trading systems.[623]

According to these general requirements, algo-traders must have governance arrangements to establish and monitor their algo-trading

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[618] *See* EC, 'Proposal for a Commission Delegated Regulation Supplementing [MiFID II] with Regard to Regulatory Technical Standards Specifying the Organisational Requirements of Investment Firms Engaged in Algorithmic Trading' (2016) C(2016) 4478 final; and Kern and Loiacono (n 77).

[619] MiFID II, recital (66).

[620] Indeed, amending Level 2 non-legislative acts is significantly easier than amending Level 1 legislative acts: *see* TFEU, articles 288-290.

[621] CDR 2017/589, chapter 1.

[622] CDR 2017/589, chapter 2.

[623] *See,* i.a., articles 1 and 3 of CDR 2017/589.

systems[624]—which must have regard to the 'nature, scale and complexity' of their business, and which should set out clear lines of accountability, effective procedures for communicating information, and a separation of tasks and responsibilities between trading desks and supporting functions, including the risk, control and compliance functions.[625]

The role of the compliance function is also regulated under CDR 2017/589. Namely, algo-traders must ensure that the staff allocated to this function has sufficient knowledge of algo-trading and the authority to act when needed.[626] Additionally, they must have 'at least a general understanding' of how the algo-trading systems and algorithms employed by the trader operate—and must remain in 'continuous contact' with the persons that have detailed technical knowledge of those systems and algorithms.[627]

In this regard, CDR 2017/589 requires traders to employ a sufficient number of persons with the skills needed to manage their algo-trading systems and algorithms—who must have sufficient technical knowledge of those systems, of how they are monitored and tested, of the strategies deployed through them, and of the legal obligations that pertain to their use.[628]

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[624] CDR 2017/589, article 1. These requirements should ensure 'reduced dependency on a single person or unit' (*see* CDR 2017/589, recital (3)).

[625] CDR 2017/589, article 1.

[626] CDR 2017/589, article 3(4).

[627] CDR 2017/589, article 2.

[628] CDR 2017/589, article 3.

By contrast, the risk assessment team only needs to have sufficient (non-technical) knowledge of the algo-trading activity of the trader, the skills needed to follow up on information conveyed through automatic alerts, and the authority to challenge the persons responsible for such activity when it threatens market integrity, or raises suspicions of market abuse.[629]

These requirements are complemented by rules that apply whenever traders outsource some of these functions, or procure software or hardware to be used in that activity. In such situations, traders remain 'fully responsible for [their] obligations under [CDR 2017/589].'[630]

5.4.1.3 The specific organisational requirements for ensuring system resilience in CDR 2017/589

In addition to mandating a general governance framework for algo-traders, CDR 2017/589 also lists specific requirements for ensuring the resilience of their algo-trading systems.

These include both *(1)* organisational requirements that apply before or as a trader first deploys or modifies its algo-trading systems, algorithms or

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[629] *See* CDR 2017/589, article 3(4). These requirements are similar to those applicable to the staff responsible for the compliance function (*see* CDR 2017/589, article 2(4))—but, unlike the latter, the former are not required to have 'at least a general understanding of how the algorithmic trading systems and trading algorithms of the investment firm operate,' nor are they required to be in continuous contact with the persons within the trader 'who have detailed technical knowledge of [its] algorithmic trading systems and algorithms,' or have the responsibilities listed in CDR 2017/589, article 2(2) (*see* CDR 2017/589, article 2).

[630] CDR 2017/589, article 4(1)-(2). *See* also article 2(3) for the rules that apply in the specific case than an algo-trader decides to outsource its compliance function.

strategies ('pre-deployment and deployment requirements'),[631] and *(2)* organisational requirements that only apply after their deployment ('post-deployment requirements').[632]

(1) Pre-deployment and deployment requirements

The organisational requirements that apply before or as a trader deploys or modifies its algo-trading systems, algorithms, or strategies are found in articles 5-8 of CDR 2017/589 and belong to the first category of requirements in article 17(1) of MIFID II, which mandate firms to apply systems and risk controls to their algo-trading.[633] Articles 5-7 regulate the deployment of new (or modified) algo-trading systems, algorithms and strategies, while article 8 applies only to new algorithms and introduces limits to their programming.

Broadly, article 5 of CDR 2017/589 requires traders to establish 'clearly delineated methodologies' to develop and test any algo-trading system, algorithm and strategy before it is deployed or substantially updated.[634] Such methodologies must 'address the design, performance, recordkeeping and approval' of these systems, algorithms and strategies, as well as the allocation of the responsibilities and resources that pertain to their use[635]—and should prevent behaviour that breaches CDR 2017/589 or the rules and systems of

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[631] CDR 2017/589, chapter II, section 1.

[632] CDR 2017/589, chapter II, sections 2-3.

[633] MiFID II, article 17(1).

[634] CDR 2017/589, article 5.

[635] CDR 2017/589, article 5(3).

the venues (and markets)[636] accessed by the trader, or that contributes to disorderly trading conditions. Additionally, they must ensure that the systems, algorithms and strategies employed by algo-traders 'work effectively in stressed market conditions' and can be switched off when necessary.[637]

The testing methodologies and tests employed to ensure compliance with these requirements vary depending on whether traders are looking to ensure that their algo-trading systems, algorithms and strategies behave properly, comply with the requirements in CDR 2017/589 and do not contribute to disorderly trading conditions—or whether traders are instead looking to ensure compliance with venue rules and systems.

In the first case, article 7 of CDR 2017/589 requires traders to conduct testing in a specialised environment, separated from their 'production environment.'[638] In the second case, article 5(5) of CDR 2017/589 requires traders to adapt their testing methodologies to the trading environments with which they interact,[639] to ensure that their algo-trading systems, algorithms and

[636] Although article 5(4)(c) of CDR 2017/589 does not specifically refer to 'markets,' articles 5(5) and 6 of the CDR seem to assume the need to test compliance not just with the systems of the venues accessed by the algo-trader, but also with the systems of any DMA service providers through which the trader is able to access particular markets.

[637] CDR 2017/589, article 5(4).

[638] CDR 2017/589, article 7.

[639] CDR 2017/589, article 5(5).

strategies operate as intended, and in accordance to the rules of the venues and direct market access ('DMA')[640] providers on which they rely.[641]

Specifically, traders must test the interaction between their algo-trading systems, algorithms and strategies and the systems of the venues (or DMA service providers) in which (or through which) they intend to engage in algo-trading—as they first engage in that activity.[642] More testing will then be required if and as there are any material changes to the systems or access arrangements through which algo-traders reach the markets[643]—as well as when there is a material change to the systems or relevant functionalities of the venues and DMA service providers with which those traders interact.[644]

Somewhat surprisingly, article 5(6) of CDR 2017/589 clarifies that most requirements described earlier 'only apply to trading algorithms leading to order execution.'[645] However, it is worth recalling that all trading algorithms can, by their own nature, lead to order execution—as all algo-trading involves both the automated formulation and the automated implementation of trading

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[640] DMA services are a sub-type of DEA services; for the distinction between DMA and DEA (and SA), *see* chapter 8.

[641] The reference to DMA (as opposed to DEA) is explained by the fact that, in DMA, the trader uses the system of the DEA provider instead of its own; for a discussion, *see* chapter 8. In addition, traders are required to test whether their algo-trading systems, algorithms and strategies are compatible with the matching logic of the different venues where they trade and can adequately process data obtained from those venues (*see* CDR 2017/589, Article 6(2)).

[642] CDR 2017/589, recital (4) and article 6.

[643] CDR 2017/589, article 5(5).

[644] CDR 2017/589, article 6(1).

[645] Specifically, article 5(6) clarifies that '[p]aragraphs 2 to 5 [of article 5 of CDR 2017/589] shall only apply to trading algorithms leading to order execution.'

decisions—and, indeed, the only justification for this clarification seems to be that the EU wanted to exclude the use of pure investment decision algorithms from most of the organisational requirements in its article 5.[646] Such algorithms, however, are not trading algorithms at all—with ESMA recently clarifying that 'the use of algorithms…is not considered as algorithmic trading, provided that the execution is not algorithmic.'[647]

In addition to the development and testing methodologies and requirements that apply to the systems, algorithms and strategies used by algo-traders, CDR 2017/589 also includes requirements that apply only in regard to those algorithms. Such rules apply prior to deployment and require traders to program predefined limits into their algorithms[648]—which should set (cautious)[649] boundaries around the 'number of financial instruments,' the 'price, value and numbers of orders,' the 'strategy positions, and the 'number of trading venues to which orders [can be] sent.'[650]

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646 CDR 2017/589, recital (6)

647 *See* European Securities and Markets Authority, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (2020) ESMA70-872942901–38. *See*, also, the FCA noting that 'investment decision algorithms that do not initiate orders or the timing, price or quantity of an order may not fall under the definition in MIFID II' (FCA, 'Algorithmic Trading Compliance in Wholesale Markets' (n 51), 9). For a discussion, *see* chapter 4.

648 These requirements apply 'regardless of whether those trading algorithms are new or previously have been successfully deployed in another trading venue, and whether their architecture has been materially modified' (*see* CDR 2017/589, recital (7)).

649 The reference to 'cautious' is found in the CDR recitals, but not in its main body (*see* CDR 2017/589, recital (7)).

650 CDR 2017/589, article 8. These pre-defined limits should help 'ensure that the trading algorithms perform as expected in a production environment' (*see* CDR 2017/589, recital (7)).

Finally, article 5(7) of CDR 2017/589 requires traders to keep records of all substantial changes made to the software used to support their algo-trading, which must then allow that trader to determine the nature and timing of those changes, as well as the persons responsible for making and approving them.

(2) Post-deployment requirements

Once traders have deployed the systems, algorithms and strategies on which their algo-trading will rely, they become subject to post-deployment requirements. These include both *(i)* requirements that govern their algo-trading activity; and *(ii)* requirements that determine how they should ensure compliance with the specific organisational requirements in the EU regime.

The *(i)* post-deployment organisational requirements directly governing algo-trading activity are found in articles 12-18 of CDR 2017/589—with most belonging to the first category of requirements listed in article 17(1) of MiFID II, which requires algo-trading to be subject to effective systems and risk controls.[651]

Despite applying only after traders have deployed their algo-trading systems, algorithms and strategies, many of these requirements contain mechanisms that should activate before any trading has technically taken place.[652] For instance, article 15 of CDR 2017/589 requires traders to carry out

[651] The one exception is article 14 of CDR 2017/589, which belongs to the second category of organisational requirements identified in article 17(1) of MiFID II: that of business continuity arrangements designed to help algo-traders address any failures of their trading systems.

[652] Some of these pre-trade controls even apply before order submission (*see* CDR 2017/589, recital (11)).

pre-trade controls as each order is sent to the markets[653]—namely by introducing price collars, maximum and minimum order values, and maximum message limits.[654]

Additional pre-trade controls apply to the repeated use of certain algorithms, with article 15 of CDR 2017/589 requiring traders to have in place 'repeated automated execution throttles' to control the number of times that a particular strategy has been employed. Once a strategy has been executed a pre-determined number of times, the corresponding system must be automatically (and temporarily) disabled.[655] Other pre-trade controls, still, should ensure compliance with pre-determined market and credit risk limits,[656] or the automatic blocking of certain orders.[657] And, finally, article 12 of CDR 2017/589 requires traders to put in place an emergency 'kill functionality' allowing them to 'cancel immediately…any or all of its unexecuted orders.'[658]

[653] CDR 2017/589, article 15(2).

[654] CDR 2017/589, article 15(1).

[655] CDR 2017/589, article 15(3).

[656] *See* CDR 2017/589, article 15(4). These limits are determined according to capital base, clearing arrangements, trading strategy, risk tolerance and additional variables listed in article 15(4)—and can be adjusted 'to account for the changing impact of the orders on the relevant market due to different price and liquidity levels.'

[657] CDR 2017/589, article 15(5)-(6).

[658] These orders can include orders 'originating from individual traders, trading desks or, where applicable, clients'—and traders are required to identify 'which trading algorithm and which trader, trading desk or, where applicable, which client is responsible for each order' sent to the market (*see* CDR 2017/589, article 12(2)-(3)). This is as a necessary condition for the 'withdrawal to be effective' (*see* CDR 2017/589, recital (9)).

By contrast, other post-deployment organisational requirements activate only once trading is underway—and include post-trade controls which, when triggered, should allow traders to automatically adjust or shut down particular algo-trading systems and algorithms.[659]

The remaining post-deployment organisational requirements apply regardless of whether trading has already occurred. Such is the case of article 16 of CDR 2017/589, which requires algo-traders to monitor their activity using automated real-time alerts to detect signs of disorderly trading 'in real time.' This monitoring must be undertaken by an independent function of the trader, whose staff must address any operational and regulatory issues in a timely fashion.[660]

Furthermore, algo-traders must implement 'specific'[661] automated surveillance system[s] specialising in scanning all the algo-trading activity that takes place through [their] systems' for signs of market manipulation. Specifically, these systems should 'read, replay and analyse order and transaction data' *ex post* and generate 'operable alerts' at the beginning of the trading day following the day when the activity reported took place (or, if manual processes are involved, at the end of that day).[662]

[659] CDR 2017/589, recital (11) and article 17.

[660] CDR 2017/589, recitals (11)-(12) and article 16.

[661] CDR 2017/589, recital (11).

[662] *See* CDR 2017/89, article 13. Ultimately, any trading activity that appears incompatible with the policies, procedures or regulatory obligations of algo-traders should be reported to their

Importantly, algo-traders must also put in place arrangements for when disorderly activity is detected. These arrangements are mandated under the second category of requirements in article 17(1) of MiFID II—forcing traders to implement 'effective business continuity arrangements to deal with any failure of [their] trading systems'—and should be able to deal with any 'disruptive incidents' arising from algo-trading,[663] namely by shutting down the relevant systems and algorithms 'without creating disorderly trading conditions.'[664]

Finally, algo-traders must establish an overall IT strategy to ensure the security of their IT systems, and minimise their vulnerability to cyber-attacks.[665]

The second set of *(ii)* post-deployment organisational requirements that determine how traders should ensure compliance with the specific post-deployment and pre-deployment requirements under the EU regime are listed in articles 9-11 of CDR 2017/589—and essentially belong to the third category of requirements listed in article 17(1) of MiFID II, whereby traders must ensure that their systems and risk controls are tested and monitored.

This testing should take place yearly, but also every time there is a 'proposed material change to the production environment related to algorithmic

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compliance function, which is then required to take appropriate action under MAR (*see*, also, MAR, article 16(2)).

[663] *See* CDR 2017/589, article 14. These requirements should vary depending on 'the nature, scale and complexity' of the business of each trader, (*see* CDR 2017/589, article 14(1)), and should be reviewed and tested yearly (*see* CDR 2017/589, article 14(4)). The minimum content of these arrangements is found in article 14(2).

[664] CDR 2017/589, article 14(3).

[665] CDR 2017/589, article 18.

trading'[666]—in which case traders must ensure that such change is previously reviewed and communicated both to the persons in charge of the relevant trading algorithms, as well as to the compliance and risk management functions of the trader. By contrast, the yearly assessment of compliance takes the shape of an 'annual self-assessment and validation process,' which culminates in a report about the systems, algorithms and strategies employed by the trader—and the risks stemming from their use.[667]

Notably, this yearly self-assessment must be complemented by 'stress testing' the systems and arrangements mandated under the post-deployment organisational requirements in articles 12-18 of CDR 2017/589—with the purpose of assessing their ability to deal with increased order flow.[668]

5.4.2 Evaluating the organisational requirements applicable to algo-traders

The organisational requirements applicable to algo-traders are wide-ranging, forming an intricate web of obligations that apply differently to different traders, at different stages of their activity. This section assesses whether these requirements contribute to defending the integrity of EU capital markets—in

[666] CDR 2017/589, article 11.

[667] CDR 2017/589, recital (8) and article 9.

[668] *See* CDR 2017/589, article 10. These tests should include both high-messaging volume tests and high-trade volume tests.

particular by mitigating the risks associated with the use of algo-trading mechanisms.[669]

To start, it is noteworthy that these requirements target all algo-trading[670] (as defined by the EU)[671]—reflecting the idea, rightly shared by the EU,[672] that certain risks are common to all uses of algo-trading mechanisms, regardless of strategy.[673] The organisational requirements in the EU regime should then be evaluated on their ability to mitigate these common risks—particularly, the cyber and systemic risks discussed earlier in this thesis.[674]

Ultimately, this section does not discuss the merit of each individual organisational rule included in the EU regime: instead, it evaluates whether the scope, structure and general content of these requirements serve the risk-mitigation purposes for which they were designed—as well as the extent to which EU misconceptions about algo-trading may hurt their effectiveness.

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[669] EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MiFID Recast] and the Proposal for a [MiFIR]' (n 379).

[670] If not necessarily all algo-traders (*see* section 5.4.1).

[671] In particular, these requirements do not apply to simple execution algorithms: *see* chapter 4.

[672] Note, in particular, how ESMA acknowledges that 'the potential risks arising from algorithmic trading can be present in any trading model supported by electronic means' (*see* ESMA, 'Cost Benefit Analysis – Annex II - Draft Regulatory and Implementing Technical Standards MiFID II/MiFIR' (n 513)). *See* also Busch noting that '[b]y subjecting algorithmic trading…to supervision, MiFID II recognises that this form of automated trading entails special risks' (Busch (n 31)).

[673] Even if the EU ultimately decided to exclude simple execution algorithms from the scope of its regime, due to perceiving them as less risky. For a discussion, *see* chapter 4.

[674] *See* chapter 3.

5.4.2.1 Scope

(1) Subjective scope

The previous section noted that the organisational requirements applicable to algo-traders under the EU regime do not apply to all algo-traders—but only to MiFID firms and non-MiFID undertakings that are nevertheless subject to its article 17.[675] All other algo-traders—notably retail investors—are exempt from any organisational requirements under EU law.

This is not unparalleled, even within the EU regime: most of its reporting requirements apply only to investment firms, and some even apply exclusively to MiFID firms.[676] And the same reasons that explain why some algo-traders are exempt from the reporting requirements in the EU regime also explain their exemption from its organisational requirements. As such, it is again argued that it is right and proportionate that the EU exempts non-professional algo-traders from most requirements in its algo-trading regime—namely, the organisational requirements in article 17(1) of MiFID II.

As for the algo-traders that are indeed subject to the special, 'enhanced'[677] organisational requirements in the EU regime, it is worth recalling that, although such traders are, indeed, all subject to those requirements, they

[675] MiFID II, article 1(3)(a) and (5), and 17(1).

[676] *See* section 5.3.

[677] EC, 'Proposal for a Directive of the European Parliament and of the Council on Markets in Financial Instruments Repealing Directive 2004/39/EC of the European Parliament and of the Council (Recast)' (n 602).

are not all subject to the same organisational requirements under wider EU law. In particular, it is worth recalling that the general organisational requirements in article 16 of MiFID II apply only to MiFID firms and, potentially, to credit institutions authorised under CRD IV.[678]

This is not, in itself, problematic: the main reason behind exempting certain undertakings from general compliance with MiFID II is the fact that they are already regulated elsewhere—and many of the undertakings exempt from article 16 of the directive are nonetheless subject to extensive organisational requirements.[679] However, it is worth noting that the EU seems to assume that all entities subject to article 17(1) of MiFID II are also (always) subject to the general organisational requirements in its article 16. In particular, article 9 of CDR 2017/589 assumes that all undertakings subject to article 17(1) of MiFID II have established risk management functions under article 23(2) of CDR 2017/565—which, however, applies only under article 16(5) of MiFID II.

As such, it would be desirable to eliminate all unwarranted references to article 23(2) of CDR 2017/565 from CDR 2017/589. At the same time, the erroneous assumption in article 9 of CDR 2017/589 is not expected—in practice—to have a negative impact on how the organisational requirements in the EU regime apply to most non-MiFID entities. Indeed, although some of these entities are exempt from article 16 of MiFID II, most are nevertheless

[678] Under article 1 (5) of MiFID II, only the requirements in article 17(1)-(6) are extended to the non-MiFID entities that nevertheless fall under the scope of its article 17.

[679] *See*, i.a., the requirements in chapter IV of Solvency II (applicable to insurance and reinsurance undertakings) and in chapter III of the UCITS directive (applicable to collective investment undertakings and pension funds).

subject to other organisational requirements under wider EU law—which typically require them to set up risk-management functions.[680] As such, all references in article 9 of CDR 2017/589 to 'the risk management function of the investment firm referred to in Article 23(2) of Commission Delegated Regulation (EU) 2017/565' need only be read as references to 'the risk management function of the investment firm' (or any function established with these purposes) to avoid any practical difficulties in their application.

All things considered, it is therefore argued that the subjective scope of the organisational requirements applicable to algo-traders under the EU regime is broadly satisfactory: it is wide enough to capture all traders whose activity might pose an actual threat to the quality of EU markets, and any exemptions are well-justified and proportionate.

(2) Objective scope

So far, this thesis has operated under the assumption that the organisational requirements applicable to algo-traders under the EU regime capture all types of algo-trading included in the EU algo-trading definition—even if it does not capture all algo-traders, and even if it includes a few differences in treatment between investment decision algorithms and (smart) execution algorithms.[681]

[680] *See*, i.a., article 44 of Solvency II (in the case of insurance undertakings or undertakings carrying out reinsurance and retrocession activities); and article 14 of the UCITS directive (in the case of collective investment undertakings and pension funds, and the depositaries and managers of such undertakings).

[681] *See*, in particular, the small difference in treatment between investment decision algorithms and execution algorithms found in articles 8-9 of CDR 2017/590. For a discussion, *see* section 5.3.2.2.

This idea, however, appears to be challenged by article 5(6) of CDR 2017/589, which states that the organisational requirements in its '[p]aragraphs 2 to 5 shall only apply to trading algorithms leading to order execution.'

According to article 5(1) of CDR 2017/589, algo-traders must have 'methodologies' for developing and testing their algo-trading systems, algorithms and strategies before they are deployed or substantially updated—with article 5(2)-(5) establishing the contents[682] and goals[683] of such methodologies. A strict reading of article 5(6) of CDR 2017/589 then suggests that although traders employing 'trading algorithms [not] leading to order execution' are required to have methodologies for developing and testing these algorithms, they are—however—free to decide on their content and goals.

In other words, it could be argued that the objective scope of some of the organisational requirements in the EU regime is limited to 'trading algorithms leading to order execution.'[684]

In practice, that is not actually the case. Upon reading recital (6) of CDR 2017/589, it appears that what article 5(6) does instead is exclude 'pure investment decision algorithms which generate orders that are only to be executed by non-automated means and with human intervention…from the testing requirements [under the CDR]'[685]—but the truth is that these 'pure

[682] CDR 2017/589, article 5(2) and (3).

[683] CDR 2017/589, article 5(4) and (5).

[684] CDR 2017/589, article 5(6).

[685] CDR 2017/589, recital (6).

investment decision algorithms' are not trading algorithms to begin with, and they are not actually captured by the definition of 'algorithmic trading' that determines the objective scope of the EU regime at all.[686]

Indeed, it is worth recalling the clarification by ESMA that 'the use of algorithms…is not considered as algorithmic trading, provided that the execution is not algorithmic'[687]—an idea that flows from the very concept of algo-trading, which implies full automation of both decision-making and decision implementation.[688] As argued earlier in this thesis, algo-trading is fundamentally different from trading with the help of algorithms.[689]

As such, it is argued that article 5(6) of CDR 2017/589 does not actually restrict the scope of the organisational requirements applicable to algo-traders under the EU regime: such requirements would never apply to these algorithms in the first place. Ideally, this paragraph should then be deleted from article 5, or at least amended to read 'trading algorithms that can lead to order

[686] *See* chapter 4.

[687] *See* European Securities and Markets Authority, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (2020) ESMA70-872942901–38; and FCA, 'Algorithmic Trading Compliance in Wholesale Markets' (2018) <https://www.fca.org.uk/publication/multi-firm-reviews/algorithmic-trading-compliance-wholesale-markets.pdf> accessed 31 August 2018.

[688] S*ee* chapter 2.

[689] For a discussion of this difference, *see* chapters 2-3.

execution'—an expression which, although redundant, would at least be more rigorous than the wording currently found in the CDR.[690]

Ultimately, even though some of misconceptions held by the EU about algo-trading—namely about the difference between algo-trading and trading with algorithms[691]—may have originated the unfortunate wording in article 5(6) of CDR 2017/589, they have not meaningfully influenced the scope of the organisational requirements applicable to algo-traders under the EU regime. As such, that scope appears adequate for the purposes for which those requirements were conceived.

5.4.2.2 Structure and content

The organisational requirements applicable to algo-traders under the EU regime do a good job of capturing most algo-trading activity that might threaten the integrity of EU markets, but that is only a necessary condition—not a sufficient condition—for a positive evaluation of these rules.

Without dwelling on each organisational requirement applicable to algo-traders under the EU regime, this section discusses four characteristics that increase their overall value: their *(1)* variety; *(2)* frequent automation; *(3)* proportionality; and *(4)* adaptability to technological change.

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[690] Any trading algorithm can lead to order execution; whether it does is a different matter: trading algorithms can also lead to decisions not to trade—but the potential for trading is, by definition, inherent in any trading algorithm: *see* chapter 2.

[691] *See* chapter 4.

(1) Variety

The variety of organisational requirements applicable to algo-traders under the EU regime was illustrated earlier in this chapter. Now, it is argued that this variety allows 'different types of risks [to] be addressed by different controls'[692]—and the truth is that the risks associated with algo-trading are fairly varied, including operational risks, risks of inherent error and systemic risk.[693]

The operational risks that arise from the fact that all algo-trading relies on automated technology and is, thus, vulnerable to glitches and malfunctions are mitigated by the governance rules and by (some of) the pre-deployment and deployment mechanisms in the EU regime. Indeed, such governance rules ensure that all algorithms are seen by multiple—competent, (somewhat) independent and accountable—persons, significantly increasing the likelihood of detecting anomalies and errors before deployment.[694] At the same time, the obligation to test algo-trading systems in special environments[695]—together with the requirement to maintain records of all substantial changes made to any algorithms[696]—help correct any malfunctions before they can negatively impact the market.[697]

[692] CDR 2017/589, recital (11).

[693] Yadav (n 176).

[694] CDR 2017/589, articles 1-3.

[695] CDR 2017/589, article 7.

[696] CDR 2017/589, article 5(7).

[697] *See* also the organisational requirements that mandate traders to test compliance with the rules and systems of the venues and DEA providers that host or facilitate their algo-trading activity (*see* CDR 2017/589, articles 5(5) and (6))—particularly to the extent that an

The risks of inherent error associated with algo-trading—and which arise from the fact that humans are often unable to intervene in real time to control or stop this type of trading—are clearly addressed by the post-deployment requirements in the EU regime.[698] For example, the requirement to monitor algo-trading activity continuously during trading hours[699]—and the requirement for post-trade controls which, when triggered, can modify or shut down any algo-trading systems[700]—allow algo-traders to intervene as soon as their activity threatens market integrity.

The systemic risk that algo-trading errors cause wider disruption across the financial markets, with negative impact on the real economy, is most obviously[701] addressed by the rules in the EU regime that require traders to program predefined limits into all trading algorithms,[702] and by the pre-trade controls that apply to their algo-trading activity—including price collars, maximum and minimum order values, maximum message limits and limits to

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incompatibility between systems can also cause algorithms to operate incorrectly, (*see* CDR 2017/589, recital (4) and article 6(2)).

[698] These risks are also addressed by the rules that require traders to test the conformance of their algo-trading systems with those of the venues and DEA service providers on which they rely (*see*, i.a., CDR 2017/589, article 6)—particularly to the extent that they might provide extra opportunities for humans to intervene whenever an algorithm goes rogue. This is particularly relevant as these venues and DEA service providers are also subject to organisational requirements under the EU regime (*see* chapters 7-8).

[699] CDR 2017/589, article 16.

[700] CDR 2017/589, article 17.

[701] Naturally—because the impairment that causes this systemic risk comes from the operational and inherent errors to which all algo-trading activity is vulnerable—measures designed to limit the incidence and impact of these errors also mitigate this systemic risk.

[702] CDR 2017/589, article 8.

the repeated use of particular strategies. These requirements naturally constrain the extent to which any single rogue algorithm can cause damage to the trader that deployed it—but they also limit the extent to which such algorithm can cause strain on market infrastructure, soak up liquidity and spread across markets and asset classes.[703]

Finally, it is worth recalling that the EU regime operates under the misconception that algo-trading has contributed meaningfully to an increased risk of market manipulation. And although most arguments used to support this idea were dismissed earlier in this thesis, it was also conceded that the most potentially convincing of these arguments links algo-trading to difficulties in monitoring misbehaviour.[704] If such a link were found to exist, then the requirement for algo-traders to implement 'specific' automated market manipulation surveillance systems would go right to the heart of the problem.[705]

(2) Automation

Another reason why the organisational requirements applicable to algo-traders under the EU regime are such a valuable regulatory tool is the fact that they often operate automatically.

For example, the pre-trade controls in article 15 of CDR 2017/589 automatically prevent/cancel any orders that fail to meet certain parameters, or

703 *See*, i.a., Jones (n 39); and Angel (n 201).

704 *See* chapter 3.

705 CDR 2017/589, articles 3 and 13.

compromise particular risk thresholds[706]—and they also require the implementation of throttles that automatically disable strategies once they have been executed more than a pre-determined number of times.[707] Once trading is underway, traders are also required to monitor their activity for signs of manipulation—which they must do through a system that generates automated alerts of suspicious activity.[708]

The value in requiring algo-traders to put in place mechanisms that react automatically to their algo-trading comes from the fact that only automated mechanisms can keep up with a type of trading that is also inherently automated.[709] Automating (some of) the organisational requirements in the EU regime is then equivalent to updating these mechanisms in line with the type of trading—and risks—that they address.

In particular, automation makes the operational requirements in the EU regime more disintermediated and faster—helping them mitigate the risk of inherent error that comes from humans not being able to intervene in real-time to stop this type of trading, as well as the systemic risk that algo-trading errors

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[706] CDR 2017/589, article 15(1) and (3).

[707] CDR 2017/589, article 15(4).

[708] CDR 2017/589, article 13. *See* also, MAR, article 16(2).

[709] *See* chapter 3.

spread rapidly across markets. They are, in addition, particularly well-suited to deal with the problematic HFT strategies that some algo-traders may adopt.[710]

(3) Proportionality

The organisational requirements that constrain the activity of algo-traders under the EU regime should also be lauded for their proportionality—or for fully reflecting the idea that 'EU action should…not go beyond what is necessary,' but instead take into account 'the right balance of the public interest at stake and the cost efficiency' of such action.[711]

Specifically, a proportionate algo-trading regime should take into account the fact that different traders carry variably risky algo-trading activities (which may affect the public interest in markedly different ways)—and the fact that different firms are variably able to cope with the regulatory costs inherent in these requirements.

These proportionality concerns sit at the centre of MiFID II, with article 17(1) noting that the organisational requirements applicable to algo-traders must be 'suitable to the business [they operate].'[712] They are also felt in various provisions throughout CDR 2017/589, with its very first article noting that these

[710] For a discussion of how these requirements act as *de facto* constrains on HFT, *see* chapter 9.

[711] EC, 'Proposal for a Directive of the European Parliament and of the Council on Markets in Financial Instruments Repealing Directive 2004/39/EC of the European Parliament and of the Council (Recast)' (n 602).

[712] MiFID II, article 17(1).

organisational requirements must have regard to the 'nature, scale and complexity' of the business of algo-traders.[713]

This ensures that traders engaged in small-scale algorithmic trading[714]—which has a smaller impact on market quality than the large execution programs behind most 'flash crashes'[715]—only need to adopt arrangements commensurate with the level of risk inherent in their activity. At the same time, this also gives traders the opportunity to bring down the costs of regulatory compliance to a level that reflects their size and compliance ability.

(4) Flexibility

The final reason why the organisational requirements applicable to algo-traders under the EU regime are such a valuable regulatory tool is the fact that some of them are flexible and thus more adaptable to technological change.

Indeed, the organisational requirements in article 17(1) of MiFID II are described in broad terms[716] and even the rules in CDR 2017/589—which are

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[713] *See* CDR 2017/589, article 1 and recital (1). As a result, a number of its requirements reflect these concerns. *See*, i.a. the requirement to review proposed material changes to the production environment in a way that is 'proportionate to the magnitude of the proposed change,' and the requirement for traders to take into account the 'nature, scale and complexity' of their activities when setting up arrangements for mandatory staff trading, when engaging in the yearly self-assessment of compliance with article 17 of MiFID II, when establishing automated market manipulation surveillance systems, when reconciling trading logs with the records of other market players and when designing business continuity arrangements.

[714] Small-scale algo-trading refers, i.a., to volumes of instruments traded, size and complexity of order flow and markets accessed. It should not be confused with trading with just one algorithm, or with simpler algorithms—which can cause significant market disruption, as illustrated by the Knight Capital incident (*see* chapters 3-4).

[715] *See* chapter 4.

[716] *See*, i.a., the reference to 'effective' and 'suitable' systems and risk controls, to systems with 'sufficient capacity,' to systems functioning 'in a way that may create or contribute to a

meant to add detail to the directive—sometimes rely on fairly vague concepts. For example, such rules may require firms to establish ‘clearly delineated’ development and testing methodologies that ensure that algorithms ‘[do] not contribute to disorderly trading conditions,’[717] or to put in place ‘appropriate’ business continuity arrangements.

By sometimes relying on these vague terms, the EU regime ensures the long-term viability of its organisational requirements—as they remain flexible enough to keep pace with the developments of automated-trading technology.[718] At the same time, such terms are only used sparingly—which should appease concerns about unintended ambiguity, the blurring of responsibilities, or difficulties in enforcement. Indeed, the organisational requirements applicable to algo-traders under the EU regime have also been lauded for including ‘more precise rules’ than the algo-trading guidelines that had been adopted by ESMA in 2012, back when the first version of MiFID was still in force.[719]

Ultimately, it is therefore argued that these organisational requirements strike a good balance between flexibility and detail, which should contribute to

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disorderly market’—or to the fact that such systems need to be ‘properly’ monitored (MiFID II, article 17(1)).

[717] CDR 2017/589, article 5(4)(d).

[718] This is particularly important for the provisions included in MiFID II—as opposed to in CDR 2017/589—to the extent that Level 1 legislative acts are more difficult to amend than Level 2 non-legislative acts (*see* TFEU, articles 288-290).

[719] *See* Conac (n 31), 17.18. In particular, Conac speculates that the 2012 ESMA Guidelines were ‘rather limited’ because of the different views among the Board of Supervisors of ESMA in regard to the impact that certain algo-trading strategies (namely HFT strategies) could have on market quality.

enhancing their long-term value for reducing the risks inherent in a type of trading as permeable to technological evolution as algo-trading.

5.4.2.3 Practical considerations

This section has argued that the organisational requirements that regulate the activity of algo-traders under the EU regime should play an important role in mitigating the cyber and systemic risks associated with algo-trading.

This argument is supported by two claims: first, that these requirements capture most algo-trading that can threaten the integrity of EU markets; and, second, that such requirements display a series of characteristics that turn them into a particularly valuable tool for regulating the risks arising from algo-trading. Now, this is naturally a theoretical argument: in theory, these organisational requirements should contribute to strengthening the EU markets against the risks of algo-trading—but whether they actually do is an empirical question.

Although such question falls somewhat outside the scope of this thesis, it is worth noting that these requirements could have a relatively small impact on market quality if the conclusion was reached that the arrangements that they impose had already been widely adopted by algo-traders before the approval of the EU regime.[720] However, a recent report from a MS authority (or, rather, a former MS authority) suggests that this was not the case.

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[720] *See*, in particular, Armour et al noting—in regard to HFT—that '[r]egulation that raises the cost of running HFT businesses will create barriers to entry, but is neutral to the extent that it

Indeed, a 2018 review conducted by the FCA on the 'good and poor practices observed…ahead of the implementation of MiFID II' noted that while traders engaged in algo-trading had 'taken steps to reduce risks inherent to [this type of trading],' some of them also lacked appropriate processes for identifying algo-trading, appropriate development and testing procedures, adequate corporate governance frameworks and arrangements for addressing algorithmic trading-driven manipulation.[721]

As such, the organisational requirements applicable to algo-traders under the EU regime should indeed have the potential to play an important role in mitigating the risks inherent in algo-trading—and it has been argued that there are many reasons to believe in that potential.

5.5 Conclusion

This chapter is a testament to the commitment of the EU to algo-trading regulation. Having identified a number of risks that arise from all uses of algo-trading mechanisms—regardless of strategy—the EU has produced an extensive web of reporting and organisational requirements to govern the activity of all algo-traders.

These reporting requirements should be praised for their balance and for rightly focusing on empowering MS authorities to defend the integrity of EU

merely codifies pre-existing practices (such as requiring the testing of algorithms)' (Armour, Bengtzen and Enriques (n 457), 56).

[721] FCA, 'Algorithmic Trading Compliance in Wholesale Markets' (n 51), 4.

markets against the challenges of algo-trading. In turn, the organisational requirements analysed in this chapter should be commended for their variety, comprehensiveness, automation, proportionality and adaptability to change. And even though some of these requirements have been negatively impacted by misconceptions about different types of algorithms (and the risks they create), such impact was negligible—and requires no urgent action.

Absent from MiFID/MiFIR are special algo-trading licensing requirements—but this absence is fully justified, at least as the EU algo-trading regime currently stands: most algo-traders who are not MiFID firms are subject to licensing requirements under wider EU law, and the few who are exempt from such requirements are so for good reason.

In the end—if the EU regime can be described as the 'toughest package' of algo-trading measures in the world[722]—it is in no short measure because of the reporting and organisational requirements imposed on algo-traders, and it is expected that these requirements may be able to play an important role in mitigating the risks associated with this trading, not least because they reflect an accurate understanding of what those risks are.

Notably, the same cannot be said of the rules specifically applicable to algo-traders under MAD/MAR—as demonstrated in the next chapter.

[722] EC, cited by Martin Wheatley (Wheatley (n 14)).

6. NEW RULES FOR NEW MECHANISMS: THE REGULATION OF ALGO-TRADING UNDER MAD/MAR

6.1 Introduction

The rules in the EU algo-trading regime that govern the use of algo-trading mechanisms extend beyond MiFID/MiFIR—with MAD/MAR also including a conduct requirement that has been adapted in response to the concern that algo-trading makes a material contribution to the risk of market abuse: the EU prohibition on market manipulation.[723]

Now, all traders in EU markets are subject to a myriad of conduct requirements[724]—regardless of whether they engage in algo-trading—and, indeed, most misbehaviour can be just as easily perpetrated by manual traders as by algo-traders. Still, there is a pervasive idea that algo-trading has meaningfully added to the risk of market manipulation.

And although the arguments used to sustain this idea fail to hold up,[725] that has not stopped the EU from hanging on to this misconception, from addressing this perceived risk with various rules[726]—and, in particular, from

[723] Conduct rules regulate the behaviour of market participants by requiring compliance with a certain standard—which should contribute to efficiency and fairness by excluding behaviour that does not abide by that higher standard (*see* Armour and others (n 4); and Gullifer and Payne (n 97)).

[724] For a discussion, *see*, i.a., Armour and others (n 4); and Gullifer and Payne (n 97).

[725] *See* chapter 3.

[726] Indeed, the previous chapter already discussed a rule which mandates the implementation of automated market manipulation surveillance systems (*see* CDR 2017/589, article 13). Other examples include article 48(9) of MiFID II (applicable to venues and discussed in chapter 7);

explicitly extending its prohibition to engage in market manipulation to algorithmic trading-driven (and HFT-driven) manipulation.[727]

This chapter examines the new EU prohibition on market manipulation, as adapted to the peculiarities of algo-trading: discussing the scope and content of this prohibition (*6.2*), and examining whether the EU was right to change the definition of manipulation that underlies that prohibition (*6.3*).

Ultimately (*6.4*), it is argued that the EU should not have responded to the perceived association between algo-trading and market abuse by amending the definition of market manipulation in MAR. Such a response was misguided, unnecessary and harmful: misguided because it was founded on the misconception that algo-trading meaningfully increases the risk of market manipulation; unnecessary because the previous definition already captured algorithmic manipulation; and harmful because the new definition may hide a *de facto* ban on particular algo-trading strategies. To the extent that these strategies have a positive impact on market quality, the new definition in MAR is set to do more harm than good.

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and article 20 of CDR 2017/589 (applicable to DEA service providers and discussed in chapter 8).

[727] Although MAR appears to distinguish between 'algorithmic trading' and 'HFT' nothing turns on that distinction. For that reason, this section does not discuss HFT-driven market manipulation separately from algorithmic trading-driven market manipulation.

6.2 The new EU prohibition on market manipulation

One of the most noteworthy aspects of the EU algo-trading regime has been the amendment of the definition of market manipulation included in the previous version of its Market Abuse Directive.[728] The new EU definition of market manipulation is found in MAR—and now lists 'examples of specific abusive strategies that may be carried out by…[algorithmic trading].'[729]

The decision[730] to change the EU definition of market manipulation was seemingly based on the arguments typically used to sustain a relationship between algo-trading and market manipulation; in this case: on the substantive argument that algo-trading (as defined by MiFID II)[731] could have introduced manipulative behaviour uncaptured by the previous EU definition of market manipulation; and on the two pragmatic arguments that algo-trading could have contributed to increased market manipulation—or, at least, to increased

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[728] MAD I, article 1.

[729] *See* MAR, recital (38). *See* Gullifer and Payne noting that the MAR goes into 'far greater detail in providing examples of market manipulation than the [original] Market Abuse Directive' (*see* Gullifer and Payne (n 97), 12.2.2.3.2).

[730] According to the EC, one of the goals behind MAR was to keep pace with market developments, as 'the regulatory framework provided by the original Market Abuse Directive ha[d] been outpaced by…new technology such as high frequency trading (HFT)' (*see* EC, 'Getting Tough on Insider Dealing and Market Manipulation' (2011) Press Release IP/11/1217). The impact assessment accompanying the proposal for MAR also stated that 'the increased trend towards algorithmic and high frequency trading ha[d] raised issues about how regulators monitor such trading' (*see* EC, 'Commission Staff Working Paper - Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (European Union 2011) SEC(2011) 1217 final).

[731] MiFID II, article 4(1)(39)-(40).

difficulties in monitoring and detecting this type of misbehaviour in EU markets.[732]

Indeed, before the EU definition of market manipulation was eventually amended, the EC had expressed doubts about 'whether [the market abuse directive] adequately capture[d] specific strategies that [might] be abusive practices,'[733] and had endorsed the need to 'clarify which HFT strategies constitute[d] prohibited market manipulation.'[734]

In the lead-up to the EU regime, the EC also raised concerns about 'how regulators monitor[ed] [automated and high frequency trading] trading,'[735] noting the importance of 'ensur[ing] a consistent approach in monitoring and enforcement by competent authorities.'[736] And, finally, the idea that algo-trading could have led to increased market manipulation levels was at least considered in the process of reviewing MiFID II.[737]

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[732] For an analysis of these arguments, *see* chapter 3.

[733] EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 381), 2.

[734] EC, 'Getting Tough on Insider Dealing and Market Manipulation' (n 730).

[735] EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 381).

[736] *See* EC, 'Proposal for a [MAR]' (2011) 2011/0295 (COD). *See,* also, ESMA noting that '[due to] the volume and complexity of algorithmic trading…it is becoming harder for competent authorities to promote market integrity, including detecting market abuse, due to the costs and time needed to process the massive amount of information sent by algorithms to the market and to the increased complexity of algorithmic trading behaviour' (ESMA, 'Final Report: Guidelines on Systems and Controls in an Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (n 417)).

[737] *See*, i.a., CESR, 'Technical Advice to the European Commission in the Context of the MiFID Review - Equity Markets' (n 372).

It is worth recalling that the arguments that algo-trading brought about new forms to manipulate the market, or increased market manipulation levels are wholly misguided—and that the argument that algorithmic trading-driven market manipulation is harder to monitor and detect is highly debatable, and lacking in empirical support.[738] Additionally—even if this were a real risk—it is unclear if changing the EU market manipulation definition would be the best way to mitigate it.

Before definitive conclusions are reached, the next sections examine the changes made by the EU to its definition of market manipulation in more detail—looking first at the categories of algo-traders to which they apply (*6.2.1*) and, second, at their content and effects (*6.2.2*).

6.2.1 The scope of the new EU prohibition on market manipulation

The EU prohibition on market manipulation is currently found in article 15 of MAR, which establishes that 'a person shall not engage in or attempt to engage in market manipulation.'[739]

Prior to dwelling on the content of this prohibition, a small clarification should be made about its scope. Contrary to most requirements applicable to algo-traders under the EU regime, the conduct requirement that forbids traders from engaging in market manipulation—particularly in the context of algo-

[738] *See* chapter 3.

[739] MAR, article 15. Before MAR, the EU prohibition to engage in market manipulation was found in article 5 of Directive 2003/6/EC.

trading—applies to all algo-traders, even when they are wholly exempt from MiFID II.

Indeed, MAR covers broadly 'any transaction, order or behaviour concerning any financial instrument' included in its scope,[740] and most of its provisions apply to all traders—regardless of their nature,[741] and of whether they are retail or professional.

Finally, it is noteworthy that the EU regime did nothing to change the subjective scope of the market manipulation prohibition currently found in MAR. Such prohibition has always applied to all traders—long before algo-trading started growing its presence across EU markets—and it still does.

6.2.2 The content of the new EU prohibition on market manipulation

6.2.2.1 The changes made to the EU prohibition on market manipulation

The previous section started by noting that the EU prohibition on market manipulation is found in article 15 of MAR.[742] However, article 15 is silent on what makes a behaviour manipulative: that detail is found in article 12 of MAR, which defines market manipulation by listing categories and examples of

[740] MAR, article 2.

[741] *See* MAR, article 3(1)(13) noting that '"person" means a natural or legal person.' Some provisions apply with certain modifications to legal persons (*see*, for instance, articles 8(5), 9 and 12(4))—but they do not restrict the scope of the market manipulation prohibition in MAR.

[742] MAR, article 15.

manipulative behaviour,[743] and in article 13 of MAR, which lists accepted market practices to which the prohibition in article 15 does not apply.[744]

It was by adjusting article 12 of MAR[745] that the EU adapted the content of its prohibition on market manipulation to the perceived specialties of algo-trading.[746] Analysing these adjustments—examining the effects of amending the definition of market manipulation currently in article 12 of MAR—requires a small excursus on how the EU has historically approached the challenge of defining market manipulation.

6.2.2.2 The EU approach to defining market manipulation

Market manipulation is notoriously difficult to define[747]—with some suggesting that the concept 'should be abandoned altogether.'[748] Indeed, although there is widespread consensus that market manipulation should be prohibited, there

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[743] *See* MAR, article 12. Before MAR, such definition was found in article 1(2) of Directive 2003/6/EC.

[744] *See* MAR, article 13. There are other forms of behaviour that would usually be considered as manipulative, but which are expressly excluded from the EU prohibition (*see*, i.a., the price stabilisation rule in article 5 of MAR).

[745] Because the content of article 15 of MAR is determined by articles 12 and 13 of MAR, changes to article 12 (or to article 13) of MAR are effectively changes to the scope of the EU prohibition on market manipulation.

[746] Directive 2003/6/EC, articles 1(2) and 5.

[747] Emilios Avgouleas, The Mechanics and Regulation of Market Abuse: A Legal and Economic Analysis (Oxford University Press, 2005).

[748] *See* Daniel R Fischel and David J Ross, 'Should the Law Prohibit "Manipulation" in Financial Markets' (1991) 105 Harvard Law Review 503, 507. These difficulties have long been acknowledged by academics: *see*, i.a., Loss et al noting that '[t]he word "manipulative"…has never had any precise meaning' (Louis Loss, Joel Seligman and Troy Paredes, Fundamentals of Securities Regulation, vol 1 (6th Edition, Aspen Publishers 2011); and Avgouleas, observing that market manipulation is a '"virtual term of art" [which] makes it a very difficult concept to define' (Avgouleas (n 747), 104).

is less agreement over what constitutes 'manipulative behaviour' and how such behaviour should be banned.[749]

This disagreement has long affected attempts to regulate market manipulation[750]—namely by discouraging regulators from settling on and using definitions of 'market manipulation.' The decision by the EU to define market manipulation in the context of its market abuse framework has thus been regarded as a 'serious breakthrough' in legislation making.[751]

According to MAR, market manipulation includes the following activities:[752] *(i)* quoting or trading behaviour that either gives (or is likely to give) 'false or misleading signals' in regard to the supply/ demand or price of a particular asset, or sets (or is likely to set) the price of a certain asset at an artificial level;[753] *(ii)* quoting or trading behaviour that has an impact (or is likely to have an impact) on the price of a particular asset by employing 'a fictitious device or any other form of deception;'[754] *(iii)* the dissemination of information that gives (or is like to give) a false or misleading impression as to the

[749] Gullifer and Payne (n 97).

[750] Rosa M Abrantes-Metz, Gabriel Rauterberg and Andrew Verstein, 'Revolution in Manipulation Law: The New CFTC Rules and the Urgent Need for Economic and Empirical Analyses' (2013) 15 University of Pennsylvania Journal of Business Law 357.

[751] Avgouleas (n 747), 105.

[752] The list of behaviours included in MAR is similar to the list of behaviours prohibited under article 1(2)(c) of Directive 2003/6/EC—with the exception of the prohibition of benchmark manipulation, which was newly-introduced by MAR.

[753] MAR, article 12(1)(a).

[754] MAR, article 12(1)(b).

supply/demand or price of a particular asset;[755] and *(iv)* the manipulation of the calculation of a benchmark.[756]

Crucially, the EU market manipulation definition 'comprises'[757] the activities listed in the previous paragraph—but may not be limited to them. Indeed, it is widely accepted that the EU has long adopted a (modified) 'effects-based approach' to defining market manipulation,[758] under which any behaviour involving an unwarranted interference with the market and its price-forming mechanisms is prohibited as manipulative—regardless of the means used to manipulate the market.[759]

Under this effects-based approach, it is this element of unwarranted interference with prices that essentially determines whether a particular behaviour is manipulative. Accordingly, the different means of manipulating the market listed in the EU market manipulation definition would be united by the fact that they all represent an illegal interference with the normal mechanisms of price-formation—regardless of whether such interference is carried out through direct trade-based assaults to market prices (article 12(1)(a)), through

[755] MAR, article 12(1)(c).

[756] MAR, article 12(1)(d).

[757] MAR, article 12(1).

[758] Although this 'effects based approach' is not the only possible lens through which market manipulation can be defined—with other jurisdictions choosing to adopt, instead, an 'intent based approach' based on identifying 'scienter,' or a mixed approach that takes into account elements from both alternatives (*see* Avgouleas (n 747))—it had already been adopted by the previous version of the EU market abuse directive (*see* EC, 'Commission Staff Working Paper - Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 730)).

[759] Gullifer and Payne (n 97).

artificial transactions (article 12(1)(b)), through information dissemination (article 12(1)(c)), or through benchmark manipulation (article 12(1)(d)). Under this approach, this classification of manipulative techniques into different categories can only help make sense of the different ways in which markets can be manipulated—and should not take from the fact that manipulative behaviour often relies on a mixture of different manipulative devices.

In addition to describing different categories of behaviours deemed manipulative, article 12(2) also provides a list of behaviours that 'shall, *inter alia*, be considered as market manipulation'[760]—and which, under an effects-based approach to defining market manipulation, cannot be taken as exhaustive.[761] It is this list that has been shaped by the EU algo-trading regime to now include instances of algorithmic trading-driven manipulation.

Specifically, the EU regime introduced a paragraph in article 12(2)(c) of MAR stating that the 'placing of orders to a trading venue…by any available means of trading, including by electronic means, such as algorithmic and high frequency trading strategies' shall 'be considered as market manipulation,'[762] provided that it fulfils two conditions: that it causes one of the effects in article 12(1)(a) or (b)—identified above—; and that it is carried out by *(i)* affecting the functioning (or likely affecting the functioning) of the trading systems of the

[760] MAR, article 12(2).

[761] *See*, also, Gullifer and Payne noting that article 12 includes 'a non-exhaustive list of behaviours that are to be considered as manipulative' (Gullifer and Payne (n 97)).

[762] MAR, article 12(2)(c).

venues where such orders have been placed,[763] by *(ii)* making it harder (or likely making it harder) for others to identify 'genuine orders,'[764] or by *(iii)* creating (or likely creating) false or misleading impressions about the supply, demand or price of a particular financial instrument, 'in particular by entering orders to initiate or exacerbate a trend.'[765]

More detail on this algorithmic trading-driven manipulation still is added by Annex I of MAR (as complemented by Annex II of CDR 2016/522)[766]—as well as, indirectly, by Annex III, Section B of CDR 2017/565, which lists 'signals of possible market manipulation'[767] that are 'particularly relevant in an automated trading environment.'[768] These include a series of (arguably manipulative) behaviours that are often associated with algo-trading: momentum ignition, layering/spoofing, quote stuffing, smoking, pinging and phishing.

In conclusion, the EU has adopted a unique approach to defining market manipulation. On the one hand, it embraces an effects-based approach

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[763] MAR, article 12(2)(c)(i).

[764] MAR, article 12(2)(c)(ii).

[765] MAR, article 12(2)(c)(iii).

[766] CDR 2016/522 'provides a longer, albeit non-exhaustive list of indicators' of market manipulation (*see* Čuk and Waeyenberge (n 15), 7).

[767] According to Recital (121) of CDR 2017/565, this list of signals 'should be neither exhaustive nor determinative of market abuse or attempts of market abuse, as each of the signals may not necessarily constitute market abuse or attempts of market abuse per se.' Recital (121) also notes that 'transactions or orders to trade meeting one or more signals may be conducted for legitimate reasons or in compliance with the rules of the trading venue.'

[768] CDR 2017/565, Annex III, Section B.

whereby any behaviour involving an unwarranted interference with the price-forming mechanisms of the markets—and the consequent creation of artificial prices—is in principle manipulative, regardless of the means employed in that manipulation. On the other hand, it also describes categories of market manipulation and lists examples of manipulative behaviour—which would not be strictly necessary under a pure effects-based approach.

Assessing the effects of listing instances of algorithmic trading-driven market manipulation in article 12(2) of MAR requires (re)considering what algo-trading is and examining how its existence fits into the peculiar approach adopted by the EU to define market manipulation.

6.2.2.3 The effects of adapting the EU market manipulation definition to algo-trading

Earlier in this thesis, it was noted that the EU regime is essentially built around the concept of 'algorithmic trading,' as defined in article 4 of MiFID II.[769]

This observation holds true in the context of the one conduct requirement included in that regime: the (express) prohibition to engage in algorithmic trading-driven market manipulation. Indeed, article 12(2)(c) of MAR extends the list of manipulative behaviours prohibited under the EU market abuse framework to certain orders placed by 'by electronic means, such as algorithmic [trading]'[770]—and article 3(1)(18) of the regulation notes that, in this

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[769] *See* chapter 4. Parts of the EU regime are also built around the notion of 'HFT' (as discussed in chapter 9), but this is not one of them.

[770] MAR, article 12(2)(c).

context, '"algorithmic trading" means algorithmic trading as defined in point (39) of [a]rticle 4(1) of [MiFID II].'[771]

It has been argued that the key to defining algo-trading lies in identifying a certain (mechanical) way of trading—namely, trading through machines that automatically formulate and implement trading decisions.[772] It would appear then that—by reforming its definition of market manipulation by reference to its definition of algo-trading—the EU is explicitly targeting a particular *modus operandi*, or the use of particular trading mechanisms.

This focus on algo-trading—on the use of algo-trading mechanisms—as a whole is nothing new,[773] but it is particularly interesting in this context. Having (mistakenly) associated a special risk of market manipulation to algo-trading, the EU opted to amend its definition of market manipulation; and, in the context of defining market manipulation under an effects-based approach, the EU decided to target certain (algorithmic) behaviour not just because of its effects, but specifically because of how it is (mechanically) conducted.

This apparent inconsistency begs the question of whether the EU has been prompted—in particular by the popularisation of algo-trading across EU markets and the misconception that this trading meaningfully increases the risk

[771] MAR, article 3(1)(18).

[772] *See* MiFID II, article 4(1)(39) and the discussions in chapters 2 and 4.

[773] *See* the rules discussed in chapter 5.

of market manipulation—to change its approach to defining market manipulation.

On the surface, the EU gives a negative answer to this question: nothing in the documents leading up to the approval of MAR suggests a desire to abandon the effects-based approach that has been guiding the EU since the original Market Abuse Directive.[774] In fact, article 12(1) of MAR closely mirrors article 1(2) of the first version of that directive.

Still, it should be recalled that an effects-based approach to defining market manipulation does not require the listing of manipulative behaviour. Instead, this approach is concerned only with identifying whether a particular conduct unwarrantedly interferes with the normal price-forming mechanisms of the market, leading to the creation of artificial prices: the mechanisms through which such artificial prices are created are 'irrelevant.'[775]

And it is also worth recalling than even a 'modified' effects-based approach to defining market manipulation such as the one adopted by the EU—which complements its prohibition on market manipulation by listing 'a number of market practices and instances of market behaviour which are likely to

[774] Indeed, the opposite appears to be true (*see* EC, 'Commission Staff Working Paper - Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 730)).

[775] Avgouleas (n 747), 108.

amount to market manipulation under [MAR]'[776]—can only ever look at that list as a collection of (non-exhaustive) examples of manipulative behaviours.

As such, the question of whether the EU has changed its approach to defining market manipulation can only be definitively answered in the negative if it is found that the list of behaviours introduced in article 12(2)(c) of MAR by the EU algo-trading regime gives only (non-exhaustive) examples of what algorithmic trading-driven manipulation looks like in practice.

Examining first the motivations behind article 12(2)(c) of MAR, it is not clear whether this article is indeed meant to work as a (non-exhaustive) list of manipulative behaviours—or if it is rather a more substantive expansion of the original scope of the EU market manipulation definition.

On the one hand, the MAR proposal noted that 'the definition of market manipulation in the [original market abuse directive] [was] very broad and already capable of applying to abusive behaviour no matter what medium is used for trading'[777]—and its recitals reveal only the desire 'that the definition of market manipulation provide examples of specific abusive strategies that may be carried out by…algorithmic and high-frequency trading.'[778]

On the other hand, it is noteworthy that the EU introduced article 12(2)(c) of MAR out of fear that the original market abuse directive did not 'adequately

[776] ibid.

[777] EC, 'Proposal for a [MAR]' (n 736), 8.

[778] MAR, recital (38).

capture' algorithmic trading-driven abuse.[779] And, ultimately, the wording of article 12 does give mixed signals as to whether its paragraph (2)(c) only contains examples of manipulative behaviour.

If—at their core—the definitions of market manipulation in the original market abuse directive and in MAR are almost identical, the way each definition is complemented by a list of manipulative strategies is subtly different: while the original directive presented such strategies as 'instances [which were] <u>derived</u> from the core [market manipulation] definition given [in the directive]', article 12(2) of MAR merely establishes that a given set of strategies 'shall, <u>inter alia</u>, be considered as market manipulation,' without specifically deriving such instances from the definition given in its paragraph (1).

Naturally, the way article 12 of MAR is structured suggests that the strategies listed in its paragraph(2) are also derived from the definition of market manipulation in its paragraph(1). However, that interpretation is somewhat challenged by the fact that the strategies listed in article 12(2) are characterised, among other things, by a description of their effects. And article 12(2)(c) is especially puzzling, suggesting that 'the placing of orders to a trading venue…by any available means of trading, including by electronic means, such as algorithmic and high-frequency trading strategies' will only be included under its scope if it fulfils two conditions: not just having one of the effects in

[779] *See* the EC, noting—in the process of reviewing the original market abuse directive—that 'the increased trend towards automated and high frequency trading (HFT) ha[d] raised issues about…whether MAD adequately capture[d] specific strategies that may be abusive practices' (EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 381), 2).

paragraphs (1)(a) or (1)(b) of article 12—but also being carried out in the specific ways listed in paragraphs (i)-(iii) of article 12(2)(c).

The reason why this is especially puzzling is two-fold. First, the specific reference to the effects mentioned in paragraphs(1)(a) and (1)(b) of article 12 lends to the notion that, absent such a reference, it would not be possible to rely on the understanding that the strategies listed in article 12(2) are derived from the definition in article 12(1).

Second, the way article 12(2)(c) is worded also suggests that—regardless of the effects brought about by particular algo-trading behaviour—such behaviour can only be included under its scope if it is carried out in certain ways: by affecting the functioning of venues, by hindering the identification of genuine orders, or by initiating or exacerbating misleading trends.[780] And while this falls short of signifying that algorithmic trading-driven manipulation can only occur when trading is carried out in these ways, it does suggest that the means through which algorithmic trading-driven manipulation is carried out are not as 'irrelevant'[781] for identifying manipulative behaviour as would typically be the case under a pure 'effects-based' approach to defining market manipulation.

At the end of the day—however—the peculiarities of article 12(2)(c) of MAR (unfortunate as they may be) cannot be taken to support this restrictive interpretation whereby the means through which algo-trading behaviour is

[780] MAR, article 12(2)(c).

[781] Avgouleas (n 747), 108.

conducted might be decisive for its classification as 'manipulative,' nor the idea that the EU wanted to abandon or mitigate its effects-based approach to defining manipulation. That was never the express intent of the EU.[782]

And although the years that preceded MAR did see the EU worrying that its original definition of market manipulation did not capture the manipulative behaviour that might arise from algo-trading,[783] it appears that the EU ultimately settled on the idea that adding examples of algorithmic trading-driven manipulative behaviour to its prohibition on market manipulation would be enough to address the special risk of market manipulation that it associated with this type of trading.[784]

Ultimately, it is then argued that the effect of article 12(2)(c) of MAR—the effect of adapting the EU market manipulation definition to algo-trading—has not been to modify the effects-based approach that has long been adopted by the EU, but merely to complement such definition with a list of examples of algorithmic trading-driven manipulative behaviour. Whether such list is then helpful—or, indeed, unhelpful—is less clear.

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[782] In fact, the intent of the EC may have been quite the opposite: in a Commission Staff Working Paper assessing the impact of the MAR proposal, the EC actually notes that providing 'examples of specific algorithmic or HFT strategies that constitute market manipulation' has the advantage of achieving the specific purposes of increasing investor protection and market integrity 'without compromising [the] broad scope of [the] existing definition of market manipulation' (*see* EC, 'Commission Staff Working Paper - Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 730)).

[783] EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 381).

[784] At least when it comes to conduct requirements: *see* also, *i.a.,* the organisational requirement in article 13 of CDR 2017/589 (discussed in chapter 5).

6.3 Evaluating the new EU prohibition on market manipulation

Upon closer examination, the EU prohibition on market manipulation was found to apply to all agents engaging in algo-trading. Furthermore, the changes made by the EU algo-trading regime to this prohibition were found to have had just the effect of adding examples of algo-trading manipulative behaviour to the non-exhaustive list of manipulative behaviours that has accompanied the EU market manipulation definition since the original market abuse directive.

This section analyses the merits of the changes introduced by the EU algo-trading regime to EU prohibition on market manipulation: first, it examines whether it makes sense for all algo-traders to be subject to this prohibition (*6.3.1*); and, second, it analyses the impact of adding algorithmic trading-specific examples to the list of manipulative behaviours that has long complemented the EU prohibition (*6.3.2*).

6.3.1 The traders subject to the new EU prohibition on market manipulation

The EU algo-trading regime has been noted for having introduced a series of reporting and organisational requirements that apply only to algo-traders—but which, however, affect only some algo-traders.[785] By contrast, the one conduct requirement that has been modified by the EU regime—the prohibition to

[785] MiFID II, article 1(3)(a) and (5).

engage in market manipulation as defined in article 12 of MAR—neither applies only to algo-traders, nor does it exclude any algo-traders from its scope.

Indeed, although the EU prohibition on market manipulation was recently reformulated to mitigate the (putative) special manipulation risks associated with algorithmic trading,[786] that has not had the effect of turning it into a conduct requirement specific to algo-traders. And in the same way that the EU prohibition on market manipulation has always applied to all traders—regardless of their nature or profession—it also now covers all algo-traders.

This broadness of scope might appear at odds with the considerations made previously as to why retail algo-traders are (rightly) exempt from the special reporting and organisational requirements in the EU regime—namely, the fact that their algo-trading activity typically carries less risk, and the fact that these retail traders might struggle to comply with the regulatory burden inherent in such requirements.[787]

However, when discussing the possible market manipulation risk inherent in algo-trading and the conduct requirement that has been modified in response to that (potential) risk, only the first of these considerations remains relevant. Assuming that this market manipulation risk can only come from algorithmic trading-driven market manipulation being harder to monitor and detect, in particular due to a differential in technology,[788] it would seem that

[786] *See*, in particular, article 12(2)(c) of MAR, and the discussion in section 6.2.

[787] *See* the discussions about retail algo-traders in chapters 4 and 5.

[788] *See* chapter 3.

retail traders—who typically have less access to technology than professional traders—have fewer tools for hiding their manipulation from supervisors. It could then be argued that the algo-trading of retail traders carries less risk than that of professional traders—at least in this limited sense.

Crucially, that is not the same as saying that retail traders are not as capable of engaging in market manipulation as investment firms: it just means that the added risk that could come from algorithmic trading-driven manipulation being potentially harder to monitor and detect would always be more pronounced in professional rather than retail algo-trading. But because the EU prohibition on market manipulation has long applied to both professional and retail traders[789]—and the risk that retail traders manipulate the market may not have decreased with algo-trading—there is no reason to now exclude them from this prohibition.

Additionally, the consideration that retail traders may struggle to support the compliance burden inherent in regulatory requirements is less relevant for conduct requirements than for reporting or organisational requirements, from which retail traders are generally excluded. While these reporting and organisational requirements usually comprise positive obligations, the conduct requirement not to engage in market manipulation involves only a negative obligation to abstain from particular behaviours.[790]

[789] Directive 2003/6/EC, article 5.

[790] Notably, most positive obligations under MAR apply only to 'persons professionally arranging or executing transactions.' *See*, i.a., the requirement to 'establish and maintain

6.3.2 The impact of the new EU prohibition on market manipulation

This chapter started by delimiting the effects of the changes introduced by the EU algo-trading regime to the EU prohibition on market manipulation. It will now be argued that a more radical change would have been superfluous—and that even the changes brought by the EU regime were not only misguided, but also unnecessary (*6.3.2.1*). Indeed, such changes may actually turn out to be harmful to the quality of EU markets (*6.3.2.2*).

6.3.2.1 The needlessness of changing the EU prohibition on market manipulation

Article 12(2)(c) of MAR has been noted for complementing the EU definition of market manipulation with a series of 'specific abusive strategies' that may be carried out in particular through algo-trading.[791]

Importantly, while the changes to the EU prohibition on market manipulation introduced through article 12(2)(c) were initially motivated by the concern that the original EU market abuse directive did not 'adequately capture'[792] algo-trading manipulation—it appears that the EU ultimately dismissed the idea that it needed to expand its definition of market

effective arrangements, systems and procedures to detect and report suspicious orders and transactions' in article 16(2) of MAR.

[791] MAR, recital (38).

[792] EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 381), 2.

manipulation.[793] Instead, the EU thought it enough to complement such definition with 'specific' examples of algorithmic trading-driven abuse.[794]

At the same time, it is also true that article 12(2)(c) includes some peculiarities—such as listing behaviours characterised both by their effects and the way they are conducted—which could be interpreted as limiting the scope of the prohibition on algorithmic trading-driven manipulation, and ultimately robbing the EU definition of some of its adaptability. However, there is no indication that the EU ever wanted to restrict its definition of market manipulation:[795] as such, these peculiar add-ons should not be given any significance—even if it is hoped that they will be eliminated from future versions of MAR.

At the end of the day, it appears then that—sensitive as the EU might have been to the special market manipulation risks potentially inherent in algo-trading—it nevertheless opted to uphold the essence of its market manipulation definition and preserve the effects-based approach that has long guided its interpretation of this phenomenon. The non-exhaustive list of algo-trading manipulative behaviours listed in article 12(2)(c) of MAR neither expands nor restricts that definition.[796]

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[793] EC, 'Proposal for a [MAR]' (n 736).

[794] MAR, recital (38).

[795] *See*, i.a., EC, 'Commission Staff Working Paper - Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 730).

[796] *See* MAR, recital (38) and ibid.

This option reflects, first, the (correct) idea that algo-trading has not fundamentally changed the way markets are manipulated. Indeed, it was noted earlier that while algo-trading is often linked to specific manipulative practices, that is not the same as saying that those specific manipulative practices are actually new.[797]

Instead, most such strategies can be seen as just 'technologically augmented version[s] of the classic forms of market manipulation,'[798] which have long fallen under the scope of the EU market abuse regime—and typical algorithmic trading-associated practices like 'layering and spoofing' can easily be placed 'in the realm of the traditional doctrine of market manipulation.'[799]

For example, quote stuffing—which is listed by the EU as an example of manipulative behaviour that is 'particularly relevant in an automated trading environment'[800]—involves submitting a large number of orders to the market with the purpose of generating venue congestion,[801] thus preventing other traders from gaining a clear view of the order book and executing their

[797] *See* chapter 3.

[798] Korsmo (n 216).

[799] *See* Stanislav Dolgopolov, 'High-Frequency Trading, Order Types, and the Evolution of the Securities Market Structure: One Whistleblower's Consequences for Securities Regulation' (2014) 2014 University of Illinois Journal of Law, Technology & Policy 145. *See* also Prewitt, noting that techniques like 'stuffing, smoking, and spoofing' all fall 'within the commonplace understanding of market manipulation' (Prewitt (n 217), 155).

[800] CDR 2017/565, section B(21).

[801] *See*, i.a., Bruno Biais and Paul Wooley, 'High Frequency Trading' (Tolouse School of Economics and London School of Economics 2011); and Keller (n 54).

trades.[802] And the fact is that while this strategy is often associated with algo-traders[803]—and can arguably be made more effective in an automated-trading environment[804]—it is not ‘unique’ to algo-trading.[805] Indeed, most traditional definitions of trade-based manipulation have long contemplated the possibilities of exploiting market congestion.[806]

Ultimately, it seems then that algo-trading, as defined in MiFID II, provides only new mechanisms for implementing old forms of market manipulation.[807] Algo-trading manipulation is old wine in a new bottle[808]—and, as such, the EU was right to refrain from radically changing its market manipulation definition in response to it.[809]

But even if it were conceded that algo-trading had actually brought about fundamentally new ways of manipulating the market, it could still be argued that

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[802] Keller (n 54).

[803] Biais and Wooley (n 801).

[804] OICV-IOSCO, ‘Regulatory Issues Raised by the Impact of Technological Changes on Market Integrity and Efficiency - Consultation Report’ (n 207).

[805] Ashley Black, ‘Market Manipulation - Incentives and Enforcement’ (Ross Parsons Law and Business Seminar Series, 20 February 2014), 8.

[806] OICV-IOSCO, ‘Investigating and Prosecuting Market Manipulation’ (OICV-IOSCO 2000) Report prepared by the Technical Committee of the International Organization of Securities Commissions Addendum to the IOSCO report published in April 2013.

[807] The definition of ‘algorithmic trading’ under MiFID II addresses only the way trading is conducted, or the mechanisms used in trading—rather than the effects of particular strategies, or the intent of particular traders (*see* MiFID II, article 4(1)(39)).

[808] Gabriel Jaccard, ‘High Frequency Trading: The Technological Puzzle’ (2015) SSRN Scholarly Paper ID 2699547, 42.

[809] Bhupathi, for instance, notes—in regard to HFT—that while other techniques can potentially ‘lead to market manipulation, high frequency trading…seem[s] merely to raise concerns of changing market framework’, removing the risk to ‘act decisively with respect of high frequency trading’ (*see* Bhupathi (n 50)).

a definition as broad as the original EU definition of market manipulation—formulated under an effects-based approach—would always encompass any new forms of manipulative behaviour conceived by algo-traders.

Indeed, an effects-based approach to defining market manipulation prohibits all conduct leading to the formation of artificial market prices, regardless of what that conduct actually looks like, or how it is carried out.[810]

Assuming that meddling with the normal price-forming mechanisms of the market is all there is to market manipulation, ie, assuming that no behaviour is manipulative if it does not create artificial prices, then an effective market manipulation regime only needs to give supervisors the tools for identifying these artificial prices, and prohibit any conduct that can lead to their formation—regardless of how it is carried out. And, if this is a fair assumption,[811] what follows logically is that there could never be a need to complement the definition of market manipulation under such a regime with examples of manipulative strategies.

Accordingly, the decision to supplement the EU market manipulation definition with examples of algo-trading strategies that have been specifically linked to market manipulation was unnecessary. The question of whether such decision was helpful—or, indeed harmful—is more difficult to answer.

[810] Avgouleas (n 747).

[811] The analysis of the question of whether an effects-based approach covers all behaviour that should be prohibited as manipulative exceeds the scope of this thesis.

6.3.2.2 The promises and perils of changing the EU prohibition on market manipulation

Clearly the decision to complement article 12(2) of MAR with a list of 'specific abusive strategies' carried out through algo-trading was not necessary, but that does not mean that it cannot have a meaningful impact on the activity carried out by algo-traders—and, ultimately, on the quality of EU markets.

Indeed, that decision—unnecessary as it may have been—had an express goal: not that of changing the substance of the EU market manipulation definition, but the more practical purpose of helping MS authorities monitor algorithmic trading-driven misbehaviour,[812] namely by clarifying which algo-trading strategies 'constitute prohibited market manipulation.'[813]

Specifically, the EU expected that 'provid[ing] examples of specific algorithmic or HFT strategies that constitute market manipulation' would 'help regulators to take enforcement action against automated strategies that are manipulative,' 'making it easier for [them] to sanction market abuse through

[812] *See* the EC, noting that 'the 'increased trend towards algorithmic and high frequency trading' raises issues about 'how regulators monitor such trading' (EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 381)).

[813] EC, 'Getting Tough on Insider Dealing and Market Manipulation' (n 730).

automated trading strategies,'[814] ensuring 'a consistent approach in monitoring and enforcement'[815]—and contributing to 'market integrity.'[816]

The problem is that the motivation for adding examples of algorithmic trading-driven market manipulation to the list of abusive practices in article 12(2) was likely misguided: there are no strong arguments to sustain that algo-trading has contributed meaningfully to increasing the risk of manipulation.[817]

Indeed, it is worth recalling that there is no evidence that algo-trading has created new ways of manipulating the market, or increased the instances of market manipulation—and even the claim that algo-trading makes market manipulation harder to detect lacks substance.[818] This alone should have given the EU some pause before changing its prohibition on market manipulation to specifically target algo-trading behaviour—particularly when there is actual evidence linking the presence of algo-trading to a decrease in (certain types of) market manipulation,[819] and when it is speculated that algorithmic trading-

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[814] EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 381), 4.

[815] EC, 'Proposal for a [MAR]' (n 736), 2.

[816] EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MAR] and the Proposal for a [MAD]' (n 381).

[817] *See* chapter 3.

[818] ibid.

[819] *See,* i.a., Cumming, Zhan and Aitken (n 220). and Foresight, 'The Future of Computer Trading in Financial Markets: An International Perspective' (n 7).

driven manipulation might actually be easier to monitor than non-algorithmic trading misbehaviour.[820]

It is true that the EU limited itself to adding examples of algorithmic trading-driven manipulation to the list of manipulative behaviours included in article 12(2) of MAR. But—if such a list is to have any useful purpose—adding those examples should have the effect of shifting the attention and resources of supervisors to monitoring the activity of algo-traders. And to the extent that such activity may carry no special market manipulation risk—and may, indeed, make a positive contribution to market integrity—the decision to introduce article 12(2)(c) of MAR was misguided.

But even if there was, in fact, unambiguous evidence that the authorities responsible for monitoring and detecting market manipulation should place a special focus on algo-traders, introducing changes to the EU market manipulation definition is not the most obvious answer to a problem that is eminently practical.

Amending a legal definition suggests an inability of the original definition to capture the material reality that it should have been able to reflect. However, that was not the problem that ultimately prompted the EU to target algorithmic trading-driven market manipulation: such problem was essentially that this behaviour is supposedly harder to monitor and detect.

[820] Cumming and Johan (n 221).

This would then, instead, be a reason to increase or reform reporting requirements (which are primarily dealt with by MiFID/MiFIR, but also by article 16 of MAR),[821] to introduce new organisational requirements (such as the requirements to put in place automated market manipulation surveillance systems under MiFID II)[822]—or to encourage an increase in the intensity of enforcement (which is primarily dealt with by MS at national level).[823]

In the end, however, the problem with article 12(2)(c) of MAR is not only that there was little reason for the EU to change its market manipulation definition: the consequences of these (unnecessary) changes actually stand to have a negative impact on the quality of EU markets.

The argument goes as follows: by introducing examples of algorithmic trading-driven behaviour in article 12(2)(c) of MAR and by suggesting (at least implicitly) that the authorities responsible for monitoring and detecting market manipulation should be particularly wary of certain algo-trading behaviour—namely due to the way such behaviour is conducted[824]—the EU runs the risk of imposing *de facto* bans on particular algo-trading strategies. And—to the extent that the widespread use of algo-trading mechanisms (and many algo-

[821] *See* section 5.3.

[822] *See* section 5.4.1.3.

[823] *See* Gullifer and Payne (n 97).—noting, however, that MAR now imposes certain 'detailed minimum standards in relation to sanctions.'

[824] *See* the discussion in section 6.2.2.3.

trading strategies in particular) have overall improved the quality of EU markets[825]—these *de facto* bans risk driving away beneficial market behaviour.

A recent case, noted by Conac, illustrates this risk: in 2015—before MAR entered into force, but after it was approved, and long after MS authorities had been alerted to the special market manipulation risks allegedly inherent in algo-trading—the French securities regulator Autorité des Marchés Financiers ('AMF') accused Virtu Financial Europe ('Virtu Europe') of having engaged in algorithmic trading-driven market manipulation.[826]

In particular, the AMF Enforcement Committee found that the trading practices carried out by Virtu Europe in 2009—which involved submitting 'an extremely high volume of messages…relative to the number of trades actually undertaken by it and by other participants,' undertaking 'extremely rapid' operations with an 'extremely short' order life span, cancelling 'very large volumes of orders,' and securing a 'dominant position' in the venues and financial instruments in question—had given or (had been likely to have given) 'false or misleading indications as to the supply and demand for those financial instruments, constituting a market manipulation.'[827]

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[825] *See* chapter 3.

[826] Conac (n 31).

[827] AMF, 'AMF Enforcement Committee Sanctions Virtu Financial Europe and Euronext Paris' <https://www.amf-france.org/en/news-publications/news-releases/enforcement-committee-news-releases/amf-enforcement-committee-sanctions-virtu-financial-europe-and-euronext-paris> accessed 31 July 2020.

At the time, the decision—which also handed down a penalty to Euronext Paris 'for failing to meet its obligations with neutrality and impartiality'[828]—was criticised by Virtu and Euronext as 'totally disproportionate and completely anachronistic.'[829] Years later, Virtu chief executive officer ('CEO') Doug Cifu would accuse AMF of not understanding 'what market-making means.'[830]

In fact, the behaviour described by AMF perfectly fits the description of market-making—a strategy which is 'the usual behaviour of high-frequency traders,' and which was noted earlier for its potential for improving market liquidity.[831] The decision has thus been described as representing 'a fundamental misunderstanding of the way HFTs work to provide liquidity to the market'[832] that is essentially 'equivalent to a *de facto* ban on HFT in France.'[833] And the fact is that Virtu Financial has since exited the country.[834]

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[828] ibid.

[829] Philip Stafford, 'French Regulator Sanctions Euronext and Virtu for HFT Activity' (*Financial Times*, 8 December 2015).

[830] Samuel Agini, 'Virtu Boss Slams "Stupid" French Regulator for 2015 Fine' *Financial News* (London, 26 April 2018) <https://www.fnlondon.com/articles/virtu-boss-slams-stupid-french-regulator-for-2015-fine-20180426> accessed 31 July 2020.

[831] *See* chapter 3.

[832] Merritt B Fox, 'MiFID II and Equity Trading: A US View', *Regulation of the EU Financial Markets: MiFID II and MiFIR* (Danny Busch and Guido Ferrarini, Oxford University Press 2017). The risk that market-making will be mistaken for manipulative behaviour might be mitigated by article 48(3) of MiFID II, which is meant to help supervisors distinguish between the two.

[833] Conac (n 31), 17.59.

[834] *See* ibid. According to its latest 10-K report, as of 31 December 2019 Virtu had subsidiaries only in Canada, Ireland, UK, Australia, Hong Kong and Singapore (*see* Virtu Financial, Inc, '2019 Form 10-K Annual Report' (2020) <http://d18rn0p25nwr6d.cloudfront.net/CIK-0001592386/75f9b041-b12f-48f0-a386-505174e00f46.pdf> accessed 31 July 2020).

Indeed—when faced with the costs of having to refrain from engaging in legitimate behaviour that MAR nevertheless associates with market manipulation,[835] or of having to educate regulators and policymakers about their business model and strategies—algo-traders may pass some of these costs on to other market participants, or leave the market altogether. And leaving may become more attractive when the risk of non-compliance cannot easily be mitigated.

That may well be the case when it comes to compliance with article 12(2)(c) of MAR, as algo-traders may struggle to ensure complete avoidance of all behaviour listed in MAR as examples of algorithmic trading-driven manipulation. For instance, ensuring strict compliance with the prohibition of behaviour that disrupts or delays (or is likely to disrupt or delay) the functioning of the trading system of a certain venue may be particularly hard, as a number of factors regarding the resilience and capacity of such system are controlled by the venue itself.

In fact, while MiFID II notes that both algo-traders and venues should adopt measures to ensure that algo-trading and HFT are not used for abusive purposes,[836] the responsibility for guaranteeing the resilience of trading

[835] *See* Čuk and Waeyenberge, who associate the new EU prohibition on market manipulation with a significant increase in compliance costs—which might 'favour larger firms with more resources' (Čuk and Waeyenberge (n 15), 9).

[836] *See* MiFID II, recital (64), stating that 'both investment firms and trading venues should ensure robust measures are in place to ensure that algorithmic trading or high-frequency algorithmic trading techniques do not create a disorderly market and cannot be used for abusive purposes.' *See,* also, MiFID II, articles 17(1) and article 48(1).

platforms ultimately falls on their operators.[837] Yet, MAR simultaneously condemns the placing of orders which have the effect of creating abnormal prices by 'disrupting or delaying the functioning of the trading system of the trading venue or being likely to do so'[838] as abusive—even if such abnormal prices are at least partially due to venues not ensuring the resilience of their trading platforms.[839]

Compliance becomes even more difficult when the provisions in MAR are 'expressed in broad qualitative terms' which 'allow for substantially different interpretations,' and which Virtu Europe has described as 'unconstitutionally vague.'[840] This might further encourage non-predatory algo-traders to leave the EU markets, with consequent losses[841] to market efficiency.[842]

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[837] MiFID II, recital (64) and article 48(1).

[838] MAR, article 12(2)(c)(i).

[839] Naturally, 'a person who enters into transactions or issues orders to trade which may be deemed to constitute market manipulation may be able to establish that his reasons for entering into such transactions or issuing orders to trade were legitimate' (*see* MAR, recital (8))—but that does not eliminate the risk that legitimate algo-trading strategies will be deemed manipulative, particularly given the increased complexity of such strategies and the fact that supervisors might feel encouraged to pay particular attention to this type of trading.

[840] Čuk and Waeyenberge (n 15), 8.

[841] The benefits of algo-trading are discussed in chapter 3. *See* also evidence that the 'short-term impact' of rules specifically targeting HFT—in this case, a 'package of FTTs that imposes taxes on HFT' in France—was to 'significantly decrease market liquidity' (Holly A Bell and Harrison Searles, 'An Analysis of Global HFT Regulation - Motivations, Market Failures and Alternative Outcomes (Working Paper)' [2014] Mercatus Center - George Mason University, 13).

[842] Paradoxically, and to the extent that 'most manipulation cases happen in relatively inefficient markets' (*see* Rajesh K Aggarwal and Guojun Wu, 'Stock Market Manipulations' (2006) 79 The Journal of Business 1915, 1917), targeting algorithmic trading-driven market manipulation might even lead to increased levels of market manipulation—a consequence that would be consistent with the limited empirical evidence that links the presence of algo-trading with decreases in certain types of manipulation.

Ultimately, it is then argued that the changes introduced by the EU to its market manipulation definition—in the form of the list of algo-trading behaviours included in article 12(2)(c) of MAR—were not just misguided and unnecessary, but may turn out to be harmful for the overall quality of EU markets.

Finally, it is worth noting that even assuming that the concerns that algorithmic trading-driven manipulation is harder to monitor were indeed well-founded, the EU regime provides better tools for addressing such concerns than the changes made to its market manipulation definition: namely, the rules requiring the implementation of automated market manipulation surveillance systems[843]—as complemented by the rule requiring the flagging of algo-trading orders produced in the context of formal market-making obligations (and which can be mistaken for market-manipulation).[844]

In the end, the most obvious solution for empowering regulators and supervisors to identify and monitor this type of (mis)behaviour might be to just increase regulatory resources. In particular, more investment may be needed in the supervisory technology required to digest and process information obtained from market agents[845] and gathered from the markets.[846]

843 *See* MiFID II, article 17(1); CDR 2017/589, article 13; and chapter 5 (in regard to algo-traders). *See* MiFID II, article 17(5); CDR 2017/589, article 20; and chapter 8 (in regard to DEA service providers).

844 *See* CDR 2017/580, article 3(2)(a); and chapter 5.

845 This includes, in particular, information obtained from the automated market manipulation surveillance systems that investment firms are required to put in place under article 13 of CDR 2017/589.

846 *See* the concerns expressed by Avgouleas *in* Authority of the House of Lords (n 222).

6.4 Conclusion

The transformative power of automated-trading technology has reached far and wide across the markets—changing not just the mechanisms used by traders, but also their strategies, and those of venues and other intermediaries. And it is those strategies—the engagement in HFT, the provision of DEA services, the offering of co-location facilities—that are often the focal point of discussions about algo-trading regulation.

It is, then, all the more admirable that the EU has accurately identified that there is something inherently risky about all algo-trading—regardless of the strategies that it inspires. And if it is true that many such strategies have the effect of amplifying the risks associated with the use algo-trading mechanisms, the EU has rightly acknowledged that all algo-trading (as defined by MiFID II) creates at least some risk—and has rightly included in its regime a complex web of requirements that apply every time someone engages in this type of trading.

These past two chapters evaluated each of these requirements—and argued that most rules in the EU regime that govern the use of algo-trading mechanisms reflect a solid understanding of the risks inherent in this trading, and make a positive contribution to mitigating them.

The one relevant exception is the amendments made by the EU to its market manipulation definition—which differ from the rules analysed in *chapter*

5 both because they are based on a misconception and because they propose a solution that is a poor fit for the putative problem they were meant to solve.

Indeed, these amendments assume that algo-trading makes a material contribution to the risk of market manipulation, but there is no evidence to support this assumption. And even if this risk were real, the best way to mitigate it would not be to introduce changes to the EU market manipulation definition. Those changes were at best unnecessary—as the previous EU definition already captured algorithmic manipulation—and at worst harmful—as they increase the costs of engaging in beneficial algo-trading strategies. As such, it is argued that article 12 of MAR should be amended to eliminate the examples of algorithmic trading-driven manipulation included in its paragraph 2(c).

Going forward, the remainder of this thesis moves on from the rules in the EU regime that apply to all algo-trading to those that specifically govern the various strategies that the widespread use of algo-trading mechanisms has inspired—and which often cause more controversy than the vanilla use of algo-trading mechanisms. In particular, it will be argued that while the rules in the EU regime that govern the strategies adopted by trading venues and other intermediaries in response to algo-trading are a valuable part of that regime (*chapters 7-8*), the same cannot be said of the rules in the EU regime that apply specifically to HFTraders (*chapter 9*).

7. New rules for new strategies: trading venue regulation under the EU algo-trading regime

7.1 Introduction

The previous two chapters of this thesis only told half a story. As noted then, the risks from the growing use of automated-trading technology can only be mitigated 'by a combination of measures and specific risk controls' that are not only directed at firms engaging in algo-trading—but also at firms specifically engaging in 'high-frequency trading techniques, [at] those that provide direct electronic access…[and] at operators of trading venues that are accessed by such firms.'[847]

Such is the object of the last three chapters of this thesis: the provisions in the EU regime that govern the strategies developed in (indirect) response to the widespread availability of automated-trading technology across EU markets—not just by algo-traders, but also by venues and other intermediaries.

This chapter begins this analysis by examining the rules in the EU regime that regulate the behaviour of trading venues—looking first at their scope and breadth (*7.2*), and second at the reporting (*7.3*), organisational and conduct requirements (*7.4*) that they include.

Overall (*7.5*), it is argued that these rules have been key to adapting pre-existing requirements to the reality of the new EU markets—ensuring that venues

[847] MiFID II, recital (63).

can continue to help these markets perform their desired functions. In particular, the EU regime is commended for including a number of organisational requirements—like circuit-breakers—specifically geared towards curbing the cyber and systemic risks inherent in algo-trading and amplified by the strategic behaviour of EU venues.

Ultimately, it is then argued that the rules applicable to venues under the EU regime reflect an accurate understanding of the breadth of the change brought by automated-trading technology to EU markets—and stand to make an overall positive contribution to their quality. And although many of these rules also come with certain trade-offs—which may require further optimisation—it appears that the new automated EU markets may now be a safer environment for all market participants.

7.2 New rules for the regulation of trading venues

EU trading venues have experienced profound change over the last thirty years, as the mechanisms and strategies employed by their operators were transformed by forces of technology, regulation and competition.

Earlier, it was noted that these venues have changed, in particular, in (indirect) response to the availability of automated-trading technology across EU markets and to the subsequent popularisation of algo-trading. Specifically, it was argued that these venues have adopted new strategies to attract algo-trading to their floors and that many of these strategies have created significant risks for market quality—which an effective algo-trading regime should strive to mitigate.[848]

It is now argued that the EU regime tried to do exactly that. Indeed, MiFID II—the centrepiece of the EU regime—readily acknowledges the risk that venue trading systems can become overloaded in an algo-trading environment,[849] the risk that traders might face discrimination when trying to access certain venues[850] (particularly if they fail to provide co-location services 'on a non-discriminatory, fair and transparent basis')[851] and, finally, the risk that certain fee structures 'promote disorderly market conditions.'[852]

Notably, the EU did not explicitly address the risk that continuous trading may be inherently flawed, creating unavoidable latency arbitrage opportunities which can only be exploited by the fastest traders in the market, leading to 'quote run games' and negative externalities for excessive investment in low-latency technology.[853] Correspondingly, the EU regime does not advocate a radical

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[848] *See* chapter 3. *See*, also, MiFID II, recital (63), establishing a link between the 'potential risks from increased use of [automated-trading] technology' and the practices of the 'operators of trading venues that are accessed by [algo-trading] firms.'

[849] *See* MiFID II, recital (62). *See,* also, CESR, 'Micro-Structural Issues of the European Equity Markets' (n 371)); EC, 'Review of the Markets in Financial Instruments Directive (MiFID): Frequently Asked Questions' (n 520); and EC, 'Markets in Financial Instruments Directive (MiFID II): Frequently Asked Questions' (2014) Memorandum MEMO/14/305.

[850] MiFID II, recital (14) and (107).

[851] *See* MiFID II, recital (62). *See* also CESR, 'Micro-Structural Issues of the European Equity Markets' (n 371); and CESR, 'Impact of MiFID on Equity Secondary Markets Functioning' (n 256).

[852] *See* MiFID II, recital (65). The issue of asymmetric fee structures was first identified by the EU in 2010 (*see* CESR, 'Micro-Structural Issues of the European Equity Markets' (n 371)). *See* also EC, 'Markets in Financial Instruments Directive (MiFID II): Frequently Asked Questions' (n 849).

[853] *See* Budish, Cramton and Shim (n 27). This might be due to the fact that low-latency arbitrage may not be a significant problem in EU markets: *see*, on the one hand, Aquilina and Ysusi (n

transition from continuous trading to discrete trading,[854] nor does it require individual venues to introduce ‘speed bumps’[855]—even if a number of its provisions do encourage algo-traders to slow down.[856]

Nevertheless, it is clear that the EU regime does reflect an accurate understanding of most of the risks inherent in the new strategies developed by trading venues in response to the popularisation of algo-trading—and does include a number of rules that seek to position these venues ‘as a second line of defence’ against the threats created by this trading.[857]

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276))—finding no evidence of low-latency arbitrage in UK markets—and, on the other hand, Aquilina, Budish and O’Neill (n 359)).

[854] This suggestion was originally put forth *in* Budish, Cramton and Shim (n 27).—and later considered by former SEC chair Mary Jo White in the US context (*see* Mary Jo White, ‘Enhancing Our Equity Market Structure’ (Sandler O’Neill & Partners, L.P. Global Exchange and Brokerage Conference, New York, 5 June 2014) <https://www.sec.gov/news/speech/2014-spch060514mjw>). However, it is noteworthy that EU markets are experiencing a ‘progressive move towards periodic auction trading systems,’ likely as a ‘consequence of the limits to dark trading in equity and equity-like instruments introduced by MiFID II’ (*see* Oxera (n 229)). This move has been detected by ESMA, who has since proposed the development of a ‘dedicated definition for [frequent batch auction] systems, including tailored pre-trade transparency requirements,’ suggested that ‘all orders (volume and price) submitted to [frequent batch auctions] should be disclosed to meet the MiFIR pre-trade transparency requirements,’ and proposed ‘amending [a]rticle 4 of MiFIR to ensure that any non-price forming trading system would always have to operate under a pre-trade transparency waiver’ (*see* ESMA, ‘MiFID II/MiFIR Review Report on the Transparency Regime for Equity and Equity-like Instruments, the Double Volume Cap Mechanism and the Trading Obligations for Shares’ (2020) ESMA70-156–2682).

[855] This solution has been voluntarily adopted or proposed by a number of venues around the world, including ‘Cboe EDGA (2019), ICE Futures (2019), London Metals Exchange (2019), Chicago Stock Exchange (2016), and Investors’ Exchange (2015)’ (*see* Aquilina, Budish and O’Neill (n 359)). For a discussion, *see* Fox, Glosten and Rauterberg (n 2).

[856] *See*, i.a., the requirement to implement circuit-breakers in article 48(5) of MiFID II and the requirement to implement maximum order-to-trade ratios in its article 48(6) (both discussed below).

[857] Conac (n 31).

The next sections evaluate these rules (*7.3* and *7.4*)—but not before delimiting the categories of venues to which they apply *(7.2.1),* and the categories of requirements that they include *(7.2.2).*

7.2.1 The scope of the new rules

The first step in evaluating the importance of the rules in the EU regime that apply to trading venues is determining the categories of venues that attract them.

These rules are included in MiFID/MiFIR, which generally govern all 'investment firms [and] market operators…providing investment services of performing investment activities' within the EU.[858] The notion of 'investment firm' has already been discussed;[859] market operators, on the other hand, are the 'persons who manage and/or operate the business of a regulated market'[860]—or, presumably, of a multilateral trading facility.[861]

Importantly—even though the notion of market operator appears tied to the concept of 'regulated market,'[862]—the rules in the EU regime are not just relevant for 'regulated markets' ('RMs'), but also for multilateral and organised

[858] MiFID II, article 1(1).

[859] *See* chapter 4.

[860] MiFID II, article 4(1)(18).

[861] The definition of MTF in article 4(1)(22) of MiFID II contemplates the possibility of an MTF—defined in contrast with RMs—being operated 'by an investment firm or a market operator,' which seems to contradict the definition of market operator put forth by the directive in article 4(1)(18)).

[862] MiFID II, article 4(1)(18).

trading facilities ('MTFs' and 'OTFs').[863] In other words, they are relevant for all trading venues, which is the umbrella term used by the EU to refer indistinctly to RMs, MTFs, or OTFs.[864]

It is true that MiFID II establishes that all 'multilateral systems in financial instruments'—or all trading venues—must operate according to either the provisions in the directive that apply to 'MTFs or OTFs,' or those that apply to 'RMs'—respectively, title II and title III of MiFID II.[865] And it is true that the rules in the EU algo-trading regime that apply to venues are comprised in articles 48-50 of MiFID II, which are found in its title III.

A superficial reading of these provisions could then lead to the (mistaken) conclusion that only RMs and their operators are regulated under the EU regime. However, MiFID II exceptionally requires investment firms and market operators

[863] 'Regulated market' is defined by MiFID II as a 'multilateral system…which brings together or facilitates the bringing together of multiple third-party buying and selling interests in financial instruments—in the system and in accordance with its non-discretionary rules—in a way that results in a contract, in respect of the financial instruments admitted to trading under its rules and/or systems, and which is authorised and functions regularly and in accordance with Title III of [MiFID II]' (*see* MiFID II, article 4(1)(21)). By contrast, an 'MTF' brings together interests 'in a way that results in a contract in accordance with Title II of [MiFID II]' (*see* MiFID II, article 4(1)(22)). Finally, an OTF is defined as 'a multilateral system which is not a regulated market or an MTF' (*see* MiFID II, article 4(1)(23)).

[864] MiFID II, article 4(1)(24).

[865] The rules applicable to each venue category are also one of the most important factors in distinguishing between RMs, on the one hand, and MTFs and OTFs, on the other hand (*see* the definitions in MiFID II, article 4(1)(21)-(23)).

managing MTFs and OTFs to 'comply with articles 48 and 49[866] and have in place all the necessary effective systems, procedures and arrangements to do so.'[867]

In the end, it is therefore safe to conclude that the EU algo-trading regime applies equally to RMs, MTFs and OTFs. As such, the umbrella terms 'trading venues'/'venues' will hereon be used to refer to the subjects of the rules discussed in this chapter.[868]

Importantly, these rules do not apply to bilateral trading systems, namely systematic internalisers ('SIs')—investment firms that, 'on an organised frequent, systematic and substantial basis, deal on own account when executing client orders' outside a trading venue[869]—or over-the-counter ('OTC') platforms. This exclusion is significant, as SIs, in particular, have been found to sometimes

[866] MiFID II does not expressly extend its article 50 to MTFs and OTFs, but article 50 itself refers to 'trading venues,' as opposed to 'regulated markets' (like virtually all other articles in Title III of the Directive). For that reason, because the EU never expressed an intent to exclude MTFs and OTFs from article 50, because CDR 2017/574—which supplements MiFID II 'with regard to regulatory technical standards for the level of accuracy of business clocks,' as per article 50(2) of the directive—also refers to trading venues (as opposed to RMs), and because article 50 expressly applies to investment firms (in addition to trading venues), it is argued that article 50 is not just relevant for RMs.

[867] *See* MiFID II, article 18(5). Conac also notes that, 'under MiFID II, regulated markets will need to have in place effective systems, procedures, and arrangements to ensure their trading systems are resilient, have sufficient capacity to deal with peak order and message volumes, are able to ensure orderly trading under conditions of severe market stress, are fully tested to ensure such conditions are met, and are subject to effective business continuity arrangements to ensure continuity of their services if there is any failure of their trading systems'—with 'similar rules apply[ing] to MTFs and OTFs' (*see* Conac (n 31), 17.34).

[868] Notably, while OTFs are 'trading venues'—and are subject to the rules in the EU regime that apply to venues hosting algo-trading—the analysis and conclusions of this thesis are limited to RMs and MTFs, as its scope is limited to equity trading and shares cannot be traded in OTFs (*see* MiFID II, article 4(1)(23)).

[869] *See* MiFID II, article 1(7). Such firms are instead regulated by Title III of MiFIR—which contains only one provision that might be relevant in the context of algo-trading: article 17a, extending the tick size regime in MiFID II to SIs.

operate in networks functionally similar to multilateral trading venues.[870] If they do, their behaviour may create the same risks inherent in the behaviour of trading venues—but they will nonetheless be essentially exempt from the requirements applicable in response to those risks.[871]

Crucially, this is not the same as saying that SIs, in particular, are fully exempt from the EU algo-trading regime: they are MiFID firms[872] and—to the extent that they engage in, or facilitate algo-trading—they will be subject to the provisions in MiFID II that apply to traders engaging in,[873] or facilitating algo-trading.[874] However, they will essentially be spared from compliance with articles 48-50 of MiFID II.[875]

In conclusion, all venues and their operators—if not bilateral trading systems and, namely, SIs—are subject to the rules in the EU regime that apply to venues.

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[870] In other words, they sometimes operate as broker crossing networks ('BCNs')—which have essentially been banned by MiFID II (*see,* i.a., MiFID II, recital (17)).

[871] This 'potential [regulatory] loophole' has already been identified by ESMA, who has since proposed a partial extension of the rules that govern minimum tick sizes to SIs. That extension was enacted through Regulation (EU) No 2019/2033 and is currently found in article 17a of MiFIR. ESMA is currently considering further changes to the SI regime (*see* ESMA, 'MiFID II/MiFIR Review Report on the Transparency Regime for Equity and Equity-like Instruments, the Double Volume Cap Mechanism and the Trading Obligations for Shares' (n 854)).

[872] MiFID II, articles 1(7) and 4(1)(20).

[873] *See* chapters 5-6.

[874] *See* chapters 8.

[875] They will only be (partially) subject to the minimum tick size regime described in section 7.5.6, in the terms described in fn 871.

7.2.2 The categories of requirements in the new rules

The rules in the EU regime that apply to trading venues are essentially included in articles 48-50 of MiFID II.[876]

Article 48 contains a vast number of reporting, organisational and conduct (or trading)[877] requirements, which are then detailed in a series of delegated regulations. Article 49 establishes a conduct requirement whereby venues are required to implement minimum tick sizes for shares[878]—and, finally, article 50 contains a rule that requires all venues to synchronise their business clocks with their members, for the purposes of fulfilling any relevant reporting requirements.[879]

Importantly, these requirements are not the only rules that govern the activity of EU venues, who are subject to a myriad of other requirements under wider EU law—regardless of whether they host algo-trading or not.

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[876] *See* also the transaction reporting requirements applicable to venues under MiFIR and which have been somewhat adapted to the fact that some trading is now conducted by algorithms (*see,* i.a., article 25(2) of MiFIR, as complemented by article 2(1)(b)-(c) of CDR 2017/580).

[877] For an alternative way of re-arranging the requirements applicable to venues under the EU regime, *see* the dichotomy between organisational and trading requirements suggested *in* Conac (n 31).

[878] This requirement is then complemented by CDR 2017/588 (as amended by CDR 2019/443), which establishes the regulatory technical standards applicable to the tick size regime for shares, depositary receipts and ETFs.

[879] Article 50 of MiFID II is complemented by CDR 2017/574, which determines the regulatory technical standards for the level of accuracy of business clocks. *See* also the discussion of this requirement in chapter 5.

These broader requirements include, in particular, licensing requirements, (which are essentially absent from the EU algo-trading regime).[880] Indeed, all investment firms and market operators managing EU venues must be authorised under MiFID II. Specifically, MiFID II requires firms whose regular occupation is the professional operation of MTFs and/or OTFs[881] to be authorised under the directive[882]—and a similar requirement applies to market operators.[883] Correspondingly, MiFID II requires all venues to be registered with MS authorities.[884]

This broader EU financial regulation framework also subjects venues to a number of reporting, organisational and conduct requirements beyond those found in the EU algo-trading regime. For example, venues must abide by the organisational requirements in article 16 of MiFID II—and MTFs and OTFs, in particular, must comply with the general organisational requirements in articles

[880] This is not problematic. One of the main goals of licensing requirements is to bring particular market players to the attention of the authorities responsible for monitoring and supervising them (*see* chapter 5)—and this role is sufficiently fulfilled by the general licensing requirements applicable to venues under wider EU law, which already capture all EU venues.

[881] It is worth recalling that, according to article 4 of MIFID II, 'investment firm' means 'any legal person whose regular occupation or business is the provision of one or more investment services to third parties and/or the performance of one or more investment activities on a professional basis'—and 'investment services' means 'any of the services and activities listed in Annex I, Section A [of MiFID II]' (relating to any of the instruments listed in Section C of Annex I of the directive). Annex I, Section A, paragraphs (8) and (9) then lists the operation of MTFs and OTFs as investment services.

[882] MiFID II, article 1(2)(a) and article 5(1).

[883] *See*, specifically, articles 1(2)(c) of MiFID II noting that MiFID II 'establishes requirements in relation to the…authorisation and operation of regulated markets' and article 5(2) of MiFID II, noting that 'Member States shall authorise any market operator to operate an MTF or an OTF, subject to the prior verification of their compliance with [Chapter I of MiFID II].'

[884] In regard to RMs, *see* article 44(1) of MiFID II; in regard to MTFs and OTFs, *see*, in particular, article 18(10) of MiFID II.

18, 31 and 32 of MiFID II, as well as with the specific organisational requirements included in articles 19-20 of the directive. Finally, they are also subject to the general reporting requirements in MiFIR.[885]

However, these broader requirements cannot be said to belong to the EU algo-trading regime: they derive from the condition of venues and venue managers as investment firms or market operators—as well as from the fact that managing a venue is a regulated activity; namely, they are not a response to the special risks that arise from the strategies adopted by EU venues in reaction to the popularisation of algo-trading across EU markets.

Accordingly, and given the scope of this thesis, the next sections focus only on the rules that apply to trading venues under the EU algo-trading regime—even if they build on the work of a broader EU regulatory framework.

7.3 Reporting requirements

The previous section noted that EU venues are subject to a myriad of reporting requirements under wider EU law—as well as to a series of special reporting requirements specifically inspired by the risks associated with algo-trading.

It was also noted that this chapter does not discuss the general reporting requirements applicable to venues under wider EU law—although it is worth noting that some of these requirements have been somewhat modified in light of

[885] *See*, i.a., the transaction reporting requirements in articles 24-27 of MiFIR, as complemented by CDR 2017/580.

the fact that most trading is now conducted by algorithms. For example, the transaction reporting and record-keeping rules applicable to venue operators under MiFIR—and which require them to keep records of 'the relevant data relating to all orders in financial instruments which are advertised through their systems'[886]—now specifically require that records be kept of any investment decision and execution algorithms used by their members.[887]

This section discusses only, then, the special reporting requirements applicable to venues under the EU algo-trading regime, which include requirements for venues to provide specific information about the algo-trading that they host *(7.3.1)*,[888] a requirement for venues to provide specific information about their own order books *(7.3.2)*,[889] and a requirement for venues to provide specific information regarding trade-halting *(7.3.3)*[890]—as well as the strict clock-sync requirements that govern those reporting practices, and which are particularly 'relevant'[891] in an automated trading environment *(7.3.4)*.[892] In the end, these requirements are evaluated based on their ability to address the risks

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[886] *See* MiFIR, article 25(2). These records should be kept for a period of 5 years.

[887] *See* CDR 2017/580, article 2(1)(b)-(c). The codes used to identify investment decision and execution algorithms in this context are the same codes used in the identification of algorithms by algo-traders under article 26(1) of MiFIR and CDR 2017/590. For a discussion, *see* chapter 5.

[888] *See* MiFID II, article 48(10), regarding information pertaining to all algo-traders, and article 48(3), regarding information pertaining to market-making agreements entered into with certain algo-traders.

[889] MiFID II, article 48(11).

[890] MiFID II, article 48(5).

[891] *See, a contrario,* recital (4) of CDR 2017/574.

[892] MiFID II, article 50.

earlier associated with the strategies developed by trading venues in response to algo-trading (*7.3.5*).

7.3.1 Requirements to provide information about algo-trading

Article 48 contains two reporting requirements for venues: a requirement to identify and report all orders generated by algo-trading—regardless of strategy—and a requirement to disclose the terms of any mandatory market-making agreements entered into between venues and algo-traders specifically engaging in market-making strategies ('market-making agreements').[893]

7.3.1.1 <u>Requirement to identify and provide information about algo-trading activity</u>

According to article 48(10) of MIFID II, venues must put in place arrangements[894] to identify all orders generated by algo-trading, as well as the different algorithms—and persons[895]—that initiated those orders.[896] Upon request, this

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[893] The rule requiring certain algo-traders to enter into written market-making arrangements is found in article 17(3) of MiFID II; for a discussion, *see* chapter 9.

[894] Such arrangements may rely on venue members flagging their own algo-trading (*see* Armour, Bengtzen and Enriques (n 457)). Indeed, article 48(10) of MiFID II notes that the identification of algo-trading activity should be carried out 'by means of flagging from members or participants.'

[895] Notably, the possibility of 'persons initiating [algorithmic trading] orders' fundamentally conflicts with the definition of algo-trading proposed earlier in this thesis—as well as, arguably, with the EU algo-trading definition. However, the unfortunate wording of article 48(10) of MiFID II appears to be inconsequential.

[896] In truth, only the obligation to communicate this information to MS authorities is a reporting requirement—the requirement to identify algo-trading activity falls more easily into the category of organisational and conduct requirements, and is discussed as such in section 7.4.

information must then be communicated to the authorities responsible for their supervision.[897]

There are two purposes to this requirement. The first is to facilitate algo-trading supervision, namely by empowering MS authorities to respond effectively to any errors arising from this type of trading.[898] Additionally, this requirement should help authorities to gain a better understanding of the algo-trading behaviour taking place in the markets that they supervise—namely by helping them to attribute individual orders to particular algo-traders and algo-trading strategies.[899] This should then allow them to respond to behaviour that is abusive,[900] or otherwise endangers the orderly functioning of the market.[901]

7.3.1.2 Requirement to provide information about market-making agreements

Article 48(3) of MiFID II imposes a narrower reporting requirement on venues: to inform the MS authorities responsible for their supervision about the content of any market-making agreements entered into with traders engaging in

[897] MiFID II, article 48(10).

[898] *See* MiFID II, recital (67); and chapter 3.

[899] Also for this reason, venues may be required to identify particular orders as part of a specific algo-trading strategy: *see*, i.a., the requirement to identify orders submitted to venues 'as part of a market-making strategy pursuant to [a]rticles 17 and 48 of [MiFID II]' (CDR 2017/580, article 3(2)(a)). *See*, also, answer 17 (topic 3) *in* ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414).

[900] *See* MiFID II, recital (67) and Busch (n 31). For a discussion of whether algo-trading carries a special market manipulation risk, *see* chapters 3 and 6.

[901] The algo-flagging that originates this information—and, presumably, the algo-reporting that follows it—should also assist regulators in 'audit[ing] the order trail more easily across markets' (*see* Conac (n 31), 17.50).

(algorithmic)[902] market-making strategies on their platforms.[903] Upon request, venues must also provide 'all further information' necessary to verify that they are abiding by the rules that govern these market-making agreements, and that they are appropriately monitoring and enforcing them.[904]

The analysis of this dual-reporting requirement presupposes awareness of two other rules which are only discussed later in this thesis: the rule that venues may be required to enter into agreements with firms pursuing an algorithmic market-making strategy;[905] and the corresponding rule that a trader pursuing an algorithmic market-making strategy on a particular venue may be required to enter into a written agreement with it.[906] However, the purposes of the dual-reporting requirement analysed in this section and the purposes of the rules that require venues and market-makers to enter into agreements do not entirely coincide—and it is worth analysing them separately.

Without dwelling (for now) on the purposes of mandatory market-making agreements, it is worth noting that the dual-reporting requirement in article 48(3) of MiFID II serves two goals. First, it is meant to empower the MS authorities responsible for supervising particular venues to check whether they are indeed

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[902] Article 48(3) of MiFID II does not refer to algo-trading specifically, but article 17(4)—which applies also 'for the purposes of…Article 48 of [MiFID II]' determines the circumstances under which an investment firm can be considered 'to be pursuing a market making strategy' by referring to investment firms 'engaging in algorithmic trading.' For a discussion, *see* chapter 9.

[903] MiFID II, article 48(3).

[904] Ibid.

[905] *See* MiFID II, article 48(3); and section 7.4.3.

[906] *See* MiFID II, article 17(3)(b); and chapter 9.

entering into market-making agreements with the content prescribed by MiFID II. To that extent, article 48(3) serves the same goals of the rules that force those venues to enter into market-making agreements in the first place.[907]

However, article 48(3) has one additional goal: helping supervisors to distinguish between (desirable) market-making strategies and (undesirable) manipulative trading. Indeed, article 3(2)(a) of CDR 2017/580—which adds detail to the algo-trading activity reporting requirement discussed previously—mandates venues to identify as such any orders 'submitted…by a member…as part of a market-making strategy pursuant to [a]rticles 17 and 48 of [MiFID II].'[908] This is justified by a need to 'enable the detection of market manipulation,'[909] empowering MS authorities to distinguish between order flow that originates in formal market-making agreements—and is 'based on pre-determined terms established by the issuer or the trading venue'—and that which is just a product of firms 'acting at [their] own discretion.'[910]

In conclusion, article 48(3) should play a crucial role in contextualising the information received by MS authorities under the requirement to identify algo-trading order flow,[911] and, particularly, under the requirement to flag all orders

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[907] This purpose is discussed in greater detail in section 7.4.3.

[908] CDR 2017/580, article 3(2)(a).

[909] CDR 2017/580, recital (6).

[910] ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414).

[911] MiFID II, article 48(10).

originating from the market-making agreements imposed under MiFID II[912]—which might be especially important in a regime that contains a market manipulation definition which places undue focus on algo-trading.[913]

7.3.2 Requirement to provide information about order books

The EU regime requires venues to disclose significant information about the algo-trading activity—and, namely, the algorithmic market-making activity—that they host. However, this information may not be enough for MS authorities to form to a complete picture of such trading behaviour.

In truth, the algo-trading activity that must be reported by venues under the EU regime represents only a portion of all the activity that ultimately feeds into their order books. Indeed, it is worth recalling that (typical) LOBs are formed by all non-marketable limit orders—and are shaped by all market orders (and marketable limit orders)—submitted to a particular venue;[914] as such, the activity that comprises an order book is much richer than just the algo-trading activity that needs to be reported under article 48(10).

Article 48(11) of MiFID II then includes a rule that allows MS authorities to require venues to disclose data relating to their order books—regardless of whether it pertains to algo-trading. Alternatively, they can simply ask venues for

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[912] CDR 2017/580, article 3(2)(a).

[913] *See* chapter 6.

[914] For a discussion of LOBs, *see* chapter 3.

direct access to their order books.[915] The explicit purpose of this requirement is to enable MS authorities 'to monitor trading'[916]—implicitly acknowledging that effective algo-trading supervision requires situating that activity in the wider context of order book dynamics.

7.3.3 Requirement to provide information about circuit-breakers

One of the most meaningful responses given by the EU regime to the risks inherent in algo-trading—and amplified by the strategic behaviour of venues catering to this type of trading—is the requirement for the implementation of automated circuit-breakers.[917] The nature and purpose of these circuit-breakers is discussed below,[918] but it is worth highlighting the reporting requirement attached to their implementation.

Article 48(5) of MiFID II requires venues to report the parameters established for trade-halting 'in a consistent and comparable manner,' to the relevant MS authorities—which are then required to forward it to ESMA.[919]

An additional reporting requirement applies when a venue which is 'material in terms of liquidity in that financial instrument'[920] halts trading in that

[915] MiFID II, article 48(11).

[916] MiFID II, article 48(11).

[917] MiFID II, article 48(5).

[918] *See* section 7.4.2.2.

[919] MiFID II, article 48(5).

[920] According to recital (4) of CDR 2017/570, 'for equity and equity-like financial instruments, the material market in terms of liquidity should be the trading venue that has the highest turnover in

instrument: such venues are further required to notify the relevant MS authority of their decision to suspend trading,[921] with the purpose of helping MS authorities to organise a 'market-wide response' to the activation of circuit breakers—namely by temporarily suspending trading of that particular instrument in other venues.[922]

The fact that this additional reporting requirement applies only to certain venues is rightly motivated by proportionality concerns: venues exempt from this requirement have less 'potential for market wide impact when trading is halted'—making it desirable to reduce their administrative burden.[923]

7.3.4 Requirement to synchronise business clocks

The discussion of the reporting requirements applicable to venues under the EU algo-trading regime wraps up with an analysis of the requirement for venues to synchronise their business clocks—thus establishing a 'common reference time,' as well as 'rules on maximum divergence from [that] common reference time,' and ensuring that data is recorded and reported based on that reference time and according to 'consistent standards.'[924]

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the financial instrument concerned within the Union' (*see* also article 1(a) of CDR 2017/570; and article 4 of CDR 2017/587). Such venue is presumed to have 'the greatest potential for having a market wide impact when trading is halted' (*see* CDR 2017/570, recital (4)).

[921] MiFID II, article 48(5).

[922] MiFID II, article 48(5).

[923] CDR 2017/570, recital (3).

[924] CDR 2017/574, recital (3).

This requirement was discussed earlier, when analysing the reporting requirements that apply to algo-traders under the EU regime[925]—and the same reasons why it was discussed then justify its analysis here: although article 50 is not strictly a reporting requirement, it shapes compliance with reporting requirements;[926] and although it does not just apply in an algo-trading environment, it is especially 'relevant' in such an environment.[927] Indeed, clock-sync becomes particularly crucial when 'the number of orders received every second by a…venue [is] very high' and 'higher than that of executed transactions.'[928] In such circumstances, highly accurate reporting becomes a pre-condition for effective market monitoring.[929]

Accordingly, article 50 of MiFID II then requires that venues synchronise the business clocks used to record the information that they must disclose to MS authorities. However, it also acknowledges that the level of accuracy to which clocks are to be synchronised can vary,[930] depending on two factors: 'gateway-to-gateway' latency of trading system; and type of trading system.[931]

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[925] *See* chapter 5.

[926] *See* article 50 of MiFID II, clarifying that the business clocks in need of synchronisation are the ones used by venues and their members to 'record the date and time of any reportable event.'

[927] *See, a contrario,* recital (4) of CDR 2017/574. *See*, also, the differences in level of accuracy expected of venues that host algo-trading and those that do not (CDR 2017/574, article 2(2)).

[928] CDR 2017/574, recital (2).

[929] CDR 2017/574, recital (2).

[930] MiFID II, article 50.

[931] CDR 2017/574, article 2.

According to CDR 2017/574, '[g]ateway-to-gateway latency [is] the time measured from the moment a message is received by an outer gateway of the trading venue's system, sent through the order submission protocol, processed by the matching engine, and then sent back until an acknowledgement is sent from the gateway'[932]—or, in other words, a measure for trading system speed. A venue with a 'gateway-to-gateway' latency time inferior or equal to 1 millisecond will then normally be subject to a maximum divergence from UTC[933] of 100 microseconds and a timestamp granularity of 1 microsecond or better. A slower trading system allows more leeway to venues—which can diverge from UTC by 1 millisecond and benefit from a timestamp granularity as low as 1 millisecond.[934]

Notably, however, this level of accuracy does not apply to venues with certain trading systems—namely, 'a voice trading system, [a] request for quote system where the response requires human intervention or does not allow algorithmic trading, or a system that formalises negotiated transactions in accordance with article 4(1)(b) of [MiFIR].' Such venues can have their business clocks diverge from UTC by up to 1 second, with a timestamp precision of only 1 second minimum[935]—which appears to reflect a proportionality concern.

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932 CDR 2017/574, article 2(1).

933 *See* CDR 2017/574, article 1. Accordingly, 'operators of trading venues…shall synchronise the business clocks they use to record the date and time of any reportable event with the Coordinated Universal Time (UTC) issued and maintained by the timing centres listed in the latest Bureau international des poids et mesures Annual Report on Time Activities;' alternatively, they can use the 'UTC disseminated by a satellite system'—in which case 'any offset from UTC [should be] accounted for and removed from the timestamp' (*see* CDR 2017/570, article 1).

934 CDR 2017/574, article 2(1) and table 1 of its Annex.

935 CDR 2017/574, article 2(2).

Indeed, the purpose of clock-sync requirements is to allow the 'ex post reconstruction of trading activity by regulators'[936]—enabling them to build a consolidated tape[937] where every relevant event relating to every order across every venue is recorded in an accurate time sequence,[938] and thus empowering them to conduct 'cross-venue monitoring of orders' and identify abuse.[939] However, venues whose systems are slower, incapable of hosting algo-trading, or more reliant on humans typically register a lower volume of events per time frame—decreasing the likelihood of multiple events happening simultaneously.[940]

Hence, 'imposing a finer granularity' or 'applying more stringent accuracy requirements' to slower venues would not be particularly useful[941]—while simultaneously creating significant burden for venues.[942] As such—and even

[936] Čuk and Waeyenberge (n 15), 6.

[937] CDR 2017/574, recital (1).

[938] CDR 2017/574, recital (3).

[939] In particular by allowing them to compare individual transactions with market conditions at the time of execution—*see* CDR 2017/574, recitals (1) and (3).

[940] CDR 2017/574, recital (4).

[941] ibid.

[942] Indeed, a recent report identifies a number of cost and technology concerns expressed by firms trying to comply with these requirements (*see* Monica Summerville and Neil Horlock, 'Resync on Clock Sync' (TABB Group 2019) TABB Group Market Note, as reported *in* Monica Summerville, 'Time to Rethink Clock Sync?' *FinReg alert* (17 July 2019) <http://www.finregalert.com/time-to-rethink-clock-sync/> accessed 31 July 2020). And the EC itself has recognised that high clock synchronisation standards (including timestamps with microsecond accuracy) many only actually be affordable 'to HFT firms themselves' (*see* EC, 'European Financial Stability and Integration Report 2013' (2014) Commission Staff Working Document SWD(2014) 170 final-Part 3/4).

though clock-sync is important for an accurate representation of HFT-dominated markets[943]—setting limits to this requirement was entirely appropriate.[944]

7.3.5 Evaluating the new rules

Earlier, reporting requirements were defined as rules that impose an obligation to disclose information—either to regulators and supervisors, or to markets more widely. It was also noted that their role depends on who receives the information.

The rules applicable to venues under the EU algo-trading regime all pertain to information that must be disclosed to MS authorities; as such, their purpose should be to help these authorities monitor algo-trading activity—with a view to preserving the integrity of EU markets.[945] And there are three main reasons why these requirements are expected to meet this purpose, without excessively burdening their subjects: *(i)* their comprehensiveness; *(ii)* the high standard that they set for certain venues, and *(iii)* their proportionality.

The *(i)* comprehensiveness of these requirements comes from the significant variety of information that may need to be disclosed under these rules.

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[943] *See*, i.a., Aquilina and Ysusi noting how 'clock synchronisation issues complicate[d]' their research (Aquilina and Ysusi (n 276), 12; and Farmer and Skouras, establishing the importance of having 'data synchronised at the location of trading servers and time-stamped within microsecond accuracy' for evaluating the conduct of HFTraders (J Doyne Farmer and Spyros Skouras, 'Minimum Resting Times and Transaction-to-Order Ratios - Review of Amendment 2.3.f and Question 20' (Foresight, Government Office for Science 2012) Economic Impact Assessment EIA2, 6).

[944] *See*, also, CDR 2017/574, article 4.

[945] *See*, i.a., EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MiFID Recast] and the Proposal for a [MiFIR]' (n 379).

Such information includes data on all algo-trading that takes place in a particular venue—including the identity of the algorithms and persons responsible for that activity[946]—as well as information about specific algo-trading strategies[947] and the order books that host them.[948]

The broad scope of information that may have to be disclosed plays an important role in addressing the risks inherent in algo-trading—and amplified by the venues that host it—by giving supervisors a complete picture of the wider environment where it occurs. One of the central arguments in this thesis is that the activity of algo-traders cannot be analysed in isolation—and it would be hard for supervisors to understand the context in which this type of trading occurs without enlisting the help of the venues that host it.[949]

Additionally, the information disclosed by some of these venues is also of a very *(ii)* high standard. This comes from the fact that the information disclosed by venues—and, especially, by fast venues hosting algo-trading—is subject to clock-sync requirements that do not allow for significant divergence from a common reference time, and which impose a fairly high degree of granularity.[950]

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[946] MiFID II, article 48(10).

[947] In particular, algorithmic market-making (*see* MiFID II, article 48(3)).

[948] MiFID II, article 48(11).

[949] *See* chapters 2-4.

[950] For a discussion of how these standards compare to the requirements applicable in US markets, as well as of the difficulties of complying with these high standards, *see* Summerville and Horlock (n 942).

This high-quality information should convey a fairly accurate representation of the new EU markets. Indeed, ESMA has recently stressed the importance of clock-sync[951]—not just across venues, but also across SIs and approved publication arrangements authorised to publish trade reports under MiFID/MiFIR—for the eventual implementation of an EU-wide real-time consolidated tape that can one day convey a complete, up-to-date picture of these markets.[952]

Still, the usefulness of these standards also depends on supervisors knowing what to do with this highly up-to-date, highly granular data. And the problem is that data-driven supervision is 'a different skill than more traditional form-based approaches' to financial supervision—with 'RegTech based financial supervision' bringing considerable challenges for MS authorities.[953] As such, it is unclear whether such high clock-sync standards should indeed be imposed on trading venues, especially when compliance may be so difficult.[954]

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[951] ESMA, 'MiFID II/MiFIR Review Report No. 1 - On the Development in Prices for Pre- and Post-Trade Data and on the Consolidated Tape for Equity Instruments' (2019) ESMA70-156–1606.

[952] A consolidated tape is a 'continuous electronic live data stream providing price and volume data per financial instrument' (*see* MiFID II, article 4(1)(53)). With MIFID II, the EU built a regulatory framework for guiding the development of a market-led equity consolidated tape (*see, i.a.,* MiFID II, Title V)—but no one so far has stepped up to the task (*see* ESMA, 'ESMA Recommends Real-Time Consolidated Tape for Equity' (*ESMA Press Releases*, 5 December 2019) <https://www.esma.europa.eu/press-news/esma-news/esma-recommends-real-time-consolidated-tape-equity> accessed 31 July 2020).

[953] Dirk Andreas Zetzsche and others, 'The Future of Data-Driven Finance and RegTech: Lessons from EU Big Bang II' [2019] Business Banking & Insurance e-journal.

[954] For a description of the difficulties inherent in the implementation of clock-sync requirements, *see* Summerville and Horlock (n 942).

More broadly, it is important that the reporting requirements applicable to venues under the EU regime are also guided by *(iii)* proportionality concerns.

These concerns are scattered throughout the EU regime—and can be sensed, for example, when the EU only requires venues to provide certain information 'upon request.'[955] Moreover, the EU reserves the harshest reporting requirements to only some venues. For instance, the rule requiring venues to disclose information about decisions to suspend trading in a particular instrument only applies to those which are 'material in terms of liquidity in that financial instrument'[956]—as, otherwise, it is unlikely that such decisions would have market-wide impact.[957]

Likewise, the EU applies different clock-sync standards depending on trading system speed—and only the fastest venues are prevented from diverging from UTC by more than 100 microseconds, or need to embrace a timestamp granularity of 1 microsecond.[958] Moreover, venues that essentially rely on human intervention can get away with a much lower reporting standard.[959]

Ultimately, it is true that the current variance in reporting standards could harm the goal of an EU-wide consolidated tape. However—given the difficulties

[955] For examples, *see* MiFID II, article 48(3), (10) and (11).

[956] MiFID II, article 48(5).

[957] CDR 2017/570, recital (4).

[958] CDR 2017/574, article 2(1) and table 1 of its Annex.

[959] CDR 2017/574, article 2(2).

presently reported by the industry in regard to compliance, and given that regulators and supervisors might struggle with high volumes of highly-granular data[960]—the EU was likely right to take a more nuanced approach to clock-sync.

7.4 Organisational and conduct requirements

Trading venues are subject to extensive requirements under the EU algo-trading regime: in addition to reporting requirements, they must also abide by a series of organisational and conduct rules[961]—most of which are found in articles 48-49 of MiFID II.[962]

These rules include, first, general organisational and conduct requirements to have in place—and test—the arrangements needed to ensure system resilience and capacity, orderly trading under conditions of market stress, and business continuity upon failure *(7.4.1)*.

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[960] *See* the discussion in section 7.3.5.

[961] Organisational and conduct rules are discussed in tandem because the different organisational requirements that apply to venues under the EU regime often impose mechanisms and arrangements that then form the basis for holding these venues to particular standards of conduct. For example, article 49 of MiFID II obliges venues to adopt a series of minimum tick size regimes (as an organisational requirement), which should then ensure the activity that takes place on their platforms to meet certain standards (by abiding by particular conduct requirements).

[962] According to article 2 of CDR 2017/584, before the deployment of a trading system and at least once every year, venues must 'carry out a self-assessment of their compliance' with most of these requirements (with the exception of the requirements in article 49 of MiFID II). These self-assessments should take into consideration the 'nature, scale and complexity' of their business and must discuss all the parameters listed in the Annex to CDR 2017/584 (including the percentage of algo-trading and the percentage of HFT in relation to total trading activity)—and their results must be preserved for a minimum of five years.

They also include rules specifically designed to prevent disorderly trading—namely by requiring venues to implement pre- and post-trade controls, and automated circuit-breakers *(7.4.2)*—an obligation to enter into market-making agreements with certain algo-traders *(7.4.3)*, rules on fee structures *(7.4.4)*, a requirement to identify algo-trading activity *(7.4.5)*, and a requirement to implement minimum tick size regimes for different instruments *(7.4.6)*. Finally, venues that can be accessed through DEA services, or who offer co-location services must implement systems to ensure that these arrangements and services do not threaten the quality of EU markets *(7.4.7)*.[963]

The next sections analyse these requirements in turn—discussing the extent to which each of them contributes to mitigating the risks inherent to the strategies adopted by EU venues in response to the popularisation of algo-trading.

7.4.1 General organisational and conduct requirements

Article 48(1) of MiFID II mandates venues to implement the arrangements necessary to ensure that their systems are resilient, can deal with peak order and

[963] On their face, many of these requirements appear to apply to all venues—regardless of whether they host algo-trading or not: indeed, almost none of the rules listed in articles 48-49 of MiFID II contain any limitations pertaining to the type of trading occurring in these venues (the only exceptions being the requirement to ensure and facilitate the testing of trading algorithms under article 48(6), and the requirement to identify algo-trading activity under article 48(9)). At the same time, all these requirements appear to have been designed in response to the specific risks inherent in algo-trading—and amplified by the strategies adopted by venues in response to its popularisation. Moreover, some of these requirements only make sense in the context of algo-trading. And CDR 2017/584—which supplements most rules specifically contained in articles 48-49 of MiFID II—limits its scope to 'trading venues allowing or enabling algorithmic trading' (*see* CDR 2017/584, article 1).

message volumes, and can guarantee orderly trading even under conditions of market stress. Additionally, venues must test these systems—and have in place business continuity arrangements for when they nevertheless fail.

These requirements are complemented by CDR 2017/584, which establishes detailed rules applicable to 'the systems of the trading venues allowing or enabling algorithmic trading'[964]—including general organisational requirements, but also rules specifically designed to safeguard venue capacity and resilience.

7.4.1.1 General organisational requirements

The general organisational requirements applicable to venues under the EU regime comprise, first, the obligation to implement clear and formalised governance arrangements for the monitoring of trading systems[965]—which must include a compliance function responsible, namely, for training the staff involved in algo-trading, as well as for developing arrangements to ensure compliance with the applicable rules.[966]

For these purposes, venues must also ensure they hire enough staff with the skills and knowledge required to manage their systems and algorithms[967]—

[964] CDR 2017/584, article 1(1).

[965] CDR 2017/584, article 3.

[966] CDR 2017/584, article 4.

[967] CDR 2017/584, article 5.

and opportunities to outsource operational functions regarding systems that allow or enable algo-trading[968] are limited and extensively conditioned.[969]

7.4.1.2 Capacity and resilience requirements

The rules in CDR 2017/584 specifically designed to ensure venue capacity and resilience include a broad requirement for venues to set out conditions for members looking to use their electronic order submission systems[970]—as well as an obligation to then undertake due diligence assessments,[971] and yearly risk-based assessments of compliance in regard to those members.[972]

The broad due diligence requirement in CDR 2017/584 is then complemented by a series of testing requirements—some of which apply to the trading systems of venues themselves.[973] In particular, venues must implement ‘clearly defined’ methodologies for developing and assessing their trading systems prior to any deployment or material update.[974]

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968 CDR 2017/584, article 1(3).

969 These limits and conditions are detailed in article 6 of CDR 2017/584.

970 *See* CDR 2017/584, article 7(1). These conditions include, at minimum, having in place ‘pre-trade controls,’ appropriately qualified staff, appropriate testing arrangements, a kill functionality (and a policy for its use) and provisions applicable to DEA arrangements (if applicable)—and appear to be in accordance with the organisational requirements discussed in chapter 5.

971 CDR 2017/584, article 7(2).

972 CDR 2017/584, article 7(3); *see* also article 7(4)-(5).

973 Other testing requirements pertain instead to the algo-traders that interact with those venues as members, and are discussed in section 5.4.1.3.

974 CDR 2017/584, article 8.

Besides testing their trading systems, venues must also ensure that they have enough capacity to function without failure when matching transactions 'at least at the highest number of messages per second recorded on that system during the previous five years multiplied by two'[975]—and they must assess whether system capacity remains adequate even under those conditions.[976]

Furthermore, venues must ensure that their systems can adapt to rising message flows without significant losses to performance—particularly by designing the possibility of expanding capacity into them.[977] Additionally, venues must ensure that their systems can operate continuously and regularly[978]—namely by monitoring them in real time,[979] by implementing systems that generate automated alerts within five seconds of any abnormal event,[980] and by periodically reviewing their performance and capacity.[981]

Ultimately, the requirements in article 48(1) of MiFID II are wide-reaching and detailed—but they are no guarantee against system failure. As such, the EU

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[975] CDR 2017/584, article 11(1)-(2).

[976] CDR 2017/584, article 11(3).

[977] CDR 2017/584, article 11(4)-(5).

[978] CDR 2017/584, article 12(1).

[979] CDR 2017/584, article 12(2).

[980] *See* CDR 2017/584, article 12(3). Any issues identified in the trading system during monitoring must be dealt with 'as soon as reasonably possible,' in particular by adjusting, slowing down or even killing off the system (*see* CDR 2017/584, article 13(2)).

[981] *See* CDR 2017/584, article 14. Namely, venues must perform 'stress tests where they stimulate adverse scenarios to verify the performance of the hardware, software and communications and identify the scenarios under which the trading system or parts of the trading system perform their functions with systems failures, outages or errors in matching transactions' (*see* CDR 2017/584, article 14(2)).

regime also requires venues to put in place business continuity arrangements[982] and to establish a business continuity plan[983] in case of 'disruptive incidents.'[984] Finally, venues must implement arrangements to ensure the 'physical and electronic security' of their systems, and protect them from 'misuse or unauthorised access.[985]

Overall, these general organisational and conduct requirements recruit the help of venues to mitigate the risks inherent in algo-trading—and are, for that reason, an important component of the EU regime. They also have the advantage of not being overly burdensome: venues are already subject to a myriad of organisational and conduct requirements under MiFIR—and the requirements discussed in this section represent little more than an adaptation of pre-existing rules to the particularities of automated markets.

7.4.2 Requirements to prevent disorderly trading conditions

The EU regime further imposes a series of 'reinforced organisational requirements' on venues that are specifically designed to mitigate the risk of disorderly trading that can arise 'as a result of [algorithmic trading]'[986] and the

[982] *See* CDR 2017/584, article 15. Namely, these arrangements must 'ensure that trading can be resumed within or close to two hours' of any disruptive incident—and that the data lost from IT services after such incident 'is close to zero.'

[983] CDR 2017/584, article 16; *see* also article 17.

[984] CDR 2017/584, article 15(1).

[985] CDR 2017/584, article 23.

[986] *See* Oxera (n 213). *See*, also, CDR 2017/584, article 18(1).

propensity of this type of trading for (systemically relevant) operational and inherent errors.[987]

This section analyses the two categories of arrangements that venues must implement 'to prevent disorderly trading and breaches of capacity limits:'[988] pre-trade and post-trade controls; and circuit-breakers.[989]

7.4.2.1 Pre-trade and post-trade controls

Article 48(4) of MiFID II requires venues to put in place pre-trade systems to reject orders that either exceed certain 'volume and price thresholds' or are otherwise 'clearly erroneous.'[990] For each instrument traded on their platforms, venues must then implement price collars that can automatically block non-compliant orders on an order-by-order basis, maximum order values that automatically block 'orders with uncommonly large order values,' and maximum order volumes that automatically block 'orders with an uncommonly large order size.'[991]

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987 For this purpose, venues should be able to request information from most traders with access to their platforms (either as members, or via SA arrangements), to suspend access to their platforms (either by own initiative or upon request), to implement systems that can cancel orders and revoke transactions under certain circumstances, and to balance order entrance across different trading system gateways (if applicable) (*see* CDR 2017/584, article 18(2)(a)-(e)).

988 *See* CDR 2017/584, article 18(1). *See* also article 18(3)-(5).

989 Although, *see* article 8(2) of CDR 2017/584.

990 MiFID II, article 48(4).

991 *See* CDR 2017/584, article 20(1). The monitoring of these orders cannot have a delay of more than five seconds (*see* CDR 2017/584, article 20(2)(b)); whenever an order breaches a particular limit, it must be automatically rejected (*see* CDR 2017/584, article 20(2)(c)).

The issue with pre-trade controls is that they restrict trading behaviour *ex ante*—with the risk of banning beneficial behaviour along with predatory behaviour.[992] However, the EU regime mitigates this risk by requiring venues to ensure that these limits can be readjusted during the trading session, and that there are procedures in place to allow orders to temporarily and exceptionally go above those limits upon request from the relevant trader.[993]

Article 48(6) of MiFID II, on the other hand, requires venues to implement post-trade systems to manage any disorderly conditions that may in fact arise from trading—including systems that limit the ratio of unexecuted orders or transactions (maximum order-to-trade ratios, or 'OTRs'), systems that can slow down the flow of orders when a venue is at capacity, and systems that can limit and enforce any minimum tick size regimes that may apply.[994]

The exact configuration of these controls depends on how venues view the risk inherent to the activity of their members.[995] However, the EU does offer some specific guidance when it comes to OTRs.[996] Namely, CDR 2017/566 establishes, first, that venues are required to calculate OTRs in regard to each of

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[992] Oxera (n 213).

[993] CDR 2017/584, article 20(2)(a) and (d).

[994] These minimum tick size regimes are discussed in section 7.4.6. Article 48(6) also imposes an obligation for venues to require their members engaged in algo-trading 'to carry out appropriate testing of algorithms'—as well as to provide environments that can facilitate that testing, with the purpose of ensuring that such algorithms 'cannot create or contribute to disorderly trading conditions.' *See* also CDR 2017/584, articles 9-10.

[995] CDR 2017/584, article 20(3).

[996] The idea behind this specific guidance is to 'ensure sufficient harmonisation across the Union of the arrangements to prevent disorderly trading conditions' (*see* CDR 2017/566, recital (5)).

their members[997] and in regard to every financial instrument traded on their electronic systems[998]—and, second, that these OTRs must be calculated in two ways: by taking into account total volume of orders and total number of orders (as a proportion of total volume and total number of transactions, respectively).[999]

Additionally, venues must define maximum OTRs—again taking into account both the maximum total volume of orders and the maximum total number of orders that they are willing to tolerate per volume/number of transactions (in regard to each of the instruments traded on their electronic platforms)[1000]—which venue members cannot exceed during any given trading session.[1001]

Ultimately, the purpose of requiring venues to establish maximum OTRs is to encourage them to curtail HFT activity—alleviating the stress put on their trading systems.[1002] At the same time, the EU refrained from determining what

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[997] CDR 2017/566 uses the word 'member' throughout—but there are not any apparent reasons why the enhanced organisational requirements pertaining to OTRs should not also apply in regard to trading by DEA clients.

[998] *See* CDR 2017/566, article 2. This requirement applies regardless of whether the market is order-driven, quote-driven or hybrid, and regardless of whether the venue is an RM, an MTF, or an OTF (*see* CDR 2017/566, recital (3)). Voice trading systems, however, are explicitly exempt from the scope of CDR 2017/566 (*see* CDR 2017/566, recital (2) and CDR 2017/584, article 1(1)).

[999] CDR 2017/566, article 3(1).

[1000] MiFID II, article 48(6) and CDR 2017/566, article 3(2). The method for calculating the number of orders received from each venue member is described in the Annex to CDR 2017/566 (*see* CDR 2017/566, article 3(3)).

[1001] MiFID II, article 48(6) and CDR 2017/566, article 3(2) and recital (7).

[1002] EC, 'Commission Staff Working Document - Impact Assessment Accompanying the Document Proposal for [MiFID and MiFIR]' (n 380).

those ratios should be, beyond requiring that they be sufficient to prevent the creation of disorderly trading conditions, and excessive volatility.[1003]

This relatively light approach to OTRs is justified by a concern that they can damage liquidity or distort the market[1004]—and rightly so, as maximum OTRs respond to trading patterns that are common in all HFT strategies, including beneficial HFT behaviour.[1005] From that perspective, it is commendable that the exact configuration of such controls has been left up to venues.[1006]

Still, this light approach also means that there may be little incentive for venues to select OTRs that can materially contribute to making trading more orderly. While HFTraders might place a heavy burden on venue capacity, they are also 'a key source of…revenues for market operators.'[1007] As such, venues might feel tempted to adopt less than optimal OTRs 'in order of attract flows from

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[1003] *See* CDR 2017/566, recitals (1) and (4). *See* also answer 18 (topic 3) *in* ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414).—noting that 'trading venues may set the maximum ratio of unexecuted orders to transactions at the level they consider appropriate to prevent excessive volatility in the financial instrument concerned.'

[1004] *See* EC, 'Commission Staff Working Document - Impact Assessment Accompanying the Document Proposal for [MiFID and MiFIR]' (n 380). *See,* also, some empirical evidence of decreased liquidity upon implementation of OTRs in Italy (pre-MiFID): Sylvain Friederich and Richard Payne, 'Order to Trade Ratios and Their Impact on Italian Stock Market Quality' (Foresight, Government Office for Science 2012).

[1005] *See* a report by Foresight, noting that a (uniform) 'order-to-execution ratio is a blunt measure that catches both abusive and beneficial strategies' (Foresight, 'Economic Impact Assessments on MiFID II Policy Measures Related to Computer Trading in Financial Markets' (Foresight, Government Office for Science 2012) Working Paper, 26).

[1006] In particular, venues can set different maximum OTRs 'on the basis of the different categories of market participants that operate in their systems' (*see* answer 18 (topic 3) *in* ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414)).

[1007] EC, 'Commission Staff Working Document - Impact Assessment Accompanying the Document Proposal for [MiFID and MiFIR]' (n 380).

HFT traders'[1008]—ultimately rendering the EU requirement to adopt maximum OTRs less meaningful.[1009]

7.4.2.2 Circuit-breakers

The second category of organisational requirements designed to enlist the help of venues in preventing disorderly trading is the rule that mandates the implementation of automated circuit-breakers.

Specifically, article 48(5) of MiFID II requires venues to adopt both mechanisms that allow them to stop trading temporarily and for a short period in case of certain significant price movements, and mechanisms that exceptionally allow them to 'cancel, vary or correct any transaction' placed on their platforms.[1010]

Content-wise, the parameters for these automated mechanisms must be calibrated to avoid disorderly trading—taking into account instrument liquidity, market model nature and user type.[1011] They must also be tested—both before implementation and every time the capacity and performance of trading systems

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[1008] Foresight, 'Economic Impact Assessments on MiFID II Policy Measures Related to Computer Trading in Financial Markets' (n 1005).

[1009] Still, ESMA has noted that venues should set maximum OTRs at a level 'appropriate to prevent excessive volatility in the financial instrument concerned'—as 'supported by statistical analysis of the activity of the different categories of members or participants and the liquidity of the instruments in which they operate' (*see* ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414)).

[1010] MiFID II, article 48(5). Such mechanisms must remain operational at all times during trading hours (*see* CDR 2017/584, article 19(1)).

[1011] MiFID II, article 48(5). *See* also CDR 2017/584, article 19(3).

are reviewed[1012]—and continuously monitored.[1013] Additionally, they should include procedures to deal with situations where they must be manually overridden to ensure orderly trading.[1014]

Ultimately, the requirement to implement circuit-breakers might be one of the most significant rules in the EU regime: indeed, while these circuit-breakers have much the same purpose as the pre-trade and post-trade requirements discussed earlier, their effects are significantly wider—as trading halts ‘affect how markets operate for all market participants.’ At the same time, they also have a ‘much larger scope for indirect consequences.’[1015]

Indeed, there is evidence that circuit-breakers can play an important role in combatting the (systemically relevant) operational and inherent error risks associated with algo-trading:[1016] by temporarily suspending trading, venues give traders the opportunity to re-evaluate and re-adjust[1017]—which can help curb

[1012] CDR 2017/584, article 19(2)(a).

[1013] CDR 2017/584, article 19(2)(b)-(c).

[1014] CDR 2017/584, article 19(4).

[1015] Oxera (n 213).

[1016] *See* ibid. This, in turn, should have a positive impact on liquidity and price accuracy: *see* chapter 3.

[1017] For instance, Corwin and Lipson find that ‘market and limit order submissions and cancellations increase significantly during trading halts,’ which indicates that—when given the opportunity to do so—traders re-evaluate and re-adjust, re-entering the market ‘before trading resumes’ (*see* Shane A Corwin and Marc L Lipson, ‘Order Flow and Liquidity around NYSE Trading Halts’ (2000) 55 The Journal of Finance 1771, 1771). More broadly, Jones also notes that ‘a trading pause should give market participants a chance to re-evaluate and stabilize prices if the price moves appear unwarranted’ (*see* Jones (n 39), 2).

excessive volatility,[1018] and prevent or mitigate systemic 'flash crash'-type events.[1019] Simultaneously, circuit-breakers have also been associated with decreases in liquidity,[1020] and delays in price-discovery,[1021] creating costs that are essentially borne by all market players.[1022]

As such, determining whether the circuit-breakers imposed under the EU regime can have a positive impact on market quality depends on how they are designed and implemented. And there are some reasons for optimism: many EU venues were already relying on circuit-breakers even before MiFID II, and a recent study—looking at circuit-breakers triggered between 1 April 2016 and 31 December 2016 by EU venues, for a sample of 10,000 instruments—found that these mechanisms had made a significant contribution to decreasing volatility,

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[1018] *See,* i.a., Benjamin Clapham and others, 'Managing Excess Volatility: Design and Effectiveness of Circuit Breakers' (Leibniz Institute for Financial Research SAFE 2017) SAFE Working Paper Series 195.

[1019] Following the 2010 Flash Crash, regulators and market participants noted that 'a 5-second pause in e-mini S&P futures trading was sufficient to end the flash crash slide,'—which prompted the SEC to start phasing in single-stock automated circuit-breakers one month after the 2010 Flash Crash took place (*see* Jones (n 39), 38).

[1020] *See,* i.a., Michael Goldstein and Kenneth A Kavajecz, 'Trading Strategies during Circuit Breakers and Extreme Market Movements' (2004) 7 Journal of Financial Markets 301.

[1021] *See,* i.a., Jonathan Brogaard and K Roshak, 'Prices and Price Limits' [2016] Econometric Modelling: Financial Markets Regulation eJournal.

[1022] *See,* i.a., William G Christie, Shane A Corwin and Jeffrey H Harris, 'NASDAQ Trading Halts: The Impact of Market Mechanisms on Prices, Trading Activity, and Execution Costs' (2002) 57 The Journal of Finance. However, a report by Oxera notes that some of these effects might be more pronounced following the triggering of 'static,' as opposed to 'dynamic' circuit breakers. The same report also notes that even the expectation that a circuit-breaker might soon be triggered can distort market behaviour—but that particular risk is again mitigated by requiring venues to implement dynamic (rather than static) circuit-breakers (*see* Oxera (n 213)).

without negatively affecting the price-discovery process (even if they also had had a negative impact on bid-ask spreads).[1023]

Still, it is worth noting that the EU regime newly imposes a series of rules requiring venues to calibrate, test and monitor their circuit-breakers. It becomes important, then, to evaluate how the costs from complying with these additional rules, on the one hand, and the benefits from mandatorily dynamic circuit-breakers, on the other hand, impact the desirability of these mechanisms.

And although empirical evidence in this regard is still missing, it can be speculated that the fact that circuit-breakers have long been popular with EU venues—reflecting a widespread belief in their ability to 'prevent crashes and reduce the risk of significant market volatility'[1024]—could mean that the costs of implementing or updating them upon the implementation of MiFID II may have been relatively small.

Additionally, it is worth considering that the importance of the MiFID II circuit-breakers is set to increase, as the evolution of algo-trading towards embracing machine-learning technology might make the risks inherent in algo-trading more difficult to mitigate, and 'flash crashes' more difficult to predict.[1025]

[1023] Cyrille Guillaumie and others, 'Market Impacts of Circuit Breakers – Evidence from EU Trading Venues' (2020) ESMA Working Paper No.1, 2020.

[1024] Oxera (n 213).

[1025] *See*, Guillaumie *et* al, noting that machine-learning can make algorithms 'more reactive to market developments' (Guillaumie and others (n 1023), 40).

In such a world, the wider bid-ask spreads typically inherent in circuit-breakers might be a fair price to pay for increased stability and market confidence.[1026]

7.4.3 Requirement to enter into market-making agreements

Earlier in this chapter,[1027] a brief reference was made to the rule whereby algo-traders carrying out market-making strategies may be required to enter into market-making agreements with the venues that host those strategies,[1028] forcing them to provide continuous liquidity in all but exceptional circumstances—the occurrence of which must be publicised by the relevant venue.[1029]

These requirements are arguably tough on algo-traders—and an in-depth discussion of their benefits and costs is postponed until this thesis examines the rules in the EU regime that regulate market-making.[1030] However, it is worth noting that the rule requiring certain algo-traders to enter into market-making agreements with the venues where they trade is complemented by a rule that

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[1026] *See* a recent report issued by Oxera, where market crashes and disorderly trading are noted for impairing market confidence (Oxera (n 213)).

[1027] *See* section 7.3.1.2.

[1028] MiFID II, article 17(3) and CDR 2017/578, article 1.

[1029] *See* MiFID II, article 17(3) and CDR 2017/578, article 4(1). Venues must also 'set out clear procedures to resume normal trading after the exceptional circumstance have ceased to exist, including the timing of such resumption' (*see* CDR 2017/578, article 4(2)).

[1030] *See* chapter 9.

correspondingly requires venues to undertake such agreements with those traders—as well as to monitor and enforce them.[1031]

Indeed, article 48(2) of MiFID II requires venues to enter into written agreements with all firms[1032] carrying out an (algorithmic) market-making strategy[1033] on their platform.[1034] It also imposes a requirement for venues to adopt schemes to guarantee that they enter into these agreements with a sufficient number of firms to ensure that enough liquidity is provided on their platforms ('market-making schemes').[1035]

Article 48(3) of MiFID II further regulates the minimum content of these agreements. From the perspective of algo-traders, they must establish liquidity-provision obligations, as well as any obligations that may arise from participation in market-making schemes.[1036] From the point of view of venues, they should list

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[1031] MiFID II, article 2.

[1032] Article 48(2) uses the expression 'investment firms,' but article 17(3) of MiFID II (where the corresponding requirement for algo-traders can be found) applies to both investment firms and credit institutions authorised under CRD IV (*see* MiFID II, article 1(3)).

[1033] The EU defines the conditions under which a particular algo-trader is deemed to be pursuing a 'market making strategy' in article 17(4) of MiFID II. For a discussion, *see* chapter 9.

[1034] MiFID II, article 48(2)(a).

[1035] *See* MiFID II, article 48(2)(b). Article 5 of CDR 2017/578 clarifies that venues only need to have market-making schemes in place for certain classes of financial instruments, and only when those instruments are traded through a continuous auction order book trading system. Taking into account the scope of this thesis, it is worth noting that venues are required to have a market-making scheme when 'shares and exchange traded funds for which there is a liquid market as defined in accordance with Article 2(1)(17) of [MiFIR] and as specified in [CDR] 2017/567' are traded through 'a continuous auction order book trading system' (*see* CDR 2017/578, article 5(1)(a)). For a definition of 'continuous auction order book trading system,' *see* article 5(2) of CDR 2017/578; and chapter 3.

[1036] As will be noted in chapter 9, these obligations cease to apply 'under exceptional circumstances,' which must be identified by trading venues under CDR 2017/578, article 4.

any incentives offered to algo-traders in exchange for liquidity provision, or for participation in market-making schemes[1037]—as well as the requirements that algo-traders must meet before accessing those incentives.[1038]

It is worth recalling that venues are subject to a general requirement to 'ensure orderly trading under conditions of severe market stress.'[1039] As such, venues may offer better incentives to algo-traders willing to run the additional risks of providing liquidity under 'stressed market conditions'[1040]—in which case they must establish how such conditions are to be identified.[1041]

At the same time, venues must also ensure that the terms and conditions of their market-making schemes are fair and non-discriminatory[1042]—in particular by providing the same incentives to 'all participants who perform equally in terms of presence size and spread,'[1043] given particular market conditions,[1044] and by

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[1037] The minimum content of these market-making agreements is detailed in article 2(1) of CDR 2017/578. For a discussion, *see* chapter 9.

[1038] CDR 2017/578, article 6.

[1039] *See* MiFID II, article 48(1); and section 7.4.1.

[1040] *See* CDR 2017/578, article 6(1). As such, venues are expected to offer different incentives under 'normal trading conditions' and 'stressed market conditions.' When it comes to the incentives offered under 'normal trading conditions,' venues can specify that those incentives will only be offered to the traders that provide the most liquidity (*see* CDR 2017/578, article 6(3)).

[1041] *See* CDR 2017/578, article 6(2). These parameters should take into account any significant short-term changes of price and volume. Additionally, venues must implement procedures to communicate the existence of stressed market conditions on their platforms to all participants in their market-making schemes (*see* CDR 2017/578, article 7(6)).

[1042] *See* CDR 2017/578, article 7. Additionally, venues must publish detailed information on their websites regarding their market-making schemes (*see* article 7).

[1043] CDR 2017/578, article 7(3).

[1044] Article 7(3) of CDR 2017/578 does not explicitly address the differences in treatment that may arise between traders required to provide liquidity under 'normal trading conditions' and those not limiting the number of traders that can participate in market-making schemes.[1045]

Ultimately, the rules in the EU regime that mandate market-making agreements are not fully evaluated until the last chapter of the thesis.[1046] Regardless, it can already be argued that those rules are necessarily made more effective by imposing obligations on both traders and venues—and, particularly, by enlisting the help of venues in ensuring that enough such agreements are signed, under conditions that are fair for all traders.

7.4.4 Rules on fee structures

The EU regime also contains rules that regulate the strategies adopted by venues in regard to fee structures—and which have been significantly modified in response to the widespread popularisation of algo-trading across EU markets.

It is worth recalling the three most important fee structure trends developed in response to algo-trading: the sale of more market data products varying in detail and speed; the slight increase of market data fees and the sharp decrease of trading fees; and the popularisation and subsequent decline of certain asymmetric fee models. It is also worth recalling that most of these trends

that agree to provide liquidity under 'stressed market conditions'—but article 6(1) of CDR 2017/578 expressly authorises venues to take those differences into account.

[1045] *See* CDR 2017/578, article 7(4). However, they can 'limit the access to the incentives included in the scheme to the firms which have met pre-determined thresholds.'

[1046] *See* section 9.3.

have fed into the trading models of algo-traders—amplifying the risks generally associated with this type of trading, while also raising fairness concerns.[1047]

These risks and concerns are then explicitly addressed by article 48(9) of MiFID II—which requires venues to refrain from adopting fee structures that incentivise 'disorderly trading…or market abuse,' as well as to adopt 'transparent, fair, and non-discriminatory' fee structures.[1048]

In particular, venues must apply the same fees and conditions to everyone using 'the same type of service,' according to transparent[1049] objective criteria.[1050] However, there are exceptions to this 'same fee for same service rule.' In particular, article 48(9) of MiFID II allows venues to adjust their fees to reflect the additional risk and burden inherent in particular algo-trading behaviour—namely, placing fleeting orders, maintaining high order-cancellation and OTRs, and generally engaging in HFT strategies.[1051]

[1047] *See* chapter 3.

[1048] MiFID II, article 48(9).

[1049] According to the 'transparency of fee structures' requirement in article 4 of CDR 2017/573, venues are required to publish the objective criteria used to determine their fees, fee structures and other conditions applied to traders under those structures. This information must also be complemented by information on 'execution fees, ancillary fees, rebates, incentives and disincentives'—and all the relevant information should be published by venues on their website, in 'one comprehensive and publicly accessible document' (*see* CDR 2017/573, article 4).

[1050] CDR 2017/573, article 3(1). Additionally, fee structures should be 'sufficiently granular' to allow users to calculate their actual payable fees (*see* article 3(2)).

[1051] MiFID II, article 48(9).

As such, venues can establish different fee structures for the same type of services[1052] based, in particular, on total volume traded, numbers of trades, scope or field of use demanded, and whether a trader is subject to market-making obligations[1053]—with the latter being a condition for receiving rebates.[1054]

In the end, the general requirement for venues to adopt transparent, fair and non-discriminatory fee arrangements should contribute to mitigating the risk of fee structures being used to accentuate differences between traders in the two-tiered markets arguably created by algo-trading.

Additionally, allowing (and, indeed, encouraging) venues to implement fee structures that punish particular (algorithmic) trading strategies—namely those that have come to be associated with HFT[1055]—addresses the concern that (some of) those strategies can be a threat to market integrity. Indeed, it has been argued that 'explicit fees charged by exchanges on excessive messaging' can be

[1052] Still, it is worth noting that, even in these cases, venues should base any distinctions on 'non-discriminatory, measurable and objective criteria' (*see* CDR 2017/573, article 3(1)).

[1053] CDR 2017/573, article 3(1).

[1054] Specifically, article 48(9) of MiFID II notes that 'trading venues must impose market making obligations in individual shares or a suitable basket of shares in exchange for any rebates that are granted.' ESMA has since clarified that 'the purpose of the requirement in Article 48 is to ensure that any party receiving financial incentives, such as rebates, to provide liquidity on a trading venue is subject to appropriate market making obligations, but these need not always take the form of a market making agreement' (*see* ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414)).

[1055] *See* CDR 2017/573, recital (6) noting that 'fee structures that contribute to conditions leading to disorderly trading conditions,' in particular 'through encouraging intensive trading' should be prohibited.

'more effective' at dealing with the risks inherent in HFT than, for instance, the OTRs discussed previously.[1056]

However, the same argument—warning against the dangers of punishing all HFT behaviour without distinguishing between HFT strategies—that justifies caution with OTRs also applies here. As such, it is commendable that MiFID II only allows—rather than requires—venues to impose higher fees on HFTraders.

Finally, the rule that prohibits venues from granting rebates to anyone other than the traders who are subject to market-making obligations[1057] is a clear response to the concerns raised by typical asymmetric fee structures—which use rebates to favour particular types of traders (either makers or takers of liquidity) without requiring commitment to any consistent behaviour.

The problem with these asymmetric fee structures is that they may create a conflict of interests for execution intermediaries, who might feel tempted to forward client orders to a particular venue because of the offered rebates.[1058] By limiting the occasions that give rise to rebates, the EU presumably mitigates the risk that intermediaries might engage in this type of opportunistic behaviour.

[1056] Foresight, 'Economic Impact Assessments on MiFID II Policy Measures Related to Computer Trading in Financial Markets' (n 1005).

[1057] *See* MiFID II, article 48(9) and answer 9 (topic 5) *in* ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414).

[1058] *See* chapter 3.

7.4.5 Requirement to identify algo-trading activity

Earlier discussions of the reporting requirements applicable to venues under the EU regime noted that the MS authorities responsible for their supervision may ask them to provide information about the algo-trading activity that takes place on their platforms.[1059]

It was then also noted that this rule presupposes an organisational requirement whereby venues must identify all orders originating in algo-trading, all algorithms used to create those orders and all persons initiating them. This is a significant requirement—that might play an important role in the supervision of algo-trading by MS authorities—but which should not be overly burdensome for venues: indeed, article 48(10) of MiFID II also notes that this identification should be achieved ‘by means of flagging from members’ themselves.

7.4.6 Requirement to implement minimum tick size regimes

One of the most noteworthy aspects of the EU algo-trading regime is the adoption of minimum tick size regimes as tools to mitigate the risks arising from algo-trading activity, and amplified by the strategic behaviour adopted by the competitive network of venues that host this type of trading across EU markets.[1060]

[1059] MiFID II, article 48(10).

[1060] Naturally, the minimum tick size regimes discussed in this section as part of the EU regime apply in regard to ‘all trading [and] not just automated trading’ (*see* EC, ‘Public Consultation - Review of the Markets in Financial Instruments Directive (MiFID)’ (n 601)); however, they were

In this regard, it is worth recalling that the first version of MiFID encouraged the creation of several 'new trading platforms' with different tick sizes—and that competition for order flow (in particular algo-trading order flow) led these venues to offer ever 'lower tick sizes.'[1061] It is also worth noting that, although smaller tick sizes have been associated with narrower bid-ask spreads,[1062] they have also been linked to risks of increased complexity,[1063] 'disorderly trading, erratic price movements, and [venue] capacity overload.'[1064]

In response to these risks, the EU regime newly requires venues to implement minimum tick size regimes in a variety of financial instruments, including shares,[1065] with article 49 of MiFID II stating that the minimum tick sizes applicable to each instrument should reflect its particular liquidity profile—and strive to prevent excessive price volatility, 'without unduly constraining further narrowing of [bid-ask] spreads.'[1066]

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inspired by concerns born out of markets where most trading is algorithmic and where venues felt compelled to decrease their tick sizes in response to this trading.

1061 CESR, 'Micro-Structural Issues of the European Equity Markets' (n 371), 6.

1062 *See*, i.a., Fox, Glosten and Rauterberg (n 2).

1063 CESR, 'Micro-Structural Issues of the European Equity Markets' (n 371). The problem of complexity might improve naturally as markets become more automated and better able to deal with a larger number of decimals (*see* Angel (n 316)).

1064 EC, 'Markets in Financial Instruments Directive (MiFID II): Frequently Asked Questions' (n 849). *See* also the discussion in chapter 3.

1065 MiFID II, articles 48(6) and 49(1).

1066 MiFID II, article 49(2)(a).

The result is a system that contains different minimum tick sizes applicable to different instruments.[1067] And—since the scope of this thesis is limited to equity markets[1068]—it is worth noting that the method for calculating the minimum tick sizes applicable to shares is included in CDR 2017/588,[1069] which calibrates them to the average daily number of transactions[1070] on the most liquid market in the EU[1071] for each particular share.[1072] Finally, article 49(1) of MiFID II notes that the application of tick sizes does not—however—prevent venues from 'matching orders large in scale at mid-point within the current bid and offer prices.'

Ultimately, MiFID II is not entirely clear on what the expectations were for the introduction of these mandatory tick size regimes[1073]—but the recent CDR 2019/443 reveals a triple goal: harmonising price increments on venues across the EU; preserving market depth and liquidity; and ensuring the 'orderly functioning of equity trading.'[1074]

[1067] MiFID II, article 49(2)(b).

[1068] *See* chapter 1.

[1069] CDR 2017/588 is also relevant for depositary receipts and exchange-traded funds.

[1070] The average daily number of transactions for shares (and depositary receipts) is determined in accordance with article 3 of CDR 2017/588.

[1071] According to article 1 of CDR 2017/588, the most relevant market in terms of liquidity for a share should be determined in accordance with article 4(1)(a) of MiFIR and article 4 of CDR 2017/587—which defines it as 'the trading venue with the highest turnover within the Union for that financial instrument.' *See*, also, CDR 2017/588, article 3(8)-(10) —recently inserted by CDR 2019/443.

[1072] CDR 2017/588, article 2(1) and (2) and the table included in its Annex.

[1073] *See* a report by Oxera, noting that 'the MiFID review consultation document [did] not explain the objective of this…rule' (Oxera (n 213), 10).

[1074] *See* CDR 2019/443, recital (2). *See* also CESR, 'Micro-Structural Issues of the European Equity Markets' (n 371); and EC, 'Markets in Financial Instruments Directive (MiFID II): Frequently

The purpose of harmonising tick sizes across the EU is effectively achieved by requiring all EU venues to offer the same minimum tick size for any particular financial instrument—and the recent extension of these requirements to SIs[1075] should contribute even further to this goal.[1076]

Evaluating whether the EU minimum tick size rules achieve the purpose of preserving 'market depth and liquidity' while ensuring 'the orderly functioning of equity trading' is trickier.

In theory, minimum tick sizes increase bid-ask spreads[1077]—at least 'anytime the spread…would be smaller than the minimum tick'[1078]—and trading

Asked Questions' (n 849). Another reason for adopting a uniform tick size regime is preventing collusion between market players to keep spreads artificially high (*see* Angel (n 316)). However, this has become less of a problem since venues transitioned into privately-owned for-profit companies and it does not look like the EU had this particular goal in mind when it approved its regime.

[1075] This extension resulted from Regulation 2019/2033, which amended MiFIR 'to subject systematic internalisers' quotes, price improvements and execution prices to the tick size regime when dealing in all sizes' and determined that the technical standards dealing with such tick size regime should also apply to the extended scope of MiFIR (*see* Regulation 2019/2033, recital (44)). As a result, a new article 17a has been added to MiFIR stating that '"Systematic internalisers" quotes, price improvements on those quotes and execution prices shall comply with tick sizes set in accordance with Article 49 of Directive 2014/65/EU.' Article 17a came into force on 26 March 2020, but—in the wake of the recent COVID crisis—ESMA has noted that it is not expecting MS authorities to prioritise enforcement of the new rules until 26 June 2020 (*see* ESMA, 'Public Statement - Actions to Mitigate the Impact of COVID-19 on the EU Financial Markets Regarding the New Tick Size Regime for Systematic Internalisers' (2020) ESMA70-1556–2485).

[1076] The extension of the EU minimum tick size regime to SIs should also contribute to closing an important regulatory loophole identified by ESMA in 2017: *see* chapter 4.

[1077] *See*, i.a., Angel (n 201); and Fox, Glosten and Rauterberg (n 2). For a discussion of the bid-ask spread as a common measure of liquidity, *see* chapter 2.

[1078] *See* Fox, Glosten and Rauterberg (n 2), 74. Indeed, data from the US—discussed by Fox *et al*—shows that, in the US, most shares priced between $10 and $40 trade on a spread of 1 penny (equal to the minimum tick size), suggesting that spreads (and, particularly, spreads for highly liquid shares) could be smaller than 1 penny without this minimum tick size.

costs for investors.[1079] Simultaneously, larger tick sizes also increase the value of time and price priority in LOBs—offering greater incentives for traders to provide liquidity by placing (non-marketable) limit orders.[1080] This may then have the effect of increasing market-depth at the spread—potentially decreasing the market impact of large orders.[1081]

Additionally, a minimum tick size regime can both prevent venues from competing for ever-smaller tick sizes—in an attempt to attract execution intermediaries (who are bound by best execution requirements)[1082]—and prevent traders from using meaningless price improvements to jump to the front of the LOB 'queue,'[1083] resulting in excessive price volatility.[1084]

[1079] Or, at least, small investors: *see* Angel (n 316); Michael Goldstein and Kenneth A Kavajecz, 'Eighths, Sixteenths, and Market Depth: Changes in Tick Size and Liquidity Provision on the NYSE' (2000) 56 Journal of Financial Economics 125; and Charles M Jones and Marc L Lipson, 'Sixteenths: Direct Evidence on Institutional Execution Costs' (2001) 59 Journal of Financial Economics 253.—although, *see*, also, Bollen and Busse, who find that 'the average change in trading costs of actively managed funds was positive' following two episodes of reductions in tick sizes in US equity markets (Nicolas PB Bollen and Jeffrey A Busse, 'Tick Size and Institutional Trading Costs: Evidence from Mutual Funds' (2006) 41 The Journal of Financial and Quantitative Analysis 915, 915).

[1080] *See*, i.a., Angel (n 201); and Thierry Foucault and Sophie Moinas, 'Is Trading Fast Dangerous?', *Global Algorithmic Capital Markets - High Frequency Trading, Dark Pools, and Regulatory Challenges* (Walter Mattli, Oxford University Press 2019).

[1081] *See* Angel (n 316). In particular, larger tick sizes might increase 'certainty to traders about the amount of liquidity actually available at any point in time' (*see*, *a contrario*, Oxera (n 213), 45).

[1082] Angel (n 316).

[1083] ibid.

[1084] FCA, 'Quarterly Consultation No. 27 - Consultation Paper' (2020) Consultation Paper CP 20/4.

Finally, minimum tick sizes limit the amount of information that needs to be considered by traders, reducing the time spent bargaining and negotiating, and eventually mitigating the risk of trading errors.[1085]

Ultimately, the EU minimum tick size rules should then make a positive contribution to 'the orderly functioning of equity trading' in the EU[1086]—even if that contribution may be hard to quantify.[1087] Whether those rules are also able to preserve market liquidity—however—is more difficult to determine, as the answer depends on the extent to which increases in bid-ask spreads are off-set by increases in market depth. Indeed, it is worth recalling that liquidity is a multi-dimensional concept—and the fact that a large order does not have to walk the order book does not necessarily equate with cheaper execution.[1088]

In the end, the optimal trade-off between narrower bid-ask spreads, on the one hand, and increased market depth, on the other hand—or, in other words, the optimal tick size—might depend on the nature of the underlying financial instrument.[1089] In particular, actively traded shares might benefit comparatively

[1085] *See*, i.a., Lawrence Harris, 'Stock Price Clustering and Discreteness' (1991) 4 The Review of Financial Studies 389; and Angel (n 201).

[1086] CDR 2019/443, recital (2).

[1087] *See* Angel, noting that 'if regulatory action prevents a destructive race to the bottom, then it could have significant, although hard to quantify, benefits.' (Angel (n 316), 12).

[1088] *See* Fox, Glosten and Rauterberg (n 2). *See,* also, Angel, arguing that 'reductions in tick sizes produce ambiguous results for institutional traders who trade in sizes far larger than available at the inside spread' (Angel (n 316), 8).

[1089] *See* Angel (n 316). It also depends, in particular, on market structure—with lower tick sizes being generally preferable in markets where there are less formally-appointed liquidity intermediaries (and market players interact directly with one another). This is the case with order-more from narrower bid-ask spreads than from added market-depth—and the opposite is true for less frequently-traded shares.[1090]

It is thus commendable that the EU establishes different minimum tick size regimes depending, in particular, on the 'average daily number of transactions' for each particular instrument—allowing venues to offer lower minimum tick sizes for shares that are more actively traded.[1091] And it is also positive that the EU (recently) amended its minimum tick size rules to expressly exclude 'large scale' orders matched at mid-point[1092]—as these are circumstances that the EU tick size regime never meant to cover,[1093] presumably because they do not raise the same risks of fleeting liquidity and excessive price volatility otherwise inherent in trading at smaller tick sizes.[1094]

At the same time, it is unclear whether the range of minimum tick size values chosen by the EU under its regime are actually optimal from the point of

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driven markets, which have become increasingly popular in most developed economies (*see* chapter 3).

[1090] ibid.

[1091] CDR 2017/588, article 3(1), and its Annex. For that same reason, it is also important that firms retain the ability to split their shares, which allows them to manipulate their relative tick size. For a discussion, *see*, i.a., Fox, Glosten and Rauterberg (n 2); and Angel (n 316).

[1092] The final part of article 49(1) of MiFID II was added by Directive 2019/2034. Directive 2019/2034 should be transposed by 26 June 2021, but the changes made to the EU minimum tick size rules have been in force since 26 March 2020 (*see* Directive 2019/2034, article 67(1)).

[1093] FCA, 'Quarterly Consultation No. 27 - Consultation Paper' (n 1084).

[1094] Additionally, according to the FCA, 'allowing large-in-scale trades to execute at the mid-point enables buyers and sellers to equally share the benefits, in terms of a lower explicit cost of execution, where both are happy to trade outside of the constraints of the tick-size regime' (*see* ibid, 27).

view of liquidity preservation[1095]—and while recent empirical evidence gives reason for optimism,[1096] market participants have proposed a number of changes to the method used by the EU for calculating these tick sizes.[1097] Additionally, it is worth keeping in mind the increased costs of dynamic tick size regimes—which may require frequent monitoring of market conditions[1098]—as well as the costs of driving trading activity away from 'lit venues'[1099] and into (dark) trading environments that might be exempt from minimum tick size rules.[1100]

Before concluding the evaluation of the EU minimum tick size rules included in the EU regime, it is worth noting that—in addition to the goals explicitly pursued by that regime—it is possible that such rules had a fourth purpose: 'curtailing HFT.'[1101]

[1095] *See* a report by Oxera, noting that 'determining the optimal tick size is far from straightforward in itself' and that while it might be 'appropriate for a regulator to determine the optimal tick size,' 'this is a challenging task and would require industry consultation' (Oxera (n 213), 46).

[1096] Indeed, according to a recent study conducted by AMF, the implementation of the EU tick size rules 'seems to have had the desired effect on market quality'—with several indicators pointing towards greater depth, less noise and more stable order books, as well as improved price efficiency; at the same time these rules have also resulted 'in a slight widening of the spread for the most liquid securities' (*see* AMF, 'MiFID II: Impact of the New Tick Size Regime after Several Months of Implementation' (2019) Risks & trends, 2).

[1097] ESMA, 'MiFID II/MiFIR Review Report on the Transparency Regime for Equity and Equity-like Instruments, the Double Volume Cap Mechanism and the Trading Obligations for Shares' (n 854).

[1098] Angel (n 316).

[1099] Angel (n 316).

[1100] This concern justified the extension of minimum tick size rules to SIs (*see* section 7.4.6).

[1101] Oxera (n 213), 10.

Indeed, it is worth recalling that the popularisation of algo-trading across EU markets encouraged the development of the new strategies discussed earlier under the umbrella term of 'HFT'—and that some of these HFT strategies stand to be particularly affected by the minimum tick size rules imposed by MiFID II.

Specifically, there is evidence that financial instruments with smaller tick sizes are more attractive for HFTraders,[1102] namely by facilitating electronic front-running strategies[1103]—and allowing HFTraders to prey on larger traders while 'improving [share] price by the smallest possible amount.'[1104] Simultaneously, 'the value of time priority is higher in stocks with larger tick sizes,' encouraging high-frequency market-makers to be more active in shares with larger minimum tick sizes[1105]—although it is not clear whether this increased HFT market-making activity then improves liquidity.[1106]

[1102] *See*, i.a., Elvis Jarnecic and Mark Snape, 'The Provision of Liquidity by High-Frequency Participants' (2014) 49 Financial Review 371.

[1103] *See,* i.a., Dan Marcus and Miles Kellerman, 'The FX Race to Zero - Electronification and Market Structural Issues in Foreign Exchange Trading', *Global Algorithmic Capital Markets - High Frequency Trading, Dark Pools, and Regulatory Challenges* (Walter Mattli, Oxford University Press 2019); and Soheil Mahmoodzadeh and Ramazan Gençay, 'Human vs. High-Frequency Traders, Penny Jumping, and Tick Size' (2017) 85 Journal of Banking & Finance 69. As a result, it is possible that most benefits of spread reduction resulting from decreases in tick sizes could end up being 'absorbed' by HFTraders (*see* ibid). Čuk and Van Waeyenberge also associate smaller tick sizes with 'unnecessary volatility by HFT'—although it is unclear what the authors mean by 'unnecessary' in this context (*see* Čuk and Waeyenberge (n 15), 6).

[1104] *See* Mahmoodzadeh and Gençay (n 1103). While increasing tick sizes could lead to opportunities to run in front of slower trades becoming less frequent, 'each movement [would be] worth slightly more' (*see* Oxera (n 213), 48).

[1105] *See* Foucault and Moinas (n 1080), 19. *See,* also, a report by Oxera, noting that increasing the tick size is unlikely to significantly change the strategies of high-frequency market-makers (Oxera (n 213)).

[1106] *See* Ye and Yao, noting that proposals to increase tick size 'will not improve liquidity,' but, instead 'encourage high frequency trading and lead to the proliferation of markets that bypass the tick size constraints (Mao Ye and Chen Yao, 'Tick Size Constraints, Market Structure, and Liquidity' (2014) WBS Finance Group Research Paper 212, 1). Indeed, there is some evidence

Finally, it would appear that the minimum tick size regimes imposed under MiFID II could have an ambiguous effect on HFT arbitrage strategies: while larger tick sizes reduce the frequency with which arbitrage opportunities occur, they also increase the value of each opportunity.[1107]

Ultimately, there is no clear indication that the EU meant to use the new tick size rules in its algo-trading regime to curtail HFT as a whole. And that is a good thing: HFT is an umbrella-term that covers many strategies, with different impact on different aspects of market quality[1108]—and it is therefore misguided to treat HFT as a monolithic category of trading. Additionally, the introduction of minimum tick size rules could impact different HFT strategies differently, making them a very blunt instrument to deal with HFT.

Still, there is no question that these minimum tick size rules can have an impact on HFT activity.[1109] For that reason, and because optimal tick sizes are hard to determine, it is hoped that the EU will keep a close eye on the evolution of the market quality indicators that respond to these rules—even if early signs

that market depth can be reduced 'due to the occupation of the top of the order book by HFT's' (*see* Mahmoodzadeh and Gençay (n 1103), 1).

[1107] Oxera (n 213).

[1108] *See* a report by Oxera, noting that 'if tick sizes were to be set too large…it would potentially curtail HFT and the potential benefits of HFT' (*see* ibid, 45).

[1109] As such, they are discussed again as *de facto* constrains on HFT in chapter 9.

have been mostly positive.[1110] And it is also hoped that any necessary adjustments will be made swiftly.[1111]

7.4.7 Rules on DEA and co-location services

Earlier it was noted that one of the strategies adopted by trading venues to compete for algo-trading order flow has been the development of channels that improve access to their trading systems.

It was also noted that these access improvements have contributed to amplifying the effects of algo-trading, including the systemically relevant operational and inherent risks associated with this type of trading. Additionally, investment in these channels represents an important cost of the 'quote run games' that are thought to occur in modern capital markets—and which pit the fastest traders in these markets against each other, while increasing the divide separating them from slower investors.

There are two mains strategies adopted by EU venues to improve access to their systems: allowing access via DEA services and providing co-location services to market participants—and both are subject to requirements under the EU regime.

[1110] *See* AMF (n 1096). At the same time, there have also been a 'slight widening of the spread for the most liquid securities' and a rise in the 'effective transaction costs for HFT' following the implementation of the EU minimum tick size rules (*see* ibid, 2).

[1111] These adjustments should be facilitated by the fact that the range of tick sizes that can apply to trading in a particular financial instrument are determined via CDRs.

7.4.7.1 Requirements regarding DEA services

The rules in the EU regime that apply to venues that allow access to their systems via DEA services are laid down in article 48(7) of MiFID II and include two sets of requirements: some regarding DEA service providers,[1112] and others regarding DEA service users.

In regard to DEA service providers, article 48(7) of MiFID II requires venues to put in place arrangements to ensure that only investment firms authorised under MiFID II (or credit institutions authorised under the CRD IV) are able to provide DEA services.

Additionally, venues must make sure that anyone providing DEA services uses 'appropriate criteria' to assess the suitability of the persons to whom they grant access—and remains responsible for ensuring that orders and trades executed under these DEA arrangements comply with MiFID II. In particular, venues are expected to publish the rules and conditions that should guide the provision of DEA services for access their systems.[1113]

Venues that also allow sponsored access ('SA') to their systems are subject to additional requirements:[1114] first, they must subject the provision of SA

[1112] The requirements applicable to DEA providers themselves are discussed in chapter 8.

[1113] *See* CDR 2017/58, article 21. The minimum content of these rules and conditions is also established by article 21 of CDR 2017/584, which notes that such rules and conditions must cover at least the requirements set out in article 22 of CDR 2017/589.

[1114] SA is a sub-type of DEA. For a discussion, *see* chapter 8.

services to prior authorisation;[1115] and, second, they must retain the power to suspend or withdraw the provision of SA services upon infringement of MiFID/MiFIR, MAR, or their own rules.[1116]

In regard to DEA services users, article 48(7) of MiFID II requires venues to subject all trading through DEA services to appropriate risk controls and thresholds.[1117] Additionally—if DEA service users also enjoy SA—venues must subject them to the same pre-trade and post-trade controls applicable to venue members under article 18(3)(b) of CDR 2017/584.[1118]

At the end of the day, venues should be able to identify and 'if necessary' stop any orders and trades originated under DEA service arrangements.[1119] And, finally, they should be able to suspend or cancel the provision of DEA services in case their systems detect any behaviour contrary to article 48(7) of MiFID II.[1120]

Ultimately, these powers help enlist trading venues as an additional 'line of defence'[1121] against the risks inherent in algo-trading—and amplified by giving

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[1115] *See* CDR 2017/584, article 22(1). Venues are also required to ensure that any providers of SA are 'exclusively entitled to set or modify the parameters that apply to the controls' applicable to SA users and their order flow under article 22(1) of the same CDR (*see* CDR 2017/584, article 22(2)).

[1116] CDR 2017/584, article 22(3).

[1117] MiFID II, article 48(7).

[1118] *See* CDR 2017/584, article 22(1)*. See,* also, section 7.4.2 for a discussion of these pre-trade and post-trade controls.

[1119] MiFID II, article 48(7).

[1120] MiFID II, article 48(7).

[1121] Conac (n 31), 17.33.

algo-traders disintermediated access to EU markets. Indeed, not only do they require venues to impose conditions on, and monitor the activity of DEA service providers and their users, but they also require venues to retain the ability to stop trading or even cancel the provision of DEA services in the face of misbehaviour.

The resulting sharing of responsibilities between venues and DEA providers is welcomed, as it creates additional opportunities for detecting and stopping algorithmic misbehaviour, while distributing costs among a number of—necessarily professional—market agents.[1122]

7.4.7.2 Requirements regarding co-location services

MiFID II regulates the provision of co-location services by establishing just one rule: that venues offer co-location services on a 'transparent, fair and non-discriminatory' basis.[1123]

More detail is found in CDR 2017/573, which states that a venue must provide 'fair and non-discriminatory co-location services,'[1124] namely by giving the same access to all users subscribed to the same co-location services, under the 'same conditions,'[1125] and by taking all reasonable steps to ensure that users with

[1122] For a discussion of the requirements applicable to DEA service providers, *see* chapter 8.

[1123] MiFID II, article 48(8).

[1124] CDR 2017/573, article 1(1).

[1125] *See* CDR 2017/573, article 1(2). These conditions can have regard, i.a., to 'space, power, cooling, cable length, access to data, market connectivity, technology, technical support and messaging types.'

the same access are treated fairly.[1126] Additionally, venues must unbundle co-location services and sell them individually.[1127]

As for the requirement to provide co-location services on a 'transparent basis,' article 2 of CDR 2017/573 lists a series of information that venues must publish on their website—including the conditions for accessing the service, the different types of access available and the process by which co-location space is allocated.[1128]

Ultimately, the purpose of these requirements is to limit the formation of unfair markets[1129]—so it is noteworthy that the EU regulates the provision of co-location services, rather than prohibit them. Indeed, it is worth recalling that one of the goals of financial regulation is to curtail practices that make certain groups of market players consistently and disproportionately better off than other (more vulnerable) groups,[1130] and co-location services put their users—often HFTraders[1131]—in a position that is unambiguously superior.[1132]

[1126] *See* CDR 2017/573, article 1(3). In particular, a venue is expected to 'take all reasonable steps to monitor all connections and latency measurements.'

[1127] CDR 2017/573, article 1(4).

[1128] CDR 2017/573, article 2—in particular, paragraphs (c)-(e).

[1129] CDR 2017/573, recital (1).

[1130] *See* chapter 2.

[1131] *See* MiFID II, article 4(1)(40), noting that HFT is characterised, *i.a.,* by 'infrastructure intended to minimise network and other types of latencies, including…co-location.'

[1132] The issue has been extensively discussed in the US, where similar rules (in particular, 17 CFR § 242.603—'SEC Rule 603(a)(2)') forbid venues from distributing market data in an 'unreasonably discriminatory way.' And while the SEC finds it acceptable that data reaches certain market players before others—namely because of 'colocation and other technological differences'—as long as the information is sent simultaneously to everyone in the market, some

At the same time, trading is a zero-sum game and most market interactions have clear winners and losers—often as a function of how much time, money and resources are poured by each player into those interactions.[1133] Thus, the co-location rules in the EU regime fall short of forbidding venues from offering co-location services to market players who are willing to pay for a competitive edge—but they do ensure that everyone in the market can invest in co-location services, knowing that they are fully informed about the services on offer, and that they are treated fairly by service providers.[1134]

Ultimately, the extent to which these rules effectively contribute to fairer markets depends on how they are interpreted and applied, but there are reasons for optimism: the fact that venues must consider a variety of conditions in evaluating whether they offer non-discriminatory services—namely, 'space, power, cooling, cable length, access to data, market connectivity, technology, technical support and messaging types;'[1135]—the fact that venues must monitor latency measurements (which are objective and quantifiable) to ensure non-discriminatory treatment;[1136] and the fact that venues have a responsibility to

have noted that this interpretation of the rule leaves certain traders 'consistently' better off than others. For an account of these different views, *see* Fox, Glosten and Rauterberg (n 2).

[1133] *See* chapter 2.

[1134] In practice, venues are not required to 'extend their co-location capacities beyond the limits of the space, power, cooling or similar facilities available and should have discretion to decide whether they expand their co-location space or not.' Indeed, they can even determine to 'which types of market participants they want to grant access to those services provided that their commercial policy is based on objective, transparent and non-discriminatory criteria (*see* CDR 2017/573, recital (4)).

[1135] CDR 2017/573, article 1(2).

[1136] CDR 2017/573, article 1(3).

ensure non-discrimination even when co-location services are owned or managed by third parties.[1137]

Finally, it is notable that these non-discrimination rules come coupled with transparency requirements, which should empower traders to understand the extent of their disadvantage if they do not acquire co-location services—and to gain a clear understanding of how they can close the technological gap that separates them from faster players.[1138]

Whether that is true fairness depends on the definition of 'fairness' used: a broad notion of fairness that requires all market participants to enjoy equivalent processing capabilities and bargaining power would require harsher rules than those found in the EU regime—but a narrower definition of fairness based on notions of 'unavoidable harm' would likely be satisfied by the EU rules.[1139]

7.5 Conclusion

The popularisation of algo-trading across Europe led to a profound change in venue behaviour, creating new risks—and new challenges—for regulators. The EU rose to those challenges and its algo-trading regime includes a complex web

[1137] *See* CDR 2017/573, article 1(b)-(c), recital (3) and answer 2 (topic 5) *in* ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414).

[1138] *See* CDR 2017/573, article 2. These transparency requirements also ensure that the 'fair and non-discrimination' rules are not circumvented (*see* CDR 2017/573, recital (5)).

[1139] *See* chapter 2.

of rules that regulate the new strategies adopted by venues in response to this type of trading.

Many of these rules—including most of the reporting and general organisational requirements in article 48 of MiFID—do little more than adapt pre-existing requirements to the specificities of the new automated markets. Venues—like most market intermediaries—are hoped to help markets perform their desired functions,[1140] and most of these rules only just ensure that EU venues can continue to do so.

Still, there is much to praise about these new requirements: they helpfully apply to all venues; they contain extensive but proportionate reporting requirements that should help authorities gain a clearer view of markets that have become increasingly complex; and they sensibly regulate fee structures and the provision of co-location services. Most of all, they include a wide-ranging package of organisational requirements that force venues to implement systems capable of ensuring continued venue capacity, as well as a series of pre- and post-trade controls designed to prevent disorderly trading—including what is perhaps the greatest weapon to prevent or mitigate 'flash crashes:' circuit-breakers.

But there is also room for improvement: for instance, the requirement to impose maximum OTRs may have very little impact on market quality, as venues are free to decide on the size of their maximum OTRs and they may not have much incentive to adopt low maximum OTRs. Other requirements still are more

[1140] Armour and others (n 4).

difficult to evaluate. In particular, the impact of the new EU minimum tick size regime on market liquidity is still being assessed—and although early empirical evidence shows overall improvements in market quality,[1141] market participants have been suggesting a number of changes to these requirements.[1142]

Regardless, none of the issues found with these provisions are particularly worrisome—nor do they reflect any fundamental lack of understanding of the change brought by automated-trading technology to the strategies of EU venues.

It is therefore argued that venue regulation under the EU algo-trading regime is overall a key component of that regime—and while trade-offs are inevitable and (further) adjustments may still need to be made, these requirements appear to have made a broadly positive contribution to strengthening EU markets against the challenges created by automated-trading technology.

[1141] AMF (n 1096).

[1142] ESMA, 'MiFID II/MiFIR Review Report on the Transparency Regime for Equity and Equity-like Instruments, the Double Volume Cap Mechanism and the Trading Obligations for Shares' (n 854).

8. NEW RULES FOR NEW STRATEGIES: INTERMEDIARY REGULATION UNDER THE EU ALGO-TRADING REGIME

8.1 Introduction

The role played by trading venues in helping ensure market quality is meaningfully complemented by the actions of multiple other agents acting as information, liquidity, execution and post-trade intermediaries. And, much like venues, these intermediaries too have seen their strategies change drastically in response to algo-trading.

Most notably, the popularisation of algo-trading has led execution intermediaries to start providing entirely novel services with the purpose of facilitating this type of trading.[1143] Specifically, these intermediaries now 'facilitate' DEA 'by their clients to markets through the use of their trading facilities, through direct market access or sponsored access.'[1144]

The phenomenon did not escape the attention of the EU, who has accurately noted that the 'potential risks from increased use of [trading] technology' require a 'combination of measures and specific risk controls'

[1143] The availability of automated-trading technology has also transformed the strategies of information and liquidity intermediaries—but its influence was more drastic regarding execution intermediaries, who not only integrated (execution) algorithms into their activity, but actually started offering entirely new services to their clients (*see* chapter 3).

[1144] MiFID II, recital (62).

applicable, namely, to firms 'that provide [DEA]' services.[1145] As a result, the EU regime also contains rules that address—in particular—the risk that these services may threaten the gatekeeping role of execution intermediaries, or contribute to aggravating differences between market players.

This chapter then continues the analysis of the rules in the EU regime that address the strategies that have been (indirectly) inspired by the availability of automated-trading technology across EU markets by examining the requirements applicable to DEA service providers (*8.2*).

Additionally, this chapter discusses one further set of rules relevant for another type of intermediaries in their interactions with algo-traders: post-trade intermediaries, acting as general clearing members *(8.3)*. In truth, it is unclear whether such rules are part of the EU algo-trading regime—or whether they address any risks arising specifically from interactions with algo-traders—so the discussion is kept brief.

In the end (*8.4*), it is argued that the rules applicable to DEA service providers under the EU regime are an important element of that regime—revealing an accurate understanding of the extent to which automated-trading technology has changed EU markets, and working effectively to enlist execution intermediaries as gatekeepers against the risks inherent in algo-trading.

[1145] MiFID II, recital (63). This cannot be taken to mean that the provision of DEA services carries no benefits for market quality. In particular, it has been argued that DEA play an important role in increasing the transparency of the trading process—as well as trader control over that process (*see* chapter 3).

But these requirements are not exempt from criticism. First, the far-reaching responsibility imposed on DEA service providers increases the costs of services that have a number of positive impacts on market quality. It is also regrettable that the EU regime ignores some of the differences in risk between DMA and SA by giving similar regulatory treatment to all DEA service providers. Finally, it is unfortunate that the EU has made little attempt to ensure that DEA services are offered on a fair basis to all market players.

8.2 New rules for the regulation of DEA service providers

The concern of the EU with DEA service providers dates from the same period when the EU first started discussing the need to regulate algo-trading.

Indeed, as the CESR first began to consider the challenges posed by algo-trading, back in 2009, it also noted that the low latencies enjoyed by algo-traders had only been made possible due to the SA mechanisms developed by certain players with the purpose of allowing their clients to establish direct technical connections to trading venues.[1146]

The faster connections enjoyed by algo-traders continued to preoccupy the CESR through 2010, when a call for evidence was issued to assess these (and other) technology-driven developments.[1147] At that point, CESR described SA as ‘an adaptation of the concept of direct market access’—while also noting

[1146] CESR, ‘Impact of MiFID on Equity Secondary Markets Functioning’ (n 256).

[1147] CESR, ‘Micro-Structural Issues of the European Equity Markets’ (n 371).

that DMA services allowed clients of venue members to access these venues without themselves becoming members, namely by routing their orders through their internal systems. By contrast, SA allowed clients to send orders directly to venues without having to pass through any member systems.[1148]

Naturally the EU was then especially worried about SA[1149]—and it was also sensitive[1150] to the consultation that had been conducted by IOSCO in 2009,[1151] and which noted the dangers of removing intermediary control over order-routing, curtailing the ability of intermediaries to gain a real-time view of orders and potentially stop them.[1152]

It is therefore no wonder that the regulation of DEA services has been included in the EU algo-trading regime. But it is worth noting that the EU regime does not ban the provision of DEA services. For all their risks—discussed earlier[1153]—DEA services have also been praised, not least by ESMA, for

[1148] ibid.

[1149] This concern was compounded by the fact that, already then, the SEC had taken steps to prohibit 'naked' sponsored access, while requiring broker-dealers to manage the risks associated with (fully) disintermediated access (*see* ibid).

[1150] ibid.

[1151] OICV-IOSCO, 'Policies on Direct Electronic Access - Consultation Report' (n 169). This consultation eventually culminated in the publication of the IOSCO 'Principles for Direct Electronic Access the Markets' in 2010 (*see* OICV-IOSCO, 'Principles for Direct Electronic Access to Markets - Final Report' (n 172)).

[1152] OICV-IOSCO, 'Policies on Direct Electronic Access - Consultation Report' (n 169).

[1153] *See* chapter 3.

allowing investors to 'access markets and place orders with greater independence, speed and reduced cost.'[1154]

Specifically, DEA services offer market participants who are not venue members—and who wish to engage in algo-trading—'a more direct or independent route to market than conventional trading through an intermediary,' helping them achieve lower latencies and greater anonymity.[1155] Accordingly, DEA services are advertised as giving traders 'greater control of [their] trades,' levelling the playing field between venue members and smaller investors—and allowing the latter to 'trade like market professionals.'[1156]

As such, the EU regime regulates—rather than bans—the provision of DEA services. The next sections analyse the scope of these rules (*8.2.1*), before examining the reporting, organisational and conduct requirements that they contain (*8.2.2—8.2.3*).

8.2.1 The scope of the DEA rules in the EU regime

The logical starting point for analysing the rules in the EU regime that regulate the provision of DEA services is determining their scope. This requires

[1154] ESMA, 'Consultation Paper: Guidelines on Systems and Controls in a Highly Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (n 171).

[1155] ibid.

[1156] LSEG, 'Direct Market Access: Take Control of Your Trades' <https://www.londonstockexchange.com/prices-and-markets/stocks/tools-and-services/direct-market-access/direct-market-access.htm> accessed 31 July 2020.

establishing which DEA services are regulated under the EU regime and which DEA service providers are covered by that regime.

8.2.1.1 The DEA services regulated under the EU regime

According to MiFID II, DEA (services) are any arrangement whereby venue members give permission to any particular person to use their trading code with the purpose of 'electronically transmitting' orders 'directly' to those venues.[1157]

The link explicitly made by the EU between DEA (services) and the 'electronic transmission of orders' translates a very particular understanding of DEA (services) as a mechanism that is essentially used to facilitate electronic trading—or, at least, orders that are transmitted electronically.

CDR 2017/565 further notes that a trader can only be said to be able to 'electronically transmit orders…directly' to a venue if they are able to 'exercise discretion regarding the exact fraction of a second of order entry and the lifetime of the order within that timeframe.'[1158] So, in addition to establishing an explicit link between DEA (services) and electronically-transmitted orders, the EU also

[1157] *See* MiFID II, article 4(1)(41). Importantly, this thesis has argued that DEA has a wider meaning and also encompasses direct access through venue membership (*see* chapter 3, in line with IOSCO: OICV-IOSCO, 'Policies on Direct Electronic Access - Consultation Report' (n 169)).

[1158] *See* CDR 2017/565, article 20. This means that a DEA service user who initiates an order that is then implemented through 'arrangements for optimisation of order execution processes' that are embedded into the systems of the DEA provider is not actually engaging in DEA. The exception is when an order takes place through 'arrangements for optimisation of order execution processes' that only determine 'the venue or venues where the order should be submitted'—or, in other words, through 'simple execution algorithms,' which are regretfully excluded from the EU algo-trading definition (*see* chapter 4).

establishes an explicit link between DEA (services) and disintermediation—which is (also) a necessary characteristic of algo-trading.

In other words, the EU falls just short of endorsing the idea that DEA services are always used to facilitate algo-trading[1159]—which seems right[1160]—but conveys the belief that they are essentially used as a channel for algo-trading, strengthening the notion that their regulation is a part of the EU algo-trading regime.[1161]

MiFID II also divides DEA services into the two sub-categories discussed earlier: simple DMA arrangements, whereby traders use the connecting systems of venue members to reach that venue; and SA arrangements, which do not require the use of such infrastructure[1162]—allowing non-members to use the member identification ('ID') of execution intermediaries without having to go through their infrastructure. As a result, SA is generally associated with higher speeds and greater disintermediation than DMA.[1163] And, for that reason, SA—if

[1159] *See* recital (14) of *See* CDR 2017/589, noting that the clients of DEA providers 'may use the DEA to engage in algorithmic trading'—which seemingly assumes that they may not.

[1160] *See* chapter 3.

[1161] Additionally, the requirements applicable to DEA service providers under the EU regime are all contained in either article 17 of MiFID II (named 'algorithmic trading') or in articles 19-23 of CDR 2017/589 (which specifies the 'organisational requirements of investment firms engaged in algorithmic trading)—indicating that the EU may stand by the notion that DEA is always used to facilitate algo-trading. The issue is more theoretical than practical as, for reasons discussed in chapter 4, most DEA users will indeed be algo-traders.

[1162] MiFID II, article 4(1)(41).

[1163] Gomber and others (n 174).

not the provision of SA services[1164]—is more harshly regulated by the EU than DMA,[1165] culminating in the prohibition of non-members using SA services 'without any prior control' by that intermediary ('naked SA').[1166]

8.2.1.2 The DEA service providers subject to the EU regime

One of the most noteworthy aspects of the rules in the EU regime that govern the activity of DEA service providers is that they only allow certain—professional—venue members to provide these services.

Indeed, MiFID II only allows two categories of venue members to facilitate DEA: MiFID firms; and credit institutions authorised under CRD IV.[1167]

From the moment that a venue member in one of these categories starts providing DEA services, it automatically becomes subject to the rules in the EU regime that govern the provision of those services—which make no differentiation between categories of DEA providers. Indeed, those rules are included in article 17(5) of MiFID II, which applies to MiFID firms because they are MiFID firms,

[1164] Importantly, MiFID II clarifies that DEA service providers should 'assess and review the suitability of clients using that service and ensure that risk controls are imposed on the use of the service and that those firms retain responsibility for trading submitted by their clients through the use of their systems or using their trading codes…irrespective of the form of the direct electronic access provided' (*see* MiFID II, recital (66)).

[1165] Namely, venues that allow SA are subject to harsher organisational and conduct requirements under article 22 of CDR 2017/584. For a discussion, *see* chapter 7.

[1166] CESR, 'Micro-Structural Issues of the European Equity Markets' (n 371). *See,* also, MiFID II, recital (66).

[1167] *See* MiFID II, article 48(7). Strangely, the category of 'credit institutions' is not recognised by ESMA in its Q&A document on market structure—which notes that 'EU firms without a MiFID II licence are not allowed to provide DEA to their clients' (*see* ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414)).

much in the same way that it applies to credit institutions under article 1(3)(a) of MiFID II (which extends the scope of article 17 of MiFID II to credit institutions).[1168]

Crucially, these rules include special reporting requirements (*8.2.3*) and organisational and conduct requirements (*8.2.4*), but not licensing requirements—which is not the same as saying that DEA service providers do not need to be authorised under wider EU law.

On the contrary: MiFID firms must register with the relevant MS authority under article 5 of MiFID II, and credit institutions must similarly obtain authorisation under article 8 of CRD IV. However, they do not need special authorisation before they can provide DEA services[1169]—even if no venue is forced to authorise DEA to their platforms,[1170] and even if those that do are entitled (and indeed required) to ensure that only members belonging to one of the categories described earlier provide these services to their clients.[1171]

8.2.2 Reporting requirements

The EU regime imposes two types of special reporting requirements on DEA providers: initial reporting requirements; and on-going reporting requirements.

[1168] *See* chapter 4.

[1169] By contrast, the use of DEA services can cause (proprietary) traders who used to be exempt from MiFID II to become MiFID investment firms (*see* MiFID II, recital (18) and article 2(1)(d)(ii); and chapter 4).

[1170] *See* article 48(7) of MiFID II, which refers to venues ‘permit[ting]’ DEA to their platforms.

[1171] MiFID II, article 48(7).

According to MiFID II, DEA service providers must notify that fact to both the MS authorities responsible for their supervision and the MS authorities responsible for the supervision of the venue to which access is being provided. Additionally, the MS authorities responsible for supervising the DEA service provider may ask for a 'description of the systems and controls' implemented under the rules in the EU regime that govern the provision of these services—either on a regular, or on an ad-hoc basis.[1172]

Finally, DEA service providers must keep records of this information—which must be sufficiently complete to enable monitoring of compliance with the rules in the EU regime that apply to these intermediaries.[1173]

Ultimately, it is worth noting that both the mandatory initial reporting requirement and the eventual on-going reporting requirement described in this section are owed to MS authorities—and not to the market more widely. This means that they are meant to facilitate the monitoring of the provision of DEA services, with a view to ensuring the integrity of EU markets—rather than to explicitly increase their informational efficiency.[1174]

Indeed, compliance with these requirements has the effect of alerting the relevant authorities—not only of the MS that hosts the DEA provider, but also of the MS that hosts the venue reached through DEA services—to the fact that this

[1172] MiFID II, article 17(5).

[1173] MiFID II, article 17(5).

[1174] For a discussion of the role played by reporting requirements, *see* chapter 5.

faster channel for algo-trading has been opened, which should help monitor it. And by allowing supervisors to ask for extra information from DEA service providers about the systems and controls that they employ, the EU regime gives them the opportunity to ensure that these intermediaries keep acting as gatekeepers under that regime.

Simultaneously, it is notable that these requirements are not overly burdensome: they apply exclusively to (licenced) professional firms;[1175] the initial reporting requirements only need to be fulfilled once—or, rather, every time a DEA channel is opened; and the ongoing reporting requirements only need to be fulfilled if and when required for monitoring purposes.

The record-keeping requirement applicable to DEA service providers is also well-balanced: the records maintained by DEA service providers need only be 'sufficient' to enable the relevant supervisory authorities to do their job—with no further details provided on how that 'sufficiency' is to be measured.

8.2.3 Organisational and conduct requirements

The EU regime also imposes a series of special organisational and conduct requirements on execution intermediaries providing DEA services to facilitate (in particular) algo-trading.[1176]

[1175] *See* the discussion about licensing requirements in section 5.2.

[1176] The organisational and conduct requirements applicable to DEA service providers are again discussed in tandem because the relevant organisational requirements impose mechanisms and arrangements that form the basis for holding these service providers to particular standards of conduct. In particular, the organisational requirements in article 17(5) should help DEA service

Broadly, the mere existence of these requirements (applicable to all forms of DEA services and DEA service providers) is equivalent to a 'ban' on 'the provision of direct electronic access…where such access is not subject to proper systems and controls'[1177]—or a ban on 'naked' SA. Indeed, article 17(5) of MiFID II explicitly notes that 'direct electronic access without [the controls in the EU algorithmic trading regime] is prohibited.'[1178]

Beyond this general prohibition of 'naked' SA, MiFID II contains two main types of requirements exclusively applicable to DEA providers: general organisational requirements, and a more specific requirement imposing responsibility for ensuring that DEA user activity complies with the requirements in MiFID II and with the rules of any relevant venues.[1179] Finally, DEA service providers are also subject to the organisational requirements applicable to algo-traders under the EU regime—which is meant to cover the possibility of DEA clients engaging in algo-trading (regardless of whether they do).[1180]

providers ensure that any DEA users comply with the appropriate rules—and assume responsibility for any instances of non-compliance.

[1177] MiFID II, recital (66).

[1178] MiFID II, article 17(5).

[1179] *See* MiFID II, article 17(5). As will be noted, this responsibility must be enshrined in a binding written agreement between DEA provider and DEA user (*see* MiFID II, article 17(5) and the discussion below).

[1180] *See* CDR 2017/589, recital (14); and chapter 5. These requirements are given more detail by CDR 2017/589—which allows the regime to be more easily amended when 'necessary to deal with further innovation and developments' in this area (*see* MiFID II, recital (66)).

8.2.3.1 General organisational requirements

The general organisational rules applicable to DEA service providers under the EU regime require them to implement enhanced controls and systems that pertain both to the activity of the users of their services—and, in particular, to the suitability of the latter for trading through DEA service channels.[1181]

These enhanced controls are detailed in article 20 of CDR 2017/589—and include many of the same types of controls discussed in regard to algo-traders.[1182] In particular, DEA service providers must apply automated surveillance systems to detect manipulation, pre-trade controls on order entry, post-trade controls, and real-time monitoring systems to the activity of each DEA client.[1183]

As a result, most[1184]—although not all[1185]—DEA service users become subject to two sets of controls: one that they need to implement under the rules in the EU regime that govern the activity of algo-traders, and another that is

[1181] MiFID II, article 17(5).

[1182] CDR 2017/589, article 20.

[1183] *See* CDR 2017/589, article 20(1), which specifically requires DEA service providers to 'apply the controls laid down in [a]articles 13,15 and 17 and the real-time monitoring laid down in [a]rticle 16' of CDR 2017/589 (which contains the 'organisational requirements applicable to investment firms engaged in algorithmic trading') to the order flow of their DEA clients.

[1184] *See* chapter 4.

[1185] Retail algo-traders are not subject to the requirements applicable to algo-traders under MiFID II. For that reason, the gatekeeping role played by DEA providers may be especially important in regard to these traders (*see* chapters 4-5).

implemented and imposed by their DEA providers.[1186] These DEA providers must then determine which additional controls are more appropriate for their clients[1187]—and they are responsible for their effectiveness.[1188]

In addition, DEA providers must implement a series of specific systems under the EU regime, including enhanced trading systems—capable, in particular, of monitoring, blocking and cancelling orders from DEA service users[1189]—systems for evaluating, managing and mitigating 'market disruption and firm-specific risk,'[1190] systems for identifying each DEA client (via unique identification codes),[1191] systems for isolating any order flow that might come from sub-delegation arrangements (made between DEA clients and their own

[1186] Accordingly, article 20(1) of CDR 2017/589 notes that the controls applicable by DEA providers to DEA users under the EU regime 'shall be separate and distinct from the controls and monitoring applied by DEA clients.'

[1187] To this end, DEA providers may use their 'own pre-trade and post-trade controls, controls provided by a third party or controls offered by the trading venue and real time monitoring' (*see* CDR 2017/589, article 20(2)). In particular, DEA providers should base any pre-trade controls on order submission on the credit and risk limits applicable to their DEA clients, in accordance with the initial due diligence and periodic review of DEA clients imposed by articles 22-23 of CDR 2017/589 (*see* CDR 2017/589, article 20(3)). Additionally, they must ensure that they are 'solely entitled' to change the parameters and limits of those controls (*see* CDR 2017/589, article 20(2)).

[1188] CDR 2017/589, article 20(2).

[1189] CDR 2017/589, article 21(1).

[1190] CDR 2017/589, article 21(2).

[1191] CDR 2017/589, article 21(3).

clients),[1192] and, finally, systems for recording data regarding the order flow produced by DEA clients.[1193]

8.2.3.2 Specific requirement to ensure DEA client compliance with the appropriate rules

Finally, article 17(5) of MiFID II imposes a particularly harsh requirement on DEA service providers: ensuring that the activity of their clients complies with both the directive and the rules of the venues accessed through DEA services.[1194]

To that end, DEA service providers are expected to monitor the transactions of their clients and to identify any rule breach, disorderly trading conditions, or conduct that might be deemed abusive under MAR. They are also expected to enter into a binding written agreement with their clients, where they should lay down their expectations of what rights and obligations should arise from the provision of the DEA service.[1195]

Ultimately, the reason why this is such a harsh requirement is that article 17(5) of MiFID II has been taken to mean that DEA providers 'retain responsibility' for all trading activity 'submitted by their clients through the use of their systems

[1192] ibid.

[1193] *See* CDR 2017/589, article 21(5). This data should include 'modifications and cancellations, the alerts generated by [their clients'] monitoring systems and the modifications made to [their] filtering process.'

[1194] MiFID II, article 17(5), and CDR 2017/589, article 19.

[1195] MiFID II, article 17(5).

or using their trading codes'[1196]—including clients that are not EU investment firms, or who are sub-delegated DEA clients.[1197]

Naturally, this responsibility should be facilitated by the various systems that DEA service providers must implement to control and monitor the activity of their clients. And there is no denying that making DEA providers accountable for the activity of their clients preserves their position as gatekeepers,[1198] strengthening this additional line of defence against threats to market integrity.

At the same time, the burden imposed on DEA service providers is 'a far-reaching responsibility'[1199]—which should contribute to increasing the costs of DEA services provision. To the extent that DEA services are valuable—giving traders more control over the trading process, increasing market transparency, and amplifying the benefits of algo-trading—unduly increasing the costs of providing such services is undesirable.

8.3 New rules for the regulation of other intermediaries

In addition to the rules that apply to execution intermediaries offering DEA services, the EU algo-trading regime can also be said to include a set of rules

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[1196] *See* MiFID II, recital (66). Indeed, the binding agreement that DEA providers must enter into with each of their DEA clients should make it clear that the DEA provider retains all responsibility under MIFID II (*see* MiFID II, article 17(5)).

[1197] *See* answer 22 (topic 3) *in* ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414).

[1198] The notion that DEA service providers can be seen as gatekeepers can be found, *i.a., in* Čuk and Waeyenberge (n 15).

[1199] Busch (n 31).

that govern the activity of post-trade intermediaries.[1200] This section briefly examines the motivation for these rules (*8.3.1*), as well as their content (*8.3.2*).

8.3.1 The motivation for article 17(6) of MiFID II

The reason why the EU regime can be said to include rules applicable to post-trade intermediaries is that article 17 of MiFID II, named 'algorithmic trading,' contains a paragraph that imposes a series of organisational requirements on general clearing members. This paragraph is then complemented by articles 24-27 of CDR 2017/589—the CDR that contains the 'organisational requirements' applicable to 'investment firms engaged in algorithmic trading.'

At the same time, ESMA has recently clarified that 'the title of [a]rticle 17 and [CDR 2017/589] should not be interpreted as narrowing the scope of the provisions in question'—and that those provisions do not apply exclusively to clearing members that have 'algorithmic traders as clients.' As such—and also according to ESMA—'[a]rticle 17(6) should be interpreted as applying to all firms acting as general clearing members, regardless of the nature of their clients.'[1201]

The reason given for the association between the requirements included in article 17(6) of MiFID II and algo-trading is that the issues that they address

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[1200] *See*, i.a., the analysis of the EU regime made by *in* Conac (n 31), which includes a paragraph on the rules applicable to investment firms acting as general clearing members, as part of a sub-chapter on 'Direct Electronic Access and General Clearing Members.'

[1201] ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414).

might be 'more prominent with respect to algorithmic trading'[1202]—but it is not evident why. In truth, there can be no question that the influence of technology on EU markets has been so widespread that it has reached every category of market participant—including that of post-trade intermediaries.[1203] Still, it is not clear whether or how automated-trading technology—specifically—has changed the clearing services, or created risks specifically pertaining to such services.

As such, it is argued that the rules applicable to post-trade intermediaries under the EU regime should not be seen as addressing new strategies developed by those intermediaries in response to algo-trading, nor as a response to risks arising from the post-trade clearing of algo-trading transactions. Rather, these rules should be seen as simply reinforcing the role played by post-trade intermediaries in mitigating counter-party risk—which may indeed have become more important in view of the cyber risks associated with algo-trading[1204]—and it is as such that they are (briefly) discussed in this section.

[1202] ibid.

[1203] *See* chapter 3. In the particular case of post-trade intermediaries, there is a growing body of literature that analyses the potential of distributed ledger technology for transforming the activities of clearing and settlement (*see,* i.a., Joanna Diane Caytas, 'Developing Blockchain Real-Time Clearing and Settlement in the EU, U.S., and Globally' (2016) Preliminary Reference Columbia Journal of European Law).

[1204] *See* chapter 3.

8.3.2 The special requirements applicable to general clearing members under article 17(6) of MIFID II

Article 17(6) of MiFID II contains a series of requirements applicable to undertakings acting as general clearing members for other persons.

The discussion of these requirements starts with an analysis of their scope. In this regard, it is worth noting that article 17(6) purports to apply only to investment firms acting as general clearing members. As a result, even though (general) clearing members are defined by EMIR[1205] as any undertaking participating in a central counterparty and responsible for discharging the financial obligations that arise from that participation[1206]—which can include non-financial counterparties, and even individuals[1207]—article 17 does not apply to all these agents, but only to MiFID firms and to non-MiFID undertakings that are nevertheless subject to article 17.[1208]

It is also worth recalling that—despite its inclusion under the title of 'algorithmic trading'—article 17(6) of MiFID II applies regardless of the nature of the clients of the general clearing members. Therefore, even general clearing

[1205] European Market Infrastructure Regulation ('EMIR').

[1206] EMIR, article 2 (14).

[1207] *See*, in particular, the discussion about the risks of individuals and non-financial counterparties as clearing members *in* ESMA, 'Final Report - CCPs' Membership Criteria and Due Diligence' (2020) ESMA70-151–2869.

[1208] *See* MiFID II, article 1(3)(a) and (5); and chapters 4-5.

members that do not have algo-traders as their clients are subject to specific requirements under the EU regime.[1209]

In terms of content, article 17(6) of MiFID II sets out a general organisational requirement to implement the systems and controls necessary to ensure that clearing services are only offered to suitable persons (who meet pre-determined criteria).[1210] For this purpose, general clearing members are expected to make an initial due diligence assessment of any prospective clearing clients, as well as engage in a yearly review of their on-going performance against the criteria used to determine their initial suitability.[1211]

Second, general clearing members must ensure that appropriate requirements are imposed on their clients to 'reduce risks to [themselves][1212] and to the market.'[1213] Namely, clearing firms should establish 'appropriate trading and position limits' and monitor their clients' positions against those limits, in real-time. The risk of breaches should then be managed through the implementation of pre-trade and post-trade procedures and, in particular, 'by way of appropriate margining practice.'[1214]

[1209] ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414).

[1210] MiFID II, article 17(6), and, also, CDR 2017/589, article 24.

[1211] CDR 2017/589, article 25.

[1212] In particular, counterparty, liquidity and operational risks (*see* CDR 2017/589, article 26(1)).

[1213] MiFID II, article 17(6).

[1214] CDR 2017/589, article 26.

Finally, article 17(6) of MiFID II requires general clearing members to enter into a binding written agreement with each of their clients outlining the 'essential rights and obligations arising from the provision of that service.'[1215]

8.4 Conclusion

One of the most notable aspects of the EU algo-trading regime is that it does not just regulate the impact of automated-trading technology on the mechanisms and strategies employed by traders in EU markets—but also the wider impact of this technology on the behaviour of venues and other market intermediaries.[1216]

Importantly, the EU regime also addresses the threats (indirectly) created by automated-trading technology to the role played by market intermediaries in furthering the goals of financial regulation. The result is a set of rules that strengthens the ability of post-trading intermediaries to mitigate counter-party risk—and a second set of rules that enlists DEA service providers as an effective additional line of defence against the threats to market efficiency and fairness inherent in algo-trading.

The latter set of rules, in particular, reveals an accurate understanding of the extent to which EU markets have been changed by automated-trading

[1215] *See* MiFID II, article 17(6). Additionally, investment firms acting as general clearing members must offer their services 'on reasonable commercial terms'—which must then be published (*see* CDR 2017/589, article 27(1)). Also, such firms are required to 'inform its prospective and existing clearing clients of the levels of protection and of the costs associated with the different levels of segregation [they provide]' (*see* CDR 2017/589, article 27(2)).

[1216] *See* chapter 4.

technology and is a welcome addition to the EU regime: DEA arrangements have been found to weaken the position of execution intermediaries as gatekeepers of market integrity[1217]—and these rules help preserve that position. Consequently, they also mitigate the risks inherent in algo-trading and amplified by the existence of DEA service channels, particularly when that algo-trading originates in retail traders, who are generally exempt from MiFID II.[1218]

Specifically, it is commendable that these rules ban 'naked' SA,[1219] in line with other jurisdictions.[1220] And it is notable that they allow only (professional) investment firms and credit institutions to provide DEA services[1221]—as these firms should be better equipped to deal with the demands of the EU regime and act as effective gatekeepers. At the same time, the EU regime nevertheless allows DEA service providers some freedom to determine how to comply with certain provisions—showing appropriate regard for proportionality.[1222]

These rules are not, however, exempt from criticism. First, concerns can be raised as to how the 'far-reaching'[1223] responsibility imposed on DEA service

[1217] OICV-IOSCO, 'Principles for Direct Electronic Access to Markets - Final Report' (n 172).

[1218] *See* chapters 4-5.

[1219] MiFID II, article 17(5).

[1220] *See*, i.a., 17 CFR § 240.15c3-5 ('SEC Rule 15c3-5'), which prevents unfiltered market access.

[1221] MiFID II, article 48(7).

[1222] *See*, for example, article 17(5) of MiFID II, which contains an on-going reporting requirement with which DEA providers only need to comply upon request; and article 20 of CDR 2017/589, which awards DEA providers freedom to determine the content of the controls applicable to the order flow of their DEA clients.

[1223] Busch (n 31).

providers may impact the costs of providing such services—particularly to the extent that they play a useful role in giving traders control over their trades, increasing market transparency and amplifying the benefits of algo-trading.[1224]

Second, it is not clear why the EU imposes the same organisational requirements on all DEA service providers—regardless of whether they provide DMA, SA, or both. If it is true that certain risks can arise regardless of 'whether [a] trader has direct access to the market or uses the facilities of another firm to access the market,'[1225] SA creates more risk than DMA. And this added risk comes not only from 'the market side,' in the sense that SA increases the likelihood of trading errors—amplifying the risks inherent in algo-trading—but also from the 'intermediaries side,' in the sense that SA increases the difficulty of monitoring DEA clients—making it harder for intermediaries to act as effective gatekeepers.[1226]

As such, while it is commendable that the EU regime contains certain rules that treat SA more harshly—in particular by imposing additional requirements on venues that allow SA (which should address the increased risk of trading errors)[1227]—it should also have addressed the risks inherent in the increased

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[1224] *See,* i.a., ESMA, 'Consultation Paper: Guidelines on Systems and Controls in a Highly Automated Trading Environment for Trading Platforms, Investment Firms and Competent Authorities' (n 171).

[1225] EC, 'Public Consultation - Review of the Markets in Financial Instruments Directive (MiFID)' (n 601).

[1226] CESR, 'Micro-Structural Issues of the European Equity Markets' (n 371), 3-4.

[1227] *See* CDR 2017/584, article 22. For a discussion, *see* chapter 7.

difficulty of monitoring these arrangements in particular by strengthening the organisational requirements applicable to SA providers. Finally, it is noteworthy that the EU regime left the risk that DEA services may make markets less fair[1228] entirely unaddressed. In this regard, it would have been appropriate for the EU regime to require DEA services to be offered on a non-discriminatory and transparent basis—much as it already does, in particular, for co-location services and fee arrangements offered by trading venues.[1229]

[1228] For a discussion of this risk, *see* OICV-IOSCO, 'Principles for Direct Electronic Access to Markets - Final Report' (n 172).

[1229] *See,* i.a., article 48(8)-(9) of MiFID II; and chapter 7.

9. NEW RULES FOR NEW STRATEGIES: HFT REGULATION UNDER THE EU ALGO-TRADING REGIME

9.1 Introduction

The analysis of the EU regime concludes with a discussion of the rules that govern the algo-trading strategies often grouped together as 'HFT.' Indeed, it is worth recalling that the EU regime does not just regulate the use of algo-trading mechanisms, but also the strategies developed in response to the widespread availability of automated-trading technology across the markets—including those developed by traders themselves and, namely, by HFTraders.

The EU regime contains two sets of rules relevant for HFTraders: one applicable to all HFT—regardless of the specific strategies pursued by HFTraders—and another that applies to one HFT strategy in particular: algorithmic market-making. This means that a trader engaging in HFT (as defined by the EU) will always be subject to the former set of rules, and may, in addition—if engaging in algorithmic market-making—also be subject to the latter.[1230]

[1230] Crucially, the rules in the EU regime that regulate algorithmic market-making are not restricted to traders engaging in HFT (as the EU defines it). As such, even though the EU recognises that market-making is eminently an HFT strategy—with earlier drafts of MiFID II restricting the application of these rules to HFTraders (*see* Dave Cliff, 'Market-Making Obligations and Algorithmic Trading Systems: A Feasibility Assessment of the March 2012 Draft of MiFID2 Article 17(3)' (Foresight, Government Office for Science 2011))—it would appear that even strategies that do not fall under the EU HFT definition may be classified as algorithmic market-making and become subject to the rules that regulate it. This issue is explored further in section 9.3.

This chapter starts by examining the rules that apply to all traders engaging in HFT, as defined by the EU (*9.2*). This is then followed by an analysis of the rules that apply specifically to algorithmic market-making (*9.3*).

Ultimately (*9.4*), it is argued that both sets of rules are riddled with problems. The first set of rules, comprised by requirements that apply to all HFT, is subject to three criticisms: first, it relies on a problematic regulatory definition of HFT; second, it is based on the misconception that HFT can be understood and regulated as a monolithic whole; and, third, it is unduly harsh, which—combined with the fact that it treats all HFT strategies equally—may cause beneficial HFT to leave the markets. And this is all the more concerning when it does not look like the worst HFT strategies are especially popular in EU markets.

The second set of rules, comprised by the requirements that apply to algorithmic market-making, is a step in the right direction, showing that the EU also understands the importance of applying specific requirements to individual HFT strategies, taking into account their specificities. Still, the continuous market-making requirements applicable to algorithmic market-makers under the EU regime are not particularly useful, as they allow them to leave the markets during the high volatility episodes associated with fleeting liquidity.

In the end, the best thing about the rules in the EU regime that apply to algorithmic market-makers might be the reporting requirements. Such requirements may indeed play a useful role in helping MS authorities distinguish legitimate market-making strategies from market manipulation, mitigating the potentially negative impact of the changes introduced by the EU regime to its definition of market manipulation—and which have been motivated by the misconception that algo-trading makes a material contribution to the risk of market manipulation.[1231]

9.2 New rules for the regulation of HFT in general

The concern of the EU with HFT dates back at least a decade. Already in 2009, CESR had named algo-trading as one of the most significant emerging trends since the first version of MiFID came into force[1232]—and, in 2010, HFT was first identified as a particular 'form of automated trading.' [1233]

At the time, the EU noted that HFTraders 'follow[ed] different strategies'[1234]—and, indeed, that HFT was 'not a strategy in itself but the use of very sophisticated technology to implement traditional trading strategies.'[1235] At the same time, it also insisted in treating HFT as a separate 'issue' that was 'different from what [was] generally referred to as algorithmic trading.'[1236] Accordingly, one of the first calls for evidence issued in advance of MiFID II asked

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[1231] *See* chapter 6.

[1232] CESR, 'Impact of MiFID on Equity Secondary Markets Functioning' (n 256).

[1233] CESR, 'Micro-Structural Issues of the European Equity Markets' (n 371), 2.

[1234] ibid, 2.

[1235] EC, 'Public Consultation - Review of the Markets in Financial Instruments Directive (MiFID)' (n 601), 14.

[1236] CESR, 'Micro-Structural Issues of the European Equity Markets' (n 371), 2.

respondents to consider whether 'overall…[they considered] HFT to be beneficial or detrimental do the markets.'[1237]

As the process of reviewing MiFID continued, the EU continued to treat HFT as a monolithic category—identifying three main concerns with HFT: a scope concern that 'not all high-frequency traders [were then] required to be authorised under MiFID' (as they could take advantage of the exemption applicable to proprietary traders); an efficiency concern with the (potentially negative) 'impact of HFT on market efficiency;' and a fairness concern that non-HFTraders were 'at a disadvantage to HFT.'[1238]

Some of these concerns were then addressed through rules that apply to all use of algo-trading mechanisms (and which 'apply equally to the use of algorithmic trading in the context of high-frequency trading').[1239] Others, however, were addressed by specific rules that apply only to algo-traders engaged in HFT—but which apply to all HFTraders in the same way, regardless of strategy. And others, still, were addressed by rules that—despite not regulating HFT directly—act as *de facto* constraints on HFT.[1240]

This configuration of rules—as it is found in the EU regime—is a clear reflection of the way the EU sees HFT. By subjecting HFT to all the same rules

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[1237] ibid, 3.

[1238] EC, 'Public Consultation - Review of the Markets in Financial Instruments Directive (MiFID)' (n 601), 15.

[1239] Authority of the House of Lords (n 222), 10.

[1240] *See,* also, the rules specifically applicable to algorithmic market-making (*in* section 9.3).

that apply to algo-trading, the EU acknowledges that HFT is a sub-type of algo-trading. By subjecting HFT to additional (*de jure* and *de facto*) constraints, the EU advocates that—despite being a sub-set of algo-trading—HFT is sufficiently different from non-HFT algo-trading and raises sufficient additional risks to require specific (harsher) rules. And, by essentially subjecting all HFT to the same rules, the EU suggests that—despite HFT being comprised of different strategies—these strategies have enough in common to be jointly regulated as a monolithic whole.[1241]

The rules in the EU regime that apply to all uses of algo-trading mechanisms have already been analysed in previous chapters.[1242] This section analyses only the rules that specifically regulate HFT—examining both those that impose *de jure* constraints on HFT (*9.2.1*) and those that impose *de facto* constraints (*9.2.2*)—and determining the extent to which the misconception that HFT can be addressed and regulated as monolithic category of trading has negatively impacted the EU algo-trading regime (*9.2.3*).

[1241] The 'monolith' of HFT is only disaggregated to allow for the separate regulation of algorithmic market-making—although even then the EU avoids classifying this strategy as an HFT strategy. For a discussion, *see* section 9.3.

[1242] *See* chapters 5-6.

9.2.1 *De jure* constraints

The *de jure* constraints that apply specifically to HFT strategies are essentially included in MiFID II—which defines their scope of application by reference to a regulatory definition of HFT that is also found in the directive.

The inclusion of this regulatory definition in MiFID II is perhaps the most unfortunate consequence of the EU looking at HFT as something 'different from what is generally referred to as algorithmic trading.'[1243]

Indeed, earlier in this thesis, it was noted that HFT is a misnomer that encompasses a variety of trading strategies, with very different impact on market quality.[1244] For instance, algorithmic market-making is generally thought to make a positive contribution to ongoing levels of liquidity—even if that liquidity might evaporate in periods of extreme volatility.[1245] The impact of electronic front-running on market quality is more ambiguous, as it depends on which categories of traders are more vulnerable to this strategy. Finally, low-latency HFT strategies—in particular low-latency arbitrage—are unambiguously bad for the market, but they do not appear to be especially popular in EU markets.[1246]

[1243] CESR, 'Micro-Structural Issues of the European Equity Markets' (n 371).

[1244] *See* chapter 3.

[1245] The impact of algorithmic market-making on market quality is discussed again in section 9.3 (together with an analysis of the rules in the EU regime that regulate this HFT strategy).

[1246] *See* chapter 3.

As such, it was also argued that HFT should not serve as a regulatory category: and not only because HFT encompasses a wide variety of strategies with different impact on market quality, but also because it can be difficult to precisely distinguish HFT from algo-trading that is not HFT[1247]—particularly in a rapidly-changing world where most trading is technology-driven and very fast.[1248]

This latter difficulty is particularly apparent when examining the definition of HFT found in MiFID II.

By way of excursus, it is worth noting that MiFID II uses a mixed approach to defining HFT, which looks both at the mechanisms and infrastructure used by traders, as well as at the strategies that they employ.[1249] HFT is then characterised by the use of automated mechanisms[1250] and (certain) 'infrastructures intended to minimise network and other types of latencies'—and by the adoption of strategies that involve high message intraday rates.[1251]

The first element of this definition—automation—is inherent in all algo-trading, thus failing to help in distinguishing HFT from vanilla algo-trading. The

1247 *See* chapter 4.

1248 *See* a 2013 report on the Australian equity markets noting that 'many [non-HFTraders] are… engaged in very fast trading, sometimes at average speeds higher than the high-frequency traders' (ASIC (n 85), 90).

1249 *See* ESMA, 'Economic Report: High-Frequency Trading Activity in EU Equity Markets' (n 284). For a discussion, *see* chapter 3.

1250 The expression used by the EU is 'system-determination of order initiation, generation, routing or execution without human intervention for individual trades or orders' (*see* MiFID II, article 4(1)(40)(b)).

1251 MiFID II, article 4(1)(40).

second and third elements are more helpful for making this distinction—but they create the risk that the EU HFT definition will eventually become obsolete.

For instance, in regard to the second element of the definition—'infrastructure intended to minimise network and other types of latencies'—it is regrettable that the EU goes on to specify that only the use of co-location, proximity hosting, or DEA services can lead to an algo-trading strategy being classified as HFT. Indeed, co-location—or proximity hosting,[1252] which is often seen as a synonym,[1253] or variant of co-location[1254]—is not a pre-requisite to engage in HFT.[1255] And neither are DEA services,[1256] as most HFTraders are venue members.[1257] Additionally, the EU definition leaves out a series of low-latency infrastructure that are regularly used to support HFT—including fiber-optic networks and microwave transmission towers.[1258]

1252 MiFID II itself is unsuccessful at distinguishing between these two concepts, as it defines co-location (*see* MiFID II, recital (66)), but fails to define 'proximity hosting' or, indeed, to refer to it outside the definition of HFT.

1253 Cumming, Zhan and Aitken (n 220).

1254 Securities and Exchange Board of India, 'Discussion Paper on Co-Location / Proximity Hosting Facility Offered by the Stock Exchanges'.

1255 *See*, Aitken *et al*, reporting that 'HFT pre-dates colocation by at least a year on most exchanges' and has 'strong predictive power in explaining the introduction of colocation services' (*see* Michael J Aitken, Douglas Cumming and Feng Zhan, 'Trade Size, High Frequency Trading and Co-Location Around the World' (2017) 23 European Journal of Finance, 799).

1256 Although note the EU definition of DEA in article 4(1)(41) of MiFID II.

1257 *See,* i.a., Simmy Grewal, 'Changes in the Regulatory and Trading Environments for European Stock Markets' (October 2012) <https://www.gmac.jp/fix2012/agenda/pdf/eng/1510_Simmy_Grewal_E.pdf> accessed 31 July 2020.

1258 While there are reasons to regulating the provision of co-location and DEA services—which might not apply to the investment in fiber-optic networks, or microwave transmission towers—that does not mean that a definition of HFT should ignore their existence.

The third element of the EU definition—'high message intraday rates'—is vulnerable to similar criticism. Here, the EU defines a high message intraday rate as that which results from the submission, on average, of either: a minimum of 2 messages/second (in regard to any single financial instrument traded on a venue); or a minimum of 4 messages/second (in regard to all financial instruments traded on a venue).[1259] However, as technology evolves, it is likely that the message intraday rates currently seen by MiFID II as 'high' may not always help distinguish vanilla algo-trading from HFT.

These shortcomings make the EU definition of HFT particularly undesirable:[1260] not just because all regulatory definitions of HFT as a monolithic whole are unworkable, but also because this definition in particular is too rigid to capture a phenomenon that is likely to continue to evolve.

As argued previously, when discussing the subjective scope of the EU algo-trading regime, the two main functions of placing a definition of HFT at the centre of the EU regime—bringing proprietary-HFT under the scope of MiFID II and curbing the negative impact of HFT on market quality—would have been better served by other regulatory techniques.[1261]

[1259] *See* CDR 2017/565, article 19(1). The details of which messages should be included in this calculation are described in paragraphs (2)-(4) of article 19. Notably, the calculation of the high message intraday rate of DEA providers does not include the messages submitted by their DEA clients.

[1260] Concerns with the HFT definition in MiFID II were also expressed by MS (or former MS) during the process that led to its approval: *see*, i.a., the UK Government, noting that their concern 'about attempts to define high-frequency trading' (Authority of the House of Lords (n 222), 13).

[1261] *See* chapter 4.

The purpose of bringing proprietary-HFT under the scope of MiFID II would have been entirely fulfilled by including all proprietary traders with disintermediated access to EU markets under the directive (which its article 2(1)(d)(ii) already does)—although extending individual MiFID II provisions (related to algo-trading) to such traders would have been preferable to turning them into MiFID investment firms, with all the inherent consequences.

The purpose of curbing the negative impact of HFT on market quality would have been better served by individually regulating particular HFT strategies—or particular aspects of HFT strategies—that create increased risk. Indeed, this is exactly what the EU did when it regulated algorithmic market-making (without resorting to any definition of HFT).[1262]

The next sections explore the *de jure* consequences from engaging in HFT—as defined by the EU—examining both licensing requirements and reporting requirements.

9.2.1.1 Licensing requirements

Earlier chapters noted that most algorithmic trading-related activities—including the use of algo-trading mechanisms by traders, and the hosting or facilitation of algo-trading by venues and intermediaries—are not subject to special licensing requirements under the EU regime. This does not mean that these agents are not subject to any licensing requirements under wider EU law—most of them

[1262] For a discussion, *see* section 9.3.

are—, it simply means that they do not need a special authorisation just because they engage in or respond to algo-trading.

However, a special licensing requirement that can be said to form a part of the EU regime is that which applies to proprietary investment firms looking to implement HFT strategies,[1263] as—unlike the agents discussed in the previous paragraph—proprietary traders will have to ask for permission before they can engage in HFT, and precisely because they wish to engage in HFT.[1264]

This licensing requirement is found in article 2(1)(d)(iii) of MiFID II—which states that investment firms engaged in proprietary trading (who are otherwise exempt from the directive)[1265] are actually subject to MiFID II if they 'apply a high-frequency algorithmic trading technique'[1266]—and in article 5 of MiFID II—which states that the performance of investment activities on a professional basis is subject to prior authorisation.[1267]

[1263] *See* Conac, arguing that 'the provisions of MiFID II include requirements on licensing of HFT traders' (Conac (n 31), 17.20) and Čuk, noting that 'before accessing markets, all HFT firms must be authorized by the regulators' (Čuk and Waeyenberge (n 15), 4).

[1264] *See* MiFID II, articles 2(1)(d)(iii) and 5(1). HFT has long been associated with proprietary trading, even if the EU definition of HFT does not contain an express reference to proprietary trading.

[1265] In the road to MiFID II, the EU noted 'concerns that not all high frequency traders [were] currently required to be authorised under MiFID as the exemption in Article 2.1(d) of the framework directive for persons who are only dealing on own account [could] be used by such traders' (*see* EC, 'Public Consultation - Review of the Markets in Financial Instruments Directive (MiFID)' (n 601)).

[1266] MiFID II, articles 2(1)(d)(iii).

[1267] MiFID II, article 5(1).

This has significant consequences for (professional) HFTraders—which have already been discussed in this thesis.[1268] Indeed, it is worth recalling that licences are typically conditional upon continued compliance with additional requirements[1269]—and a (professional) proprietary trader engaging in HFT becomes subject to a myriad of requirements under the MiFID II framework, including strict capital market requirements.[1270]

As noted earlier, these requirements are especially tough on HFTraders, whose strategies often involve avoiding intraday and overnight inventories.[1271] Particularly when it comes to algorithmic market-making, it is worth recalling that inventory costs are one of the main components of the bid-ask spread,[1272] and some commentators have aired concerns over the impact that imposing capital requirements on HFTraders will have on the liquidity of EU markets[1273]—which actually appear to have some empirical support.[1274]

[1268] *See* chapter 4.

[1269] Armour and others (n 4).

[1270] *See* articles 92 and 96 of CRD IV, soon to be amended by Directive (EU) 2019/2034. *See,* also, recital (7) and articles 5(1) and 9(1) of Directive (EU) 2019/2034. For a discussion, *see* chapter 4.

[1271] *See* chapter 3.

[1272] *See* chapter 2.

[1273] *See*, i.a. Stafford noting, in particular, that HFT are not banks and that 'they risk their own capital, and positions are either hedged or not kept open overnight' (Stafford, 'Tighter HFT Capital Rules Will Only Harm Eurozone Market Trading' (n 17); and Philip Stafford, 'EU Must Find Its Own Post-Brexit Path, Shorn of British Expertise' (19 November 2018) <https://www.ft.com/content/f876bfa0-ebff-11e8-8180-9cf212677a57> accessed 31 July 2020).

[1274] Following the approval of the German HFT Act—which applied 'significant minimum capital requirements' to HFTraders—German equity markets witnessed 'increased bid-ask spreads' (*see* Martin Haferkorn and Kai Zimmermann, 'The German High-Frequency Trading Act: Implications

Others, however, have noted that 'capital buffers would reduce the likelihood that HFT firms would be destabilised by liquidity shocks and would in turn destabilise their counterparties.'[1275] Indeed, such requirements could help ensure the effectiveness of the continuous market-making requirements that can apply to HFTraders (as discussed later in this chapter)[1276]—but their negative impact on market liquidity should not be underestimated, and it is argued that bluntly applying the capital requirements inherent in 'MiFID investment firm status' to all HFTraders may not take that impact duly into account.[1277]

9.2.1.2 Reporting and record-keeping requirements

MiFID II imposes an additional double obligation on HFTraders: a record-keeping requirement and an on-going reporting requirement—both building on the requirements applicable to algo-traders under article 17(2) of MiFID II.[1278]

Therefore, while most algo-traders must keep 'sufficient' records to enable appropriate supervision, those who are also HFTraders must further ensure that

for Market Quality' (2014) <https://papers.ssrn.com/abstract=2514334> accessed 31 July 2020, 1).

[1275] *See*, i.a., Biais and Foucault (n 464).

[1276] *See* section 9.3.

[1277] This state of things may improve with the entry into force of the new capital requirements framework for investment firms (comprised of Directive 2019/2034 and Regulation 2019/2033).

[1278] MiFID II, article 17(2).

their records are stored 'in an approved form' and contain 'accurate and time sequenced records of all its placed orders.'[1279]

The content and format of the 'approved form' in which HFT records must be stored, as well as the length of time for which those records should be kept[1280] are laid down in CDR 2017/589[1281]—which includes two tables[1282] that HFTraders must fill in with the details of each submitted order 'immediately after order submission' and any time that information needs updating. These records must then be kept for five years from the date of order submission, and should be made available upon request to the relevant MS authority.[1283]

Finally, it is worth noting that compliance with the reporting requirements applicable to HFTraders also requires them to synchronise their business clocks. This is again a requirement that applies more generally to all traders—including, in particular, those engaging in algo-trading.[1284] However, if those traders also engage in HFT, the extent to which their business clocks can diverge from the 'common reference time' set by the EU (UTC) is much smaller: 100

[1279] ibid.

[1280] In order to ensure consistency, the record-keeping period applicable to HFTraders is aligned with the record-keeping period generally applicable to all traders under article 25(1) of MiFIR (*see* CDR 2017/589, recital (17)).

[1281] CDR 2017/589, recital (16).

[1282] *See* tables 2 and 3 of Annex II of CDR 2017/589.

[1283] *See* CDR 2017/589, article 28—and particularly article 28(3), which is aligned with the record-keeping requirement described in article 25(1) of MiFIR.

[1284] *See* chapter 5.

microseconds, rather than 1 millisecond, with timestamps of 1 microsecond or better, rather than1 millisecond or better.[1285]

In the end, it would appear then that HFTraders are subject to much the same type of requirements that apply to algo-traders that do not engage in HFT under the EU regime, with two crucial differences: HFTraders need to keep much more detailed information about their activity—which must be recorded and transmitted with a much higher level of accuracy.

The importance of accurate clock-sync and timestamping was discussed earlier[1286]—but it is important to note that this double requirement places a particularly high burden on HFTraders when compared to other algo-traders.

First, the requirement to store 'accurate and time sequenced records of all…placed orders' forces HFTraders to collect and maintain 'an unimaginable quantity of data.'[1287] As for their clock-sync and timestamping requirements, they are not just harsh when compared to those that apply to non-HFTraders—but also to those that apply to HFTraders in other jurisdictions.

In the US, for instance, Section 6.8 of the recently approved Consolidated Audit Trail ('CAT') National Market System ('NMS') Plan[1288] and Financial

[1285] CDR 2017/574, table 2 of its Annex.

[1286] *See*, in particular, section 7.3.4.

[1287] Busch (n 31).

[1288] The CAT NMS Plan was created in 2016, pursuant to SEC Rule 613 (which was adopted in 2012); *see* 17 CFR § 242.613.

Industry Regulatory Authority ('FINRA') Rule 6820[1289] set the synchronisation tolerance for computer clocks used by industry members/ broker-dealers at a maximum of 50 milliseconds, using timestamps in increments more granular than milliseconds. This means—looking only at clock-sync—that US HFTraders enjoy 500 times more tolerance than EU HFTraders.[1290]

Naturally, technology evolves and industry practices change[1291]—and clock-sync standards that appear harsh today may become more manageable. For now, however, industry research suggests that ideal clock-sync solutions are 'still uncertain,' with different technical solutions each having their 'own issues.'[1292]

9.2.2 *De facto* constraints

Beyond the licensing and reporting requirements that explicitly constraint all activity defined by the EU as HFT, the EU regime also contains provisions which—despite not applying directly to HFTraders, and often not even mentioning HFT—nevertheless have the effect of discouraging HFT as a whole.

[1289] *See* Securities Exchange Act Release No. 77565 (April 8, 2016), 81 FR 22136 (April 14, 2016) (Order Approving SR-FINRA-2016-005). Notably, this FINRA rule was approved after the conduction of a survey where respondents noted that a 1 millisecond standard 'would cost over '$1.1 million to implement and more than $530,000 to annually maintain' (*see* SEC, 'Release No. 34-77196; File No. SR-FINRA-2016-005').

[1290] MiFID II, article 50 and CDR 2017/574, Table 2.

[1291] FINRA, 'Standards for Self-Reporting Deviations of Clock Synchronization Standards to FINRA CAT' (2020) CAT Alert-2020-02.

[1292] Summerville (n 942).

These rules have already been discussed in this thesis—where reference was also made to their impact on HFT—and include[1293] the new EU prohibition on market manipulation,[1294] the pre-trade controls applicable to algo-traders,[1295] the requirement for venues to establish maximum OTRs,[1296] the permission for venues to adjust their fees to reflect the additional burden inherent in intense algo-trading activity,[1297] and the requirement to establish minimum tick sizes.[1298] And already when these rules were analysed, they were criticised for their bluntness: for punishing equally all HFT strategies, regardless of their different impact on market quality.

Namely, many of these rules allow—and indeed encourage—venues to penalise HFTraders. And while it is not clear that venues will always cooperate—as venue strategies are more often geared towards attracting HFT than repelling it—it is worth noting that these rules take such a biased stance against a multi-faceted phenomenon that still generates discussions as to whether it has overall changed the markets for the better or for the worse.[1299]

1293 The EU also considered implementing other rules of this nature: in particular, the EU considered—and abandoned—the idea of introducing minimum order resting periods (*see* EC, 'Executive Summary of the Impact Assessment Accompanying the Document Proposal for a [MiFID Recast] and the Proposal for a [MiFIR]' (n 379)).

1294 *See* chapter 6.

1295 MiFID II, article 17(1), and CDR 2017/589, article 15.

1296 MiFID II, article 48(4).

1297 MiFID II, article 48(9).

1298 MiFID II, article 49.

1299 *See* chapter 3.

Still, these rules do have some advantages when compared to the *de jure* constraints on HFT. First, they do not typically rely on the rigid EU definition of HFT—and may, as such, be more successful at capturing present and future HFT. And, second, most are also more flexible, often allowing venues to decide, within certain limits, how much they want to populate their platforms with HFTraders[1300]—often taking liquidity concerns into account.[1301]

9.2.3 Evaluating the new rules

There can be little debate that concern over HFT was one of the main drivers behind the approval of the EU algo-trading regime.[1302] All algo-trading is automated, disintermediated and fast and, as such, vulnerable to operational and inherent risk—with potentially systemic consequences. And HFT is no exception; indeed, the elements typically associated with algo-trading—in particular speed—are often (if not necessarily)[1303] heightened in HFT strategies.

As such, it is commendable that the EU regime looks at HFT strategies as algo-trading strategies—subject to the same rules that govern this type of trading—and it is understandable that such regime includes rules that respond to

[1300] *See,* i.a., the fee structures in MiFID II, article 48(9).

[1301] *See,* i.a., the tick size regime in MiFID II, article 49.

[1302] *See* chapter 4.

[1303] Easley, Lopez de Prado and O'Hara (n 282).

the heightened risk inherent in certain HFT strategies. There are, however, three problems with the response given by the EU regime to HFT.

First, this response is partially anchored on a regulatory definition of HFT that does not allow for a rigorous (or future-proof) means of distinguishing between vanilla algo-trading and HFT. Second, it addresses all HFT as a monolithic whole, despite the fact that HFT is a misnomer that hides a multitude of different strategies, and the fact that the risks—and benefits—generally associated with HFT vary significantly across HFT strategies.

Finally, the EU response to HFT is unduly harsh, subjecting all HFTraders to capital requirements that are particularly punishing on most HFT strategies and to reporting and record-keeping requirements that have little parallel in other jurisdictions—and ultimately incentivising the creation of trading environments where the order-placing and trading patterns inherent in most HFT strategies are generally discouraged.

The reason why these requirements are unduly harsh is that they may encourage HFTraders to leave the market, or significantly increase costs for those who stay. Which is problematic because there is evidence that certain HFT strategies make a positive contribution to market quality—and, in fact, the most comprehensive literature review on this topic (published by Menkveld in 2016), concludes that the economic benefits of HFT outweigh its costs.[1304]

[1304] Menkveld (n 7).

Indeed, it has been noted that HFT market-making makes a significant contribution to market liquidity—even if that liquidity can be fleeting, particularly during high volatility episodes like the 2010 Flash Crash. HFT electronic front-running, on the other hand, has an ambiguous impact on market quality, depending, in particular, on which categories of traders are more vulnerable to this strategy—but empirical evidence from EU markets gives reason to believe that its impact on market efficiency may turn out to be positive.[1305]

By contrast, HFT strategies that rely on low-latency technology to exploit the small speed advantages inherent in the fragmented network of continuous LOBs that comprise most modern markets are always harmful for market quality. However, it is not clear that these strategies are particularly prevalent in EU markets—and the fact that these markets are less geographically disperse than US markets and governed by best execution requirements that lead to less predictable results than the corresponding US rules are expected to discourage their popularity in the EU.[1306] Additionally—and in any case—it can be argued that the *de facto* and the *jure* constraints that apply to HFTraders under the EU regime are not the most effective answer to the problems raised by this strategy, which could be better addressed by more radical reforms to market structure.[1307]

[1305] *See* chapter 3. *See*, in particular Fox, Glosten and Rauterberg (n 2) for a discussion of the conditions under which electronic front-running can have a positive impact on efficiency.

[1306] *See* chapter 3.

[1307] As proposed by Budish *et* al *in* Budish, Cramton and Shim (n 27)—where the authors also discuss why solutions such as those adopted by the EU in regard to HFT are not an effective response to this problem.

In conclusion, the EU algo-trading regime should have refrained from adopting a regulatory definition of HFT and from treating HFT as an opaque category of trading—and just extended the rules needed to govern the activity of algo-traders (and only those rules) to all proprietary investment firms with disintermediated access to EU markets.

Finally—and although the HFT strategies that give the most cause for concern do not appear to be particularly popular in EU markets—it would have been preferable to address those HFT strategies individually, as such. Indeed, a practical example of what such rules could look like is given below, as this thesis examines the rules in the EU regime that regulate algorithmic market-making.

9.3 New rules for the regulation of algorithmic market-making

The previous section noted how the EU regime aggregates various different algo-trading strategies under one single category—HFT—to which it applies a series of rules that show little concern about the differences between them. There is, however, one HFT strategy that the EU regulates separately: algorithmic market-making.

Earlier in this thesis, algorithmic market-making was introduced as an HFT strategy that has positioned HFTraders as the 'new market-makers.'[1308] And while HFT market-makers were praised for generally contributing to making markets more liquid, they were also noted for their tendency to leave the market

[1308] *See,* i.a., Menkveld (n 27); and chapter 3.

when they are needed the most—most worryingly during the extreme volatility episodes known as 'flash crashes.'[1309] As such, it is understandable that the EU decided to subject this algorithmic market-making to a series of special requirements.

Naturally, these requirements do not apply to HFTraders that do not engage in algorithmic market-making. However, HFTraders that engage in algorithmic market-making will be subject both to the requirements that apply to all HFTraders in general—examined previously—and to the special requirements that apply to algorithmic market-making—analysed in this section.

Crucially, however—although algorithmic market-making is typically described in the literature as an HFT strategy—it is worth noting that the EU does not refer to it as such. This means that the rules examined in this section apply even to traders whose strategies do not fall under the MiFID HFT definition.

Indeed, it will be noted that the rules in the EU regime that regulate algorithmic market-making underwent several changes during the process of approving MiFID II: while the earliest drafts of MiFID II applied these rules to all algo-traders, newer drafts applied them only to HFTraders[1310]—and the final version of the directive effectively restricts their scope to only algo-traders that pursue a market-making strategy.[1311]

[1309] *See* chapter 3.

[1310] Cliff (n 1230).

[1311] MiFID, article 17(3).

This section starts by examining the EU definition of algorithmic market-making (*9.3.1*). This is then followed by an analysis of the different requirements that apply to traders engaged in this activity—both organisational and conduct requirements (*9.3.2*), and reporting requirements *(9.3.3*)—and, finally, by a critical evaluation of those requirements (*9.3.4*).

9.3.1 Defining algorithmic market-making

According to MiFID II, an 'investment firm' pursues an algorithmic 'market-making strategy'—for the purposes of the EU regime—when, 'as a member…of one or more trading venues, its strategy, when dealing on own account, involves posting firm, simultaneous two-way quotes of comparable size and at competitive prices relating to one or more financial instruments on a single trading venue or across different trading venues, with the result of providing liquidity on a regular and frequent basis to the overall market.'[1312]

The importance of this definition of algorithmic market-making is that it clarifies both the subjective and objective scope of the requirements that can apply to algorithmic market-makers under the EU regime.

[1312] MiFID II, article 17(4).

9.3.1.1 Subjective scope

The definition of algorithmic market-making strategy in article 17(4) of MiFID II starts by determining the categories of traders who may be subject to the rules in the EU regime that govern this activity.

First, it is worth recalling that the EU definition does not equate algorithmic market-making with HFT—even though algorithmic market-making is often characterised as an HFT strategy, and most modern market-makers are HFTraders.[1313] The result is that the rules in the EU regime that govern algorithmic market-making apply to all algo-traders, even if their activity does not fall under the EU definition of HFT.[1314]

Second, MiFID II defines algorithmic market-making by referring to 'investment firm[s] that [engage] in algorithmic trading'[1315]—which could be taken to mean that the rules in the EU regime that regulate algorithmic market-making would only apply to MiFID investment firms. It seems, however, that credit institutions authorised under CRD IV are also subject to these rules[1316]—as are non-MiFID firms that are nevertheless subject to its article 17.[1317]

[1313] *See,* i.a., Menkveld (n 27); and chapter 3.

[1314] *See* MiFID II, article 17(4). However, it is worth noting that earlier versions of MiFID II restricted the scope of these rules to HFTraders.

[1315] MiFID II, article 17(4).

[1316] MiFID II, article 1(3)(a).

[1317] MIFID II, article 1(5).

Finally, it is noteworthy that only traders who pursue algorithmic market-making strategies as venue members attract the provisions in the EU regime that regulate that activity. As such, traders who only access particular venues through DEA services—and who use those services to engage in algorithm-driven market-making—are exempt from these provisions.[1318]

In conclusion, the rules in the EU regime that govern algorithmic market-making can apply to all algo-traders (and not just HFTraders), apply only to professional firms and credit institutions, and apply only to venue members.[1319]

9.3.1.2 Objective scope

The definition of algorithmic market-making in MiFID II also notes that three elements are required before a strategy falls under its scope: trading on own account (in 'at least one financial instrument on one trading venue');[1320] posting 'firm, simultaneous, two-way quotes of comparable size and at competitive prices;' and managing to provide liquidity 'on a regular and frequent basis to the overall market.'[1321]

[1318] MiFID II, article 17(4).

[1319] It is also interesting to note that even though MiFID II defines 'market-maker' in article 4(1)(7)—as a person who holds themselves out on the markets 'on a continuous basis as being willing to deal on own account by buying and selling financial instruments against that person's proprietary capital at prices defined by that person'—the definition of algorithmic market-making in article 17(4) makes no reference to the formal concept of 'market-maker.' According to MiFID II, the definition of algorithmic market-making is also 'independent from definitions such as that of "market making activities"' in wider EU law (*see* MiFID II, recital (60)).

[1320] CDR 2017/578, article 1(1)(b).

[1321] MiFID II, article 17(4).

The first element—'trading on own account'—is defined as 'trading against proprietary capital resulting in the conclusion of transactions in one or more financial instruments.'[1322] The second—posting 'firm, simultaneous, two-way quotes of comparable size and at competitive prices,'—is given more detail in CDR 2017/578, which defines 'firm quotes' as those that 'under the rules of a trading venue can be matched against an opposite order or quote;' 'simultaneous two-way quotes' as those 'posted in such a way that both the bid and the ask-price are present in the order book at the same time;' 'quotes of comparable size' as those with sizes that 'do not diverge by more than 50% from each other;'—and 'quotes with competitive prices' as those 'posted at or within the maximum bid-ask spread set by the trading venue and imposed upon every investment firm that has signed a market-making agreement with that trading venue.'[1323]

The third element is not so much a characteristic of algorithmic market-making, but a desirable result of this strategy: that liquidity is provided 'on a regular and frequent basis to the overall market.' In reality, what this element does is anticipate article 17(3) of MiFID II, which requires the provision of liquidity 'on a regular and predictable basis' to the venues where the algorithmic market-making activity takes place—as analysed below.[1324]

[1322] MiFID II, article 4(1)(6).

[1323] *See* CDR 2017/578, article 1(2)(a)-(d) (respectively).

[1324] MiFID II, article 17(3)(a).

9.3.2 Organisational and conduct requirements

Traders considered to be pursuing an algorithmic market-making strategy under the EU regime come under two main requirements:[1325] a requirement to carry out that market-making continuously, under certain conditions; and a requirement to enter into market-making agreements with the venues where they carry out that activity—which is then complemented by a requirement to implement the arrangements needed to ensure compliance with such agreements.[1326]

Indeed, according to the directive, a trader that engages in an algorithmic market-making strategy in a given venue may—in certain circumstances—be required to carry out that strategy 'continuously during a specified proportion of the trading venue's trading hours…with the result of providing liquidity on a regular and predictable basis to the trading venue.'[1327]

Determining the circumstances under which this continuous market-making requirement applies depends on two sets of provisions: one establishing the conditions that must be met before a trader falls under that requirement; and another establishing the exceptional conditions that exclude its application.

[1325] Again, organisational and conduct requirements are discussed in tandem—as they were in regard to venues and DEA providers—because of their complementarity.

[1326] *See* MiFID II, article 17(3). Assessment of compliance with both requirements should take into account 'the liquidity, scale and nature of the specific market and the characteristics of the instrument' that are the object of the market-making strategy.

[1327] MiFID II, article 17(3)(a).

Accordingly, a trader that engages in algo-trading to pursue a market-making strategy[1328] is only subject to a continuous market-making requirement where it executes that strategy 'in at least one financial instrument on one trading venue, for at least 50% of the daily trading hours of continuous trading' at the trading venue where that strategy is executed, 'excluding opening and closing auctions,' during 'half of the trading days over a one-month period.'[1329]

Even then, however, the continuous market-making requirement in MiFID II will not apply in a series of exceptional circumstances, including:[1330] extreme volatility episodes triggering certain volatility mechanisms;[1331] 'disorderly trading conditions' that compromise 'the maintenance of fair, orderly and transparent execution,' when evidence is provided of disturbance of venue performance,[1332] of the existence of 'multiple erroneous orders or transactions,' or of lack of venue capacity; and situations where traders cannot 'maintain prudent risk management

[1328] In other words, a trader that 'deals on own account in at least one financial instrument on one trading venue,' posting 'firm, simultaneous, two-way quotes of comparable size and competitive prices' (*see* MiFID II, article 17(4) and CDR 2017/578, article 1(1)).

[1329] CDR 2017/578, article 1(1)(b).

[1330] Other such exceptional circumstances are 'war, industrial action, civil unrest or cyber sabotage,' and, in the case of non-equity instruments, 'the suspension period referred to in [a]rticle 9(4) of [MiFIR]' (*see* CDR 2017/578, article 3(b) and (e)).

[1331] Specifically, episodes of extreme volatility 'triggering volatility mechanisms for the majority of financial instruments or underlyings of financial instruments traded on a trading segment within the trading venue in relation to which the obligation to sign a market making agreement applies' (*see* CDR 2017/578, article 3(a)).

[1332] In particular by delays and interruptions (*see* CDR 2017/578, article 3(c)(i)).

practices' because of technological issues,[1333] certain risk management issues,[1334] or an inability to hedge positions following a short-selling ban.[1335]

Ultimately, if the circumstances are such that a trader is required to provide continuous market-making in a particular venue, it must—as a minimum—continue to post the 'firm, simultaneous two-way quotes of comparable size and competitive prices' that had originally resulted in the classification of their strategy as algorithmic market-making[1336] 'in at least one financial instrument,' for 'at least 50% of the daily trading hours during which continuous trading takes place [in that venue] excluding opening and closing auctions and calculated for each trading day.'[1337] This is an obligation of result—compliance with which should lead to the provision of liquidity on a regular and predictable basis.[1338]

Additionally, traders considered to be pursuing algorithmic market-making strategies are required to become 'designated market-makers,'[1339] by entering

[1333] These issues include, namely, 'problems with a data feed or other system that is essential to carry out a market making strategy' (*see* CDR 2017/578, article 3(d)(i)).

[1334] These issues must refer to 'regulatory capital, margining and access to clearing' (*see* CDR 2017/578, article 3(d)(ii)).

[1335] *See* CDR 2017/578, articles 3-4; and chapter 7.

[1336] MiFID II, article 17(4).

[1337] *See* CDR 2017/578, article 2(1)(b). *See* also, MiFID II, recital (59), noting that the proportion of the venue trading hours during which algorithmic market-makers should be required to provide continuous market-making should be 'significant in comparison to the total trading hours, taking into account the liquidity, scale and nature of the specific market and the characteristics of the financial instrument traded.'

[1338] MiFID II, article 17(3).

[1339] The term 'designated market-maker' is not used in MiFID II, but can be found, *i.a.,* in MiFIR and CDR 2017/575.

into binding written agreements with the venues where they pursue those strategies[1340]—as well as to implement the systems and controls needed to ensure compliance with those agreements.[1341]

This thesis has already alluded to these market-making agreements—and, namely, to the corresponding obligation for venues to have in place agreements 'with all investment firms pursuing a market-making strategy on a regulated market.'[1342] Now, it examines what should be the content of these market-making agreements—and what implications they have for designated market-makers.

Content-wise, these agreements must at least specify 'the obligations of the investment firm in relation to the provision of liquidity'[1343]—and, namely, the minimum obligations that flow from the continuous market-making requirement discussed earlier in this section.[1344] They must also list, in particular, the terms of any applicable market-making schemes,[1345] any obligations for traders to resume trading after it has been interrupted, and details on the flagging and reporting requirements discussed in the next section.[1346]

[1340] MiFID II, article 17(3)(b).

[1341] MiFID II, article 17(3)(c).

[1342] *See* MiFID II, article 48(2); and chapter 7.

[1343] MiFID II, article 48(3).

[1344] *See* MiFID II, article 17(3) and CDR 2017/578, article 2(1)(b). These minimum obligations are measured in terms of presence, size and spread (*see* the discussion earlier in this section).

[1345] *See* chapter 7.

[1346] *See* CDR 2017/578, article 2(1). At the same time, there is no requirement for MS authorities to 'approve or examine' the content of these agreements (*see* MiFID II, recital (114)).

Before evaluating the implications that this requirement to enter into market-making agreements—and, more broadly, to provide continuous market-making—have for designated market-makers, it is worth examining the motivation for these rules, which was based on two ideas, already explored in this thesis:[1347] first, the notion that algorithmic market-making had 'added liquidity to the market [and] reduced spreads,' in replacement for 'more traditional market-making activities;' and, second, the idea that 'the value of the additional liquidity provided' by algo-traders had been harmed by the fact that they could 'withdraw [it] at any time.'[1348]

This concern with (fleeting) liquidity is now clearly stated in MiFID II, which justifies the continuous market-making requirement in the EU regime with 'the importance of liquidity provision to the orderly and efficient functioning of markets.'[1349] However, it is noteworthy that the way in which this concern is presently addressed by the EU is very different from the way in which it was addressed in earlier drafts of MiFID II.

Indeed, the October 2011 draft of the directive controversially required all algo-traders to 'be in continuous operation during the trading hours of the trading venue to which it sends orders or through the systems of which it executes transactions…with the result of providing liquidity on a regular and ongoing basis

[1347] *See* chapter 3.

[1348] EC, 'Public Consultation - Review of the Markets in Financial Instruments Directive (MiFID)' (n 601), 15.

[1349] MiFID II, recital (113).

to these trading venues at all times, regardless of prevailing market conditions.'[1350]

There were two main problems with this draft, which was met with considerable opposition:[1351] first, the fact that it forced all algo-traders to become market-makers, in ignorance of the variety of strategies that can be carried out through algo-trading mechanisms—and of the fact that most traders in modern EU markets are algo-traders; and second, the fact that it required those traders to make markets 'at all times'—independently of underlying market conditions—thus turning market-making into a prohibitively expensive activity.[1352]

As the EU continued its work on MiFID II, the trade-off inherent in these continuous market-making requirements began to emerge more clearly.

A harsh continuous market-making requirement can force (more) algo-traders to provide liquidity in a wider set of circumstances, which addresses the concern that the liquidity provided by these traders can evaporate when it is most needed.[1353] Indeed, there is evidence that continuous market-making requirements can contribute to smaller spreads, increased market depth, and

[1350] EC, 'Proposal for a Directive of the European Parliament and of the Council on Markets in Financial Instruments Repealing Directive 2004/39/EC of the European Parliament and of the Council (Recast)' (n 602).

[1351] *See*, i.a., the concerns of the UK Government 'over the continuous market making requirement and its impact on liquidity and price formation' and suggestion to apply such a requirement only to 'to only those algorithms carrying out market making strategies' (Authority of the House of Lords (n 222), 13).

[1352] Cliff (n 1230).

[1353] At the same time, there is evidence of episodes when designated market-makers fled the market during times of extreme volatility—even in breach of their requirements (*see* Jones (n 39)).

better price discovery[1354]—particularly in adverse market conditions, when information asymmetry is more severe.[1355]

At the same time, continuous market-making requirements also increase the costs of providing liquidity for algo-traders—who will either leave the market[1356] or stay but require compensation for the losses that they take during periods when they would normally leave.[1357]

This compensation could come from wider spreads, but continuous market-making requirements often come coupled with an obligation to post quotes at competitive prices.[1358] More often, it comes from 'special privileges'—such as the rebates that EU venues can grant to traders subject to market-making requirements[1359]—but there are a number of problems with this solution.

1354 For an account of the empirical evidence supporting the notion that continuous market-making requirements can have a beneficial impact on market quality, *see* Cliff (n 1230).

1355 Hendrik Bessembinder, Jia Hao and Michael Lemmon, 'Why Designate Market Makers? Affirmative Obligations and Market Quality' (2011).

1356 This risk was expressly identified by the EU in 2011, when it noted 'possible backlash effects of the measure if HFT withdraw from the market' (*see* EC, 'Commission Staff Working Document - Impact Assessment Accompanying the Document Proposal for [MiFID and MiFIR]' (n 380)).

1357 *See,* i.a., Bessembider *et al*, noting that 'to entice a market maker to assume such [a continuous market-making] obligation…therefore require[s] a subsidy or side payment' (Bessembinder, Hao and Lemmon (n 1355), 5) and Panayides, arguing that while continuous market-making obligations 'are associated with better market quality, [they] impose significant costs on the specialist' (Marios A Panayides, 'Affirmative Obligations and Market Making with Inventory' (2007) 86 Journal of Financial Economics 513, 513). For a discussion, *see,* i.a., Fox, Glosten and Rauterberg (n 226).

1358 This is the case with the EU regime: *see* MiFID II, article 17(4) and CDR 2017/578, article 1(a).

1359 MiFID II, article 48(9).

First, the value of the extra liquidity provided during the abnormal market conditions when market-makers would normally leave the market is difficult to quantify—and may not always be higher than the costs of the 'special privileges' associated with continuous market-making requirements.[1360]

Second, the costs of the special privileges awarded to designated market-makers may be passed on to other traders. In fragmented markets, this may drive away such traders to other trading environments 'during normal times'—only to have them return in 'abnormal times,' when designated market-makers are required to stay put—which increases the costs of market-making and the value of the compensation that designated market-makers will expect to receive.[1361]

In conclusion, even though there is significant evidence that continuous market-making requirements can improve market quality[1362]—regulators should tread carefully when designing such requirements.

In that regard, it is argued that the final version of article 17(3) of MiFID II represents a notable improvement over earlier drafts—fully addressing the main

[1360] *See* James J Angel, Lawrence E Harris and Chester S Spatt, 'Equity Trading in the 21st Century: An Update' (2013). This argument is especially relevant for those who find that the consequences of non-extreme episodes of volatility are not substantial (*see*, i.a., Fox, Glosten and Rauterberg (n 2)). It is also particularly relevant when measuring the benefits and costs inherent in systems that also have mechanisms to suspend trading in reaction to episodes of heightened volatility—as is the case with the EU (*see,* i.a., the circuit-breakers mandated under article 48(5) of MiFID II; for a discussion, *see* chapter 7).

[1361] *See* Angel, Harris and Spatt (n 1360); and Fox, Glosten and Rauterberg (n 2).

[1362] For a summary of this evidence, *see* Cliff (n 1230).

criticisms that were levelled at them.[1363] Indeed, the EU ultimately adopted a significantly softer continuous market-making requirement whereby only traders that engage 'in algorithmic trading to pursue a market making strategy' (and not all algo-traders) may be required to become designated market-makers. And, even then, these designated market-makers do not have to provide liquidity in a series of 'exceptional circumstances.'[1364]

Still, and even if there is no question that the current version of article 17(3) of MiFID II is preferable to previous versions—not least because most traders in modern EU equity markets are algo-traders and the earliest versions of MiFID II would burden all of them with market-making requirements—it is noteworthy that the long list of circumstances that can excuse algo-traders from making markets are exactly the circumstances where their presence would be most important (and where they would be more likely to flee EU markets).

In the end, the EU regime was then left with a provision that does not unduly increase the costs of market-making,[1365] but also does not really solve the main problem that it set out to address: disappearing liquidity during extreme volatility episodes. This may not be especially problematic: imposing harsher

[1363] For a discussion of the continuous market-making requirements found in earlier drafts of MiFID II, *see* ibid.

[1364] MiFID II, article 17(3)(a) and CDR 2017/578, article 3.

[1365] Under the current wording of article 17(3), the costs of market-making only increase to the extent that market-makers perceive a real risk of being required to post narrower quotes than they would otherwise post, or of being forced to stay in the market when they would otherwise leave.

market-making requirements would come at a difficult-to-measure cost.[1366] And it is worth recalling that this requirement does not exist in isolation, and that there are other provisions in the EU regime that already address the dangers of extreme volatility—more effectively, perhaps, than continuous market-making obligations ever could.[1367]

9.3.3 Reporting requirements

Algo-traders considered to be pursuing a market-making strategy for the purposes of the EU regime—and required to carry out that market-making continuously under article 17(3) of MiFID II—are also subject to a reporting requirement whereby they must identify as such any orders submitted as part of that market-making strategy,[1368] 'subsequent to the conclusion of a market-making agreement.'[1369]

This requirement is owed to the relevant MS authorities. In other words, it is a disclosure to supervisors, rather than to the market more generally: as such, its main purpose is to facilitate the task of safeguarding market integrity against the risk associated with algorithmic market-making.

[1366] *See* Fox *et al*, noting the difficulties in determining the value of the compensation that is required by market-makers subject to affirmative obligations to provide liquidity during times of heightened volatility (Fox, Glosten and Rauterberg (n 2)).

[1367] *See,* i.a., the circuit-breakers discussed in chapter 7.

[1368] CDR 2017/580, article 3(2)(a).

[1369] *See* CDR 2017/578, article 2(1)(f)-(g) and answer 17 (topic 3) *in* ESMA, 'Questions and Answers on MiFID II and MiFIR Market Structures Topics' (n 414).

In particular, this requirement is meant to help regulators distinguish order flow from firms engaged in algorithmic market-making (on the basis of market-making agreements) from other types of algorithmic order flow—and, in particular, from manipulative algo-trading.[1370]

The importance of empowering supervisors to make that distinction stems from the fact that the order-placing and trading patterns associated with certain algo-trading strategies—and, namely, with many of the strategies typically grouped together as HFT—are also often associated with market manipulation.[1371]

To the extent that innocent HFT trading strategies that might be misidentified as manipulative have a beneficial impact on market quality—as is often the case with algorithmic market-making—mistaking them for market manipulation is entirely undesirable. As such, it is commendable that the EU requires traders considered to be pursuing a market-making strategy for the purposes of the EU regime—and forced to enter into market-making agreements—to flag any orders placed under that strategy.

Still, this measure does not address the negative consequences of mistaking other beneficial HFT strategies for market manipulation—including algorithmic market-making strategies that escape the definition in article 17(4) of MiFID II, or which do not come coupled with a continuous market-making

[1370] *See* CDR 2017/580, recital (6). This purpose was confirmed by ESMA *in* ibid.

[1371] *See* chapter 3.

requirement under article 17(3) of MiFID II—nor does it address the broader problems that arise from the new EU definition of market manipulation.[1372]

Indeed, it has been argued that this new definition reinforces a largely misguided, unnecessary and harmful association between HFT and market manipulation—without which the importance of flagging algorithmic market-making would perhaps be diminished.

Finally, traders pursuing a market-making strategy under the market-making agreements required under MiFID II are also subject to a record-keeping obligation, whereby they should maintain separate records of all quotes and transactions relating to such agreements—which, however, only need to be made available to the relevant venues and supervisory authorities upon request.[1373]

9.3.4 Evaluating the new rules

One of the most interesting features of the EU algo-trading regime is its regulation of algorithmic market-making. The 2010 Flash Crash instilled real fear in regulators around the world and the market-making requirements in MiFID II are a clear response to the fear that HFTraders can leave the markets during such episodes of extreme volatility, amplifying their effects.

However, the harsh market-making requirements that could be found in the earliest versions of MiFID II eventually gave way to softer rules that apply only

[1372] *See* chapter 6.

[1373] CDR 2017/578, article 1(g).

to algorithmic market-makers—and which do not actually require them to stay in the market at all times. In the end, these rules should be commended for a number of reasons—but they can also be subject to criticism.

Scope-wise, it is commendable that the EU has not relied on the impractical regulatory concept of 'HFT' when determining the categories of traders to which these rules might apply: although algorithmic market-making can be justly (and usefully) characterised as an HFT strategy, that should have no bearing on how that strategy—or any strategy—should be regulated.

Simultaneously, it is perhaps unfortunate that the rules that regulate algorithmic market-making do not apply to traders that can only access venues through DEA services—although it is conceded that such rules would be more difficult to enforce in the absence of a direct relationship between venue and trader, and that most algo-traders engaged in market-making are indeed members of the venues where they implement such strategy.[1374]

Content-wise, it is praiseworthy that the requirements applicable to algorithmic market-making are not too harsh on traders, as there are questions as to the benefits and feasibility of requiring market-makers to stay in the markets at all times—particularly when the EU regime contains other tools for dealing with the episodes of extreme volatility that may cause market-makers to flee the markets. At the same time, continuous market-making requirements that do not

[1374] *See,* i.a., Grewal (n 1257).

require market-makers to stay when they would otherwise leave contribute very little to addressing the problem of fleeting liquidity.

Perhaps the most notable aspect of the rules that apply to algorithmic market-makers under the EU regime is the fact that market-makers must flag the quotes and transactions placed or executed under formal market-making arrangements. Hopefully, this will help supervisors distinguish innocent (and often beneficial) algo-trading from manipulative behaviour, which may be especially important in view of the changes made by the EU to its market manipulation definition—and which unnecessarily solidified the misconception that algo-trading creates increased risks of market manipulation.[1375]

9.4 Conclusion

There is perhaps no greater testament to the ambition of the EU algo-trading regime than the fact that some of its rules specifically target HFTraders and the strategies that these traders have adopted in response to the growing use of algo-rading mechanisms across EU markets.

Indeed, if the EU regime did not contain these special HFT rules, it would still regulate essentially all uses of algo-trading mechanisms by traders, all hosting of algo-trading by venues and all facilitation of algo-trading by execution intermediaries: such a regime would effectively cover most market players engaging in—or responding to—algo-trading. As such, the rules in the EU regime

[1375] *See* chapter 6.

that regulate HFT see the EU going above and beyond to address all the risks broadly associated with algo-trading.

This could make sense: although many HFT strategies are beneficial, others create heightened risks for market quality—and it is understandable that the EU tried to address these increased risks.

At the same time, it is also argued that the EU approach to HFT is hurt by a series of problems—chief among which is the misconception that HFT should be seen, defined and regulated as a monolithic category of trading. The one exception to this monolithic approach is the separate regulation of algo-trading market-making—but, even there, the EU failed to address the main problem with this HFT strategy: the propensity of algorithmic market-makers to flee the market during periods of abnormal volatility.

In line with the argument developed by Budish *et al* in 2015, the problem with the EU approach to HFT is that it looks at HFT as a cause—rather than as a symptom.[1376] Instead of trying to pinpoint what HFT is, or how it impacts the market (as a whole), the EU would do better to look at individual HFT strategies for clues as to how the design of its markets could be improved. In this regard, much has already been achieved by the EU algo-trading regime, but there is no lack of possibilities for further reform.

[1376] Budish, Cramton and Shim (n 27).

This thesis has already made a few suggestions for improvement—building on the rules that currently comprise the EU algo-trading regime—but there is room to consider more radical proposals.[1377] In particular, some have suggested that replacing the continuous LOB market design adopted by most venues for frequent batch auction ('FBA') models, or introducing venue speed bumps could play an important role in combatting problematic low-latency HFT strategies.[1378]

Additionally, it is argued that mandating the increased production of soft, unstructured data in the context of corporate disclosure—which trading algorithms may still struggle to decode[1379]—could strengthen the position of fundamental traders against electronic front-running, while weakening that of announcement traders. This should then contribute to ensuring that this HFT strategy has a positive overall impact on the efficiency of EU markets.[1380]

But even less radical, incremental changes could make a decisive contribution to improving the efficiency of the EU regime: namely eliminating the regulatory category of 'HFT' and the rules in the EU regime that specifically constrain HFTraders—while extending the rules needed to govern the activity of

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[1377] Although it is unclear if EU market structure is in need of such radical change, as there is little evidence that the most problematic HFT strategies—namely low-latency arbitrage—are particularly prevalent in EU markets (*see* chapter 3).

[1378] *See*, i.a., Budish et al *in* Budish, Cramton and Shim (n 27); and the speech of former SEC Chair Mary Jo White *in* White (n 854).

[1379] *See* Yadav (n 176)—noting, however, that this might change with advances in AI.

[1380] As predicted by the theoretical model developed by Fox *et al* (*see* Fox, Glosten and Rauterberg (n 2)).

algorithmic traders (and only those rules) to all proprietary investment firms with disintermediated access to EU markets.

10. CONCLUSION

Technology and automation have long fuelled human imagination, inspiring both wonder and fear.

One of the earliest accounts of this fear is found in the novel *Frankenstein*, which tells the story of a scientist who brings to life an autonomous creature that eventually turns against its creator[1381]—and, more than a century after *Frankenstein* was published, Isaac Asimov would coin the term 'Frankenstein complex' to describe this fear that technological creations may develop beyond the control of humanity.[1382]

At the same time, Asimov also prescribed a solution to mitigate this somewhat irrational[1383]—but also somewhat justified—fear: regulation. Humanity could move beyond its 'Frankenstein complex' by subjecting automated technology to just three laws:

> '1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
>
> 2. A robot must obey orders given it by human beings except where such orders would conflict with the First Law.

[1381] Mary Shelley, *Frankenstein* (Reprint edition (5 May 1992), Wordsworth Editions 1992).

[1382] Patricia S Warrick, Martin Harry Greenberg and Joseph D Olander, *Science Fiction: Contemporary Mythology, The SFWA-SFRA Anthology* (1st edition, Harper & Row, Publishers 1978).

[1383] *See,* i.a. Gorman Beauchamp, 'The Frankenstein Complex and Asimov's Robots' (1980) 13 Mosaic: A Journal for the Interdisciplinary Study of Literature 83.

> 3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.'[1384]

The idea behind the 'Three Asimov Laws' is that machines exist to serve the best interests of humanity—and that idea should be at the heart of any effective algo-trading regime. Such a regime should then ensure: *(1)* that the financial markets—viewed as inherently human institutions—are protected against the risks created by automated-trading technology; *(2)* that humans regulate automated-trading technology, but only to the extent that their intervention does not leave markets worse-off; and, finally, *(3)* that the benefits from automated-trading technology are preserved—although only to the extent that they are not outweighed by its risks.

But the problem with this solution to the 'Frankenstein complex' is that it presupposes that human regulators can accurately identify the benefits and risks of the object of their rules: the 'Three Asimov Laws' are a rational solution to a fear that—although not entirely unjustified—can be somewhat irrational.

This irrationality—these misconceptions that humans may have about technology—can decrease the effectiveness of even the most justified rules. And, surely enough, the effectiveness of the rules approved by the EU to regulate the algo-trading taking place in its capital markets—necessary as they may have been—is affected by a series of misconceptions about the change brought by automated-trading technology to those markets.

[1384] Isaac Asimov, 'Runaround', *I, Robot* (Gnome Press, 1950).

Specifically, this thesis has argued that the EU algo-trading regime erroneously assumes that not all algo-trading mechanisms create risks worth regulating, that the use of algo-trading mechanisms has meaningfully contributed to an increased risk of market manipulation, and that the benefits and risks of different HFT strategies can be considered and discussed as if HFT were a monolithic category of trading.

As a result, the EU regime fails to regulate types of execution algorithms that can significantly threaten the quality of EU capital markets, creates unnecessary suspicion that certain (often beneficial) algo-trading behaviour carries a special market manipulation risk, and imposes onerous requirements on (all) HFTraders, regardless of the particulars of their strategies. It is therefore feared that the EU regime both leaves its flank open to the risk created by simpler execution algorithms, while also discouraging beneficial market conduct.

In response to these concerns, this thesis has proposed three main solutions: amending article 4(1)(39) of MiFID II to include basic execution algorithms in the EU definition of algo-trading; amending article 12 of MAR to eliminate the examples of algorithmic trading-driven manipulation included in its paragraph 2(c); and removing the rules specifically applicable to HFT under the EU regime. Indeed, the EU should altogether eliminate 'HFT' as a regulatory category, opting instead to extend the rules needed to govern the activity of algo-traders—and only those rules—to all proprietary traders with disintermediated access to EU markets.

In the end, it is not clear what caused the EU to develop misconceptions about the change brought by automated-trading technology to its markets—nor how these misconceptions were eventually channelled into its algo-trading regime.[1385]

It could be that the irrationality inherent in any 'Frankenstein complex' mixed poorly with the uncertainties that still surround the study of algo-trading: indeed, between 2009, when the EU first started worrying about algo-trading, and 2018, when MiFID II came into force, dozens of studies were published about algo-trading, HFT and their impact on market quality—and, to this day, a consensus has still not emerged.[1386] And it may be that the decision to regulate algo-trading even in the face of such uncertainties was precipitated by a desire to 'appear to be doing something'[1387]—and something 'tough'[1388]—to address an issue that had caught the interest not only of market players, but also of the general public.[1389]

[1385] For a recent discussion of the legislative process that led to the EU algo-trading regime, *see* Karremans and Schoeller (n 31).

[1386] Menkveld (n 7).

[1387] Luca Enriques, 'Regulators' Response to the Current Crisis and the Upcoming Reregulation of Financial Markets: One Reluctant Regulator's View' (2009) 30 University of Pennsylvania Journal of International Law 1147.

[1388] *See* EC, cited by Martin Wheatley (*in* Wheatley (n 14)). Indeed, the US might have gone down a similar route—with the approval of 'Regulation Automated Trading'—had it not been for the nomination of a new chairman of the CFTC after the inauguration of the Trump administration in 2017 (*see* Lisa Lambert, 'US Derivatives Regulator to Move on from Dodd-Frank under Trump' *Reuters* (8 December 2016)).

[1389] Particularly following the publication of the 2014 novel 'Flash Boys' (*see* Lewis (n 349)).

But regardless of what might explain the EU misconceptions about algo-trading—or how they came to influence its algo-trading regime—there is also much that the EU regime gets right. Its structure and comprehensiveness—including not only rules to mitigate the risks inherent in the general use of algo-trading mechanisms, but also rules to govern the various strategies developed by market players in response to the popularisation of algo-trading—reveal an accurate understanding of the extent to which the EU capital markets were in need of protection, in strict obedience to the First Asimov Law.

And a closer look at the content of the EU regime—namely, at the rules in MiFID/MiFIR that regulate the use of algo-trading mechanisms and govern the strategies employed by trading venues and other intermediaries in response to algo-trading—reveals a pervasive concern with proportionality, as well as sensible trade-offs between the benefits and risks created by these mechanisms and strategies, in compliance with the Second and Third Asimov Laws.

As such, this thesis does not advocate drastic changes to the EU algo-trading regime: while the irrationalities that permeate the EU regime certainly hurt its effectiveness, its rules are nonetheless a valuable addition to the EU financial regulation framework.

Naturally, this should not be taken to mean that there is no room to explore radically different options for regulating algo-trading; indeed, it is hoped that the analytical frameworks produced by this thesis can provide a useful blueprint for evaluating alternative, or complementary measures to the EU regime—either coming from other jurisdictions, or from wider EU law. In particular, new market designs (such as FBA markets), pre-trade transparency and dark pool rules, disclosure regulation, trade execution rules and financial taxes could play a role in regulating algo-trading—and these are all options worth exploring in future work.

For now, however, it is argued that even small incremental changes—rather than a complete overhaul of the EU regime—could go a long way in helping the EU move beyond its ‘Frankenstein complex’ with algo-trading and HFT.

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