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Document Version
Accepted author manuscript

Published in:
Economy and Society

DOI:
10.1080/03085147.2016.1213986

Publication date:
2016

License
Unspecified

Citation for published version (APA):
Lange, A.-C., Lenglet, M., & Seyfert, R. (2016). Cultures of High-frequency Trading: Mapping the Landscape of Algorithmic Developments in Contemporary Financial Markets. *Economy and Society*, *45*(2), 149-165. https://doi.org/10.1080/03085147.2016.1213986

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Journal article (Post print version)

Cite: Cultures of High-frequency Trading: Mapping the Landscape of Algorithmic Developments in Contemporary Financial Markets. / Lange, Ann-Christina; Lenglet, Marc; Seyfert, Robert. In: *Economy and Society*, Vol. 45, No. 2, 2016, p. 149-165.

Cultures of High-Frequency Trading: Mapping the Landscape of Algorithmic Developments in Contemporary Financial Markets

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Abstract

Developing an agenda for social studies of High-Frequency trading (HFT), this paper introduces the culture(s) of HFT as a sociological problem of dealing with knowledge and practice. High-Frequency trading is often discussed as a purely technological development where all that matters is the speed of allocating, processing and transmitting data. Indeed, the speed of executing a trade and data transmission is accelerating and it is fair to say that algorithms are now the interacting agents preprogramed to operate in the financial markets. However, we make the point that HFT is first and foremost a cultural phenomenon. More specifically, both individuals and collective agents – such as algorithms – might be considered cultural entities charged with very different ways of processing information, making sense of it and turning it into knowledge and practice. This puts forward issues relating to situated knowledge, distributed cognition and action, the assignment of responsibility when regulating high-speed algorithms, their history, organizational structure and perhaps more fundamentally, their representation.

Keywords

Algorithms; cultures; economic sociology; High-Frequency trading; social studies of finance

Introduction

Financial markets all over the world have recently seen a transition from electronic 'hand' trading, where orders are manually executed by clicking on the mouse, to fully automated decision-making and high-speed order executions, generated by computer programs. Recent discourses on the consequences of this development towards what is known as High-Frequency trading (HFT), have been dominated by concerns about unusually turbulent market events, claims of market manipulations, worries about the stability of market infrastructures and, consequentially, calls for more and better market regulations. In general, uncertainty abounds as to how much this new trading practice will change the general landscape of the financial markets. In this respect the 'Flash Crash' of May 6, 2010 has become an event of historic proportions. On that day, approximately one trillion dollars evaporated within a few minutes, when the Dow Jones Industrial Average plummeted by over 600 points (approximately 5% of its total value), between 2:32 and 3:08 pm ET. Following this event, a culture of High-Frequency trading became visible to the general public, defined by multiple voices, intense contestations, and widespread disagreement (Holley, 2013; Sniper in Mahwah, 2013).

The culture of High-Frequency trading we characterize in this article also led to a series of trials and legal convictions. In February 2016 for instance, the extradition hearing in the case against British trader Navinder Singh Sarao took place in London (Davies, 2016). The trader is accused of market misbehaviour, using automated computer programs to issue fake orders, and thereby manipulate the market to move in his favour. The charges against him relate to what is called *layering* or *spoofing*: that is when a trader issues orders at millisecond intervals, fast enough to cancel them before they actually get executed, but long enough to affect other traders' expectations to its future price (Fisher, Clifford, Dinshaw & Werle, 2015). In other words, Sarao is accused of having made a false representation of his trading intentions in order to mislead the market, which in itself constitutes a major market abuse. However, the case is not only one of market manipulation, as Sarao's automated trading program is claimed to have also contributed to the Flash Crash (Stafford, Fortado & Croft, 2015). While it took market authorities five years to call this case closed (if only tentatively), others remain unsettled and open. Some say there is no evidence that Sarao's activities effectively caused the Flash Crash and that correlation was

confused with causation (Aldrich, Grundfest & Laughlin, 2016); others on the contrary wonder whether a single individual can actually cause such a massive market event, given the complexity of contemporary markets' ecology. In other words, is Sarao a villain with clear intentions and technological capabilities or a butterfly who flapped his wings and, unintentionally, set of a tornado within the financial markets?

Asking this question might seem futile, but we should stress here that interpretations matter. In general, regulators have concluded that the presence of high-speed algorithms operating in the market amplified the downward price movement (CFTC & SEC, 2010; Kirilenko, Kyle, Samadi & Tuzun, 2016). Algorithmic trading programs attempting to sell at lower and lower prices to minimize short-term losses triggered a negative feedback loop that drove the price of the E-mini stock market index down 3%, which in turn spilled over to the equities markets. The negative trends continued until computer systems paused trading temporarily, triggering an almost immediate rebound. In this respect, the Flash Crash illustrates an unwanted domino effect where algorithms causing other algorithms to respond to market moves in specific ways (Menkveld & Yueshen, 2016; Sornette & Von der Becke, 2011).

Thus, the debate and charges against Sarao amount to a much broader issue – the good and bad of what is called 'High-Frequency trading' (HFT).

After the Flash Crash, the increase in HFT and its contribution to price formation led many authors to ask two questions. First, will the growth of HFT herald another period of financial instability, and is the Flash Crash a one off event or a systematic feature that now characterizes the financial markets (Thompson, 2016)? Second, what is the value in HFT (Cartea & Penalva, 2010)? Academics in the law and economics tradition have produced numerous papers trying to answer such questions. They have offered categorizations of different types of HFT (Hagströmer & Nordén, 2013), with a view to demonstrating that HFT has either positive (Aitken, Cummings & Zhen 2015; Conrad, Wahal & Xiang, 2015) or negative effects (Easly, López de Prado & O'Hara, 2010 and 2012; Goldtsein, Kumar & Graves, 2014) on market quality. It has been argued that HFT adds liquidity to the market: indeed, the average number of trades per day was 6 million in 2009; that number reached 18 million in 2015 (Thomson, 2016, p. 2). This means that there is always someone present in the market to respond to either a sell or buy order, thus

rendering the markets more liquid and more efficient. In this line of argumentation, it has also been demonstrated that the increase of HFT is the reason for the quick recovery after the market fall from May 2010 (Brogaard, Hendershott & Riodan, 2014). Other authors on the contrary have made the point that HFT is toxic by nature, and generally detrimental to the market ecology (Arnuk & Saluzzi, 2012). While the topic remains controversial (Vuorenmaa, 2013), a number of issues have been raised with regards to the possibility of regulating these new ways of trading in financial markets (Keller, 2012; McGowan, 2010; Pasquale, 2015a)

In this special issue, our intention is not to take sides in the debates surrounding the good or bad of HFT. In fact, we take the controversies surrounding the nature of HFT and the Flash Crash as a cumulative event illustrating the various cultures that HFT is made of. Perspectives on the supposed outcomes of HFT are rarely clear-cut, always depending on the position held within the market ecology (broadly speaking, either on the market-makers / proprietary traders' side for the positive view; or on the institutional investors' side for a more nuanced, if not completely negative view). We believe that the multiplicities of such perspectives make for the nature of HFT and should not be interpreted as resulting from a state of transition in the history of financial markets, a temporary period which would be overcome once all market participants have a precise picture of HFT's functionality. We specifically make the point that HFT is a cultural phenomenon, which can be understood as one of the most recent and topical expression of how financial innovation has developed at the beginning of the 21st century. To date, the majority of investigative texts have been produced by financial economists working from a quantitative, data-oriented perspective – most often collecting and modelling the numbers of trades at one exchange. Instead we aim to address the issue of liquidity provision and price formation in relation to HFT as a cultural issue, i.e. one that can be studied from different viewpoints and probably best by conducting empirical (ethnographic) fieldwork within the field itself.

Liquidity and Price Formation

Before attempting to delineate the contours of what we mean when speaking of a 'cultural approach', let us provide some elements on how liquidity and price formation, two pivotal elements of financial markets, have been studied within the social studies of finance (SSF) tradition.

MacKenzie, Beunza, Millo & Pardo-Guerra (2012, p. 280) have presented liquidity and price formation as an issue in the sociology of knowledge. Building on Carruthers & Stinchcombe (1999) and Muniesa (2007), they write in their study of HFT that '[t]he changing material assemblages that constitute 'liquid' markets deserve detailed attention, we argue – especially the materiality of prices…'. 'A price', they continue, 'is not an abstraction: to be conveyed from one human being to another, or from one automated system to another, a price must take a material form, whether that be the sound waves created by speech, the electrical signals of the telegraph or telephone, or the optical signals that now flow through high-speed networks'. They then develop the argument that the conditions under which markets allow a large number of buyers and sellers to agree on a financial instrument's price have become precarious, as a result of the renewed material assemblage resulting from market fragmentation and algorithmic innovation. Following an STS-oriented approach, they conclude that HFT does not only provide liquidity to the markets but also create a 'new social structure of liquidity', taking the form of electronic market-making and reconfiguring market sociality (MacKenzie et al., 2012, p. 281 and 292). With the case of HFT, they highlight the impact borne on the social by a distinct sociomaterial assemblage.

The works of Beunza & Millo (2015), Lenglet (2011), Lenglet & Riva (2013), and MacKenzie & Pardo-Guerra (2014) among others, have shown how financial regulations shaped the emergence of automated exchanges and automated trading practices in general, and the specific market infrastructures required for such practices in particular. In this respect, HFT did not emerge out of nowhere: it started in cash-equities markets as a practice fostered by technological innovations on the one hand (as acknowledged by financial economists Kirilenko & Lo, 2013), and new regulations fragmenting market liquidity on the other hand (McNamara, 2016). Legislative texts such as Regulation National Market System (NMS) in 2005 in the US, and the Markets in Financial Instruments Directive (MiFID) in 2007 in the EU changed the organisation of trading

by creating a "market for markets" (Hautcoeur & Riva, 2013), which in turn allowed for the rise of alternative trading systems (ATS) and resulted in the effective removal of historical exchanges' (such as NYSE) monopolies. In the US, the transparency of prices was secured by the creation of the National Best Bid and Offer (NBBO), an SEC regulation requiring market participants to automatically route orders to the exchange offering the best price available. This created the opportunity for some actors to speculate in the time difference between exchanges and ATS (see Lange 2016). In Europe, MiFID contributed to the fragmentation of liquidity among several marketplaces, but no such mechanism was put in place in 2007, and the financial intermediaries had to organize in such a way they would be able to consolidate fragmented information by comparing available prices between execution venues. This triggered algorithmic innovation, as human beings were not able to perform such comparison efficiently.

As such, HFT is not an entirely new phenomenon: it epitomizes the culmination of decades of technological innovation and regulatory developments encouraging financial automation. Classical financial practices such as arbitrage have witnessed new developments: it is now possible to perform arbitrage between two highly correlated products, for instance treasury bonds traded on the NYSE and a corresponding futures contract traded on the Chicago Mercantile Exchange (CME). It will take around 13 milliseconds for a price move on the NYSE to have an impact on the future's price: by optimizing the material connection between the two marketplaces, HFTs can react faster (typically, in around 8 milliseconds, see Borch, Bondo Hansen & Lange, 2015) and earn a small profit on every such single trade. This means that firms are investing in the fastest technology to transmit data between exchanges. MacKenzie (2014) has portrayed the construction of fiber-optic cables and the latest developments of microwave technology to shave off a few milliseconds in the transmission of data. That of cause creates an arms race where everyone needs to keep ahead of technological developments, for instance microwave transmission (Sniper in Mahwah, 2015): this creates a pressure for all market participants to adopt them. Thus, by studying how liquidity and price formation have been historically and socially shaped, SSF have identified path dependencies and historical lock-ins that make some technological developments irreversible. These are crucial aspects of a cultural approach of HFT.

However, a cultural approach is by definition not a structural or deterministic one, but looks at the dynamic of path-decencies and path-deviations. Thus, the pressure to adopt certain technologies, to conform to an emerging or existing infrastructure, does not result in coherent and homogenous trading practices. HFT is not a monolithic culture; just as there are different types of HFT (Hagströmer & Nordén, 2013), there are various cultures of HFT. To date, the majority of investigative texts have been produced by sociologists working in the SSF tradition, and focus on dedicated aspects such as the reconfiguring effects of market automation on social structures (Beunza & Millo, 2015), the historical development of HFT (MacKenzie, 2015), the differentiated contexts giving rise to HFT practices (MacKenzie, 2014) or, in a slightly different perspective, on the embedded politics of computation borne by such object (Golumbia, 2013) and the problematization of trader subjectivities (Borch and Lange 2016). There is indeed still plenty of room for complementary and alternative studies on HFT: hence this special issue intended at investigating HFT and its cultures (broadly understood), and surveying its manifold dimensions through shared questioning, and gathering scholars from a range of disciplines, sharing algorithmic trading and HFT as a fieldwork. Together, they contribute to a small but growing literature, which explores the different aspects of automated trading as a diverse cultural phenomenon. The issue's contributions focus on the micro- and the meso-level of cultures, organizations and the situated social interactions that make up the sphere of HFT.

HFT subjects, in the end, have a reduced access to market because of all the mediations necessary to just act in such arena. Often, HFT operators lose grip on their tools contributing to the shaping of market reality (e.g. MacKenzie, 2014 and 2016). What is at stake here is the ability of HFT subjects to make sense of the objects sitting at the core of market reality, the way they construct these objects by recourse to technologies, numerical languages and algorithmic codes, and the consequences of their actions. If market operators are responsible of their actions, how does such responsibility materialize in a context where something acts on his/her behalf, while at the same time he/she remains in no capacity to access the spaces where the delegated act takes place? How is it possible for him/her to understand, accept and acknowledge responsibility issues? How does HFT modify the way we can conceive of the subject/object debate, and what are the consequences of HFT on representation?

We contend these questions are of particular importance, as they become increasingly relevant in contemporary societies at large, opening questions reaching far beyond the domain of financial markets, addressing issues relating to the proliferation of automated processes and their manifold entanglements with our daily lives. Because of the speed and the amount of data that is processed, HFT is a particular illustrative case presenting itself as one of the most advanced techniques grappling with such issues. This is why HFT can serve as an exemplary case for the study of algorithmic cultures.

Developing a cultural approach to the study of HFT

In terms of its broader contribution to economic sociology, this special issue deals with a number of questions relating to market automation and the emergence of HFT. What challenges does HFT pose for traditional sociology and its research methods? What are the implications of financial automation for epistemological and moral discourses, discussions of agency and notions of criminal intentionality? How is technology shaped by, and how in turn does it shape specific cultures within financial markets? How do we conceptualize 'automated sensemaking'? On the one hand, if algorithms are in fact interacting agents, the increase in HFT raises questions like: Who makes sense of market events, who makes decisions, and who is ultimately accountable for them? How might we hold algorithms responsible, and what and how to define criminal intentionality in such an environment? The discussions clearly move beyond the trader and his/her algorithms – as if it was a technological device operating on his/her behalf. On the other hand, attributing all agency to high-speed algorithms, which are not that sophisticated also seems to stretch the argument a bit too far.

Recently, Hardin & Rottinghaus (2015) have suggested the need to study financial technologies beyond the STS-oriented approach that, in their opinion, has been prevailing in the SSF tradition. While some of their insights are interesting, we think it worthwhile to engage and discuss some of the assumptions they make, not only because they present very common criticisms on HFT, but also because they make use (once again) of the typical critiques that have been most recently raised in studies of HFT in the social sciences. A comparison with their Marxist perspective

taking HFT as the latest technology allowing for the appropriation of political power and financial gains will help elucidate the shortcomings of applying such normative perspectives uncritically.

In their article, Hardin & Rottinghaus characterize the SSF perspective on technology as a 'tools of coordination' approach, and underline the fact that such take on technology 'has resulted in an overemphasis on coordination as the means and end of technology in financial markets without fully considering the multiple ways in which technologies constitute the epistemological and material conditions of financial practices' (2015, p. 548). While it is certainly true that some classical SSF articles have explicitly focused on coordination mechanisms, such perspective is far from being the only one present in the SSF: for instance, Godechot (2016) developed a Bourdieusian-informed analysis of the trading room, while Beunza & Millo (2015, p. 40) underline the 'key role of power and politics at the macro-organizational level, pointing to the importance of regulators and Exchange management in the design of automation'. In addition, such studies also have shown how the emergence of algorithmic trading has been accompanied by a power struggle within trading firms, e.g. between financial engineers ("quants"), IT personnel, traders and salespeople (Wansleben, 2012, p. 254; Godechot 2016, p. 417). These are just a couple of examples drawn from an extant body of SSF literature studying technology in ways that cannot be caricatured as being limited to the 'tools of coordination' approach put forward by Hardin & Rottinghaus (2015).

This point has been made clear in a number of works many years ago: de Goede (2005, p. 25) advocated that the SSF 'is not, nor should it be, a coherent research program with a singular objective or politics', but 'first and foremost an interdisciplinary forum for discussion and debate, enabling dialogue and disagreement between researchers in a diversity of disciplines who share a fascination for money, and who may otherwise not have easily engaged'. Later, Preda (2008, p. 917) stated quite rightly 'SSF (which comprises different emerging paradigms) cannot be seen as a mere extension or as an application of science and technology studies to finance'. These views have been recently reaffirmed by Chambost, Lenglet & Tadjeddine (2016) in an edited collection of contributions rooting in a diversity of academic disciplines ranging from sociology to heterodox economics, through anthropology, management studies and philosophy.

This allows for disseminating concepts outside of their core disciplines, thereby helping fostering debates and developing a critical perspective on financial practices (and not only financial markets – as the SSF are often mistakenly associated with the study of trading rooms).

This is what makes the relevance of the SSF: exchanging views on financial subjects with recourse to qualitatively informed descriptions – as there is nothing more critical than a good description. Indeed, while performing ethnographies is not the only way for producing an SSF account of a financial object, many studies falling under the SSF umbrella make use of ethnography as a major tool of inquiry. Spending some time with financial practitioners does not amount, however, to embracing their parlance, epistemic cultures and beliefs with a lack of critical distance (Hardin & Rottinghaus, 2015, p. 548), nor can it be assimilated to the reinforcing of a technocratic system (Beunza, 2015). On the contrary, it is by trying to unfold what is essentially invisible – and in this respect, black-boxed high-speed algorithms are paradigmatic – that a critique of financial practices can develop. A good example of such a view would be, for instance, Ortiz' study of financial imaginaries, showing that the notions partaking to the limited repertoire of financiers are indeed themselves objects of inquiry: just as 'we cannot consider "investors" as embodied subjects; rather, we must understand the concept as part of a complex set of procedures and technical, moral, and political justifications in a specific professional setting. The same is true of the concept of market efficiency and related financial crises.

Without clarifying what we mean by these concepts in our own analyses, we risk reproducing the financial imagination of the processes that we are observing' (2014, p. 47). It is here that we find the power of the SSF approach to financial technologies, in that it fosters a multiplicity of approaches, better described as an interdisciplinary approach. The study of epistemic differences and situated practices of market participants, of the transformative effects of diverse technologies, of historical path dependencies and lock-ins, makes such approach also a comparative cultural analysis. In addition, algorithmic processes are always also entangled with processes of making sense of the market. Thus, instead of a mere positivist description of technical processes such analyses take 'meaning' seriously, the meaning that is inscribed into the various algorithmic practices and technologies. As in other cases, HFT technologies need "to

decide what, in a sea of information, is meaningful, relevant" information (Langlois, 2012, p. 100), out of which they construct knowledge. Such processes of making sense of the market, through algorithms or otherwise, have transformative effects insofar as the market activities result from such processes of sense making.

Related to meaning and sense are other aspects that have been analysed in earlier studies on algorithmic trading, for instance the collapse of sensemaking through conflicts of numerical and semantic codes. Such sense making can be unintentional, see e.g. Lenglet (2011), Lépinay (2011) and Seyfert (this issue) but they can also be strategic, as a method to confuse competitors (see Lange, this issue). Identifying such *conflicting codes*, *strategically applied forms of ignorance* and *incompatible epistemic regimes*, requires critical distance. It engages with the various forms of meaning making of different actors, and shows how their situated use of information leads to different constructions of knowledge in each respective milieu. It shows how this leads to conflicting assessments about market events such as the Flash Crash. It also shows that semantic aspects are inseparable from technical ones. However, it is important not to limit cultural issues with power, just as it seems equally important to differentiate critical perspectives from normative views. While inequality is very often the result of power relations and while power relations are certainly an element in financial markets, a critical and comparative analysis of financial markets can show that inequality is sometimes also the (intentional or unintentional) result of different ways of making sense of markets. In such a perspective the power relations within particular organisations (e.g. between financial engineers, developers, IT personnel,traders, etc.) are far more relevant than generalized claims about HFT as the latest advancement of global capitalism.

We believe that these precisions answer to the proposals put forward by Hardin & Rottinghaus (2015), by resituating the effective contribution of SSF scholars – which obviously do not all belong or make use of 'orthodox' STS methods. This, in turn, does not mean we do not acknowledge the importance of *in situ* observations in the field, on the contrary: the papers making this special issue are one possible expression of this nuanced view.

Historical, Organizational and Regulatory Perspectives

Even if estimated HFT revenues amount to approximately 2 billion dollars a year (Bloomberg, 2013) – less than a single bank's annual bonuses (Pardo-Guerra, 2014), HFT, as an industry, remains especially secretive. As with any 'black-boxed' object, HFT is a difficult area to investigate, even with a history of successful access to industry actors (e.g. MacKenzie, 2014). The problem of trusting informants and a more general problem of how to account for the functions that the algorithms actually perform is an issue of concern. However, as stated above, access to study the sociality of HFT is not only a methodological concern but is also an analytical one. In general, market activities are especially opaque affairs, and each actor interprets such activity according to his, her, or its own observation, construction, and shared knowledge of markets. Because of this opacity, 'knowledge cultures' are always also 'cultures of non-knowledge' (or ignorance) worthy of study in their own right. The issue is not so much about opening the black box to discover what is hidden inside, but to look at how such cultures of knowledge are produced and with what effects. As in many other areas, in algorithmic trading the infamous black box is actually not one box but multiple boxes: algorithmic cultures are 'contingent on the *in-betweenness* of a plethora of actors, both human and non-human' (Roberge & Seyfert, 2016). Connecting a vast number of actors will necessarily lead to unpredictable interactions, resulting in misalignments and unintended effects.

In addressing these issues each article focuses on a different theme, so as to shed light on a specific aspect of HFT. In so doing, this special issue is structured so that the articles build upon one another towards painting a coherent picture of where HFT came from, what it involves, and what its significance is. The different cultures of knowledge are bound not only to the scopic media and technological devices used (Knorr Cetina 2014), but also to the interests and motivations of different market actors. Thus, the contributions discuss a range of cultures in HFT from the shared knowledge of traders in a trading room, to compliance officers and financial regulators, and even include the construction of knowledge by nonhuman actors. Financial regulations are especially interesting because they show how social and cultural influences shape the market structures that undergird trading practices. This analysis of cultural conditions is

particularly important in the case of HFT, because HFT itself plays an active role in the constitution and construction of contemporary markets.

The first theme relates to the history of HFT in order to situate HFT in terms of the entangled transformations in technology and financial market structure that provided the ground for the rise of HFT. Castelle, Millo, Beunza & Lubin address a transformation in the way economic transactions are carried out and focus on how the emergence of HFT reconfigured the roles of exchange platforms facilitating transactions. The particular case in point is the approval of alternative execution venues under Regulation Alternative Trading System (Reg. ATS). They identify Reg. ATS as a pivotal episode triggering the disruption of the 'traditional' functioning of financial exchanges (represented by the trading floor). The resulting change in regulatory and legal discourses redefined financial exchanges in such a way that gave electronic trading organizations access to customers' orders, liquidity flows that previously had been available only to exchanges with trading floors. This step contributed to an exponential growth in the popularity of electronic trading, to a shifting in trading practices from trading floors to computerized trading and, ultimately, to trading floors and computer-based trading platforms being pitted against each other in a competition for speed of execution. Taking their point of departure in social studies of finance they write a sociology of the exchange in order to analyze how exchanges also form a production market (as they sell the facilitation of a continuous exchange of goods). They claim that such markets are becoming ever more standardized to nothing more than symbols in a computerized database.

The underlying premise of the paper is an important one. Because what Castelle et al.'s study show is that the current market infrastructure has emerged not only from technological evolution but was influenced by pitched battles between different elites, with different motivations and intentions, and was accompanied by political contestations and deliberations.

It is in a similar manner that Lenglet & Mol introduce us to the fact that financial intermediaries operate as more than just intermediaries, i.e. a neutral technique by which one is allowed to execute a trade. The second paper thus takes us into the current regulatory landscape of automated trading and takes its point of departure in the EU's revised directive on markets in

financial instruments (MiFID/MiFIR), based on ethnographic fieldwork and regulatory documentation. They present the case of Shibboleth Securities, a brokerage firm that provides market access to clients. They describe the 'Blackbox', an algorithmic device that Shibboleth Securities designed to rationalize its clients' market order flows. With reference to Latour's distinction between mediators and intermediaries (1994, 1999) they analyse how the Blackbox acts not only as a neutral device (an *intermediary*) but also as an actant altering the course of market access (thereby serving as a *mediator*). Rather than a mere machine that obeys as instructed, the Blackbox constitutes a sociomaterial assemblage of how financial regulation is performed *in situ*. Studying regulatory compliance at the site of financial practice enables them to assess how financial regulations like MiFID and MiFIR are currently being taken up within the financial industry, thereby providing an aperture on their efficacy vis-à-vis the challenges posed by high-speed trading.

The following two papers present an inside view on HFT, based on extensive ethnographic fieldwork in high-frequency trading firms. They investigate secrecy on the one hand and the uses of algorithmic tools to understand and make sense of practices when the tools don't work on the other hand. They are both concerned with the epistemic cultures or regimes of HFT in relation to what is called 'anti-epistemic', i.e. the 'study of non-knowledge or how knowledge is deflected, covered and obscured' (McGoey, 2012, p. 3). While the field of epistemology explores the nature and limits of the production of knowledge, both articles follow its opposite: the nature of the social and political practices embedded in the effort to kindle new forms of not-knowing (as when the tools the traders use to make sense of the market get disrupted).

Lange addresses the organizational culture of secrecy and analyses the secrecy of HFT black-boxes as an organisational artefact rather than a technical-rational code. Her article treats the use of information about others' trading behaviour: how it is protected and how such information is also generated, sought and copied. When trading with algorithms (especially high-speed algorithms) it only takes a few minutes for someone to download all the codes and make use of the trading strategies in another firm. Lange makes a counterargument to the way the SSF approach has dealt with the issue of ignorance as being coupled to the notion of imitation, itself understood as a strategic act, i.e. when traders are replicating the strategies of other traders.

Instead she considers ignorance itself as a strategic unknown and investigates the kinds of imitations that might be produced from the various structures of not knowing (the attempt to divide, to obscure and to protect knowledge) at stake in HFT.

Aside from the focus on secrecy and imitation, the focus inside HFT firms is also very often centred on the access and use of high-frequency data (Brownlees & Gallo, 2006). In his contribution, Seyfert takes up the issue of irregular trading patterns that are seen as a symptom of the problematic nature of HFT. He contends that market actors have often very different interpretations of such irregular trading patterns (manipulation, predation, errors), which are not simply related to a lack of information (e.g. about the inner workings of black boxes). Rather, they depend on the *epistemic regimes* of different market participants situated within diverse ecological milieus constituting the market. Seyfert defines epistemic regimes with reference to the general affective attitude (suspicion, worries etc.) of market participants and the way they gain market information and turn this information into knowledge, for instance which calculative collective devices (Callon & Muniesa, 2005) and technological regimes (Zaloom, 2003) they are operating with. Instead of aiming at full informational access and a grand unified theory or view of HFT, he suggests that it might be worthwhile to focus and compare the multiplicities of corporate and individual perspectives.

While Lenglet & Mol, Lange and Seyfert's articles foreground the importance of *in situ* investigations of HFT, the special issue concludes with a paper by Coombs, focusing on the subject of representation itself, central to all theories of algorithmic trading. Exploring the case of the German HFT Act from 2013 where it became a requirement that the algorithms responsible for generating trading decisions be tagged with a numerical code, he explores how the financial algorithm became constituted as a governable object. This study poses some more fundamental questions about financial representation dealt with by the regulators such as: 'what is an algorithm?' and 'what is a material change in an algorithm?' Coombs tells the story of how regulators found solutions to these questions by drawing on the knowledge infrastructures of trading firms and explores the social and political dimensions of regulatory knowledge construction under the condition of generalised epistemic uncertainty.

The themes that run through all the papers in one way or another relate to such epistemic uncertainty, which is based on one particular promise (made not only by high frequency traders but in algorithmic cultures in general), namely, objectivity and profitability, e.g. through the use of numerical codes and material infrastructures. Gillespie for instance notes, 'more than mere tools, algorithms are also stabilizers of trust, practical and symbolical assurances that their evaluations are fair and accurate, free from subjectivity, error, or attempts at influence' (Gillespie, 2014, p. 13). The extent of this promise becomes particularly obvious when it remains unfulfilled or when it is contradicted in effect by algorithmic practices – that is, when algorithms fail. Again, the events of the Flash Crash are a particularly apt example. The event has been explained by so called 'hot potato effects', where the same positions were rapidly passed back and forth by trading algorithms (CFTC & SEC 2010, p. 3), and it has been visualized on the screen through images later referred to as 'crop circles' and 'the knife' (Madrigal, 2012). The imaginaries of HFT might also be analysed in their metaphors and mythologies, which are especially obvious given the ubiquity of vivid languages around the financial markets. Thus, a cultural perspective on HFT might perhaps develop a *metaphorology* in the sense of Hans Blumenberg (2010), and a 'history and mythology […] of the algorithm' in the sense of Roland Barthes (Daston, 2004, p. 362). Such analyses remain to be done, and we hope this special issue of *Economy and Society* fosters interests for further research in algorithmic cultures.

Acknowledgments

This special issue has evolved out of a series of international workshops, which took place at Copenhagen Business School in 2014 and at the University of Konstanz in 2015 (the concluding workshop will take place in Paris in 2016). Contributors' research has been funded by a number of European and national-level research councils. These include the 'Crowd Dynamics in Financial Markets' project funded by the Danish Research Council for Independent Research the 'Evaluation Practices in Financial Markets' project funded by the European Research Council, the 'Governing Financial Algorithms' project funded by the UK's Leverhulme Trust and the 'Risk, uncertainty and non-/knowledge in the financial market' project funded by the Cultural Foundations of Social Integration Center of Excellence at the University of Konstanz.

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