Taylor & Francis Online

Home ▶ All Journals ▶ Social Sciences ▶ Economy and Society ▶ List of Issues ▶ Volume 47, Issue 4 ▶ 'Making', 'taking' and the material poli ....

Economy and Society ›
Volume 47, 2018 - Issue 4

Articles

'Making', 'taking' and the material political economy of algorithmic trading

Donald MacKenzie

Pages 501-523 | Published online: 27 Nov 2018

Cite this article https://doi.org/10.1080/03085147.2018.1528076 Check for updates

Full Article Figures & data References Citations Metrics Licensing Reprints & Permissions View PDF Share

Abstra

Drawing ... frequency trading (... een algorith ... ids to buy and offe ... ialize in 'taking' ... The paper expl ... ateriality of that ... esting the importar ... aping of that trad ... t could be different

Keywords

Article contents Related research

high-frequency trading materiality market-making algorithm material political economy

social studies of finance

In many of the world's most important financial markets, most trading is now by algorithms.[1] The trading pits of the nineteenth and twentieth centuries, crowded with human beings, are now almost all closed. Humans still trade with keyboard and mouse, but in many markets most trading is now by computer algorithms, especially ultrafast high-frequency trading (HFT) algorithms. The transformation is still being digested. There is a growing literature in economics on HFT (most recently reviewed by Menkveld, 2016), and a smaller but vigorous sociological literature, the best collection of which is in the May 2016 special issue of this journal, 'Cultures of high-frequency trading' (Lange et al., 2016).

This paper makes four contributions to the sociological literature on HFT. The first is to highlight the diversity of HFT practices. While the special issue and the insightful examination of algorithmic cultures in Seyfert and Roberge (2016) are careful to invoke 'cultures' in the plural, the best existing treatment of diversity (Seyfert, 2016)

compare ... ulators and
of marke ... mong the
practice ... ortant
divide w ... HFT
algorithr ... that
specializ ... changes'
compute ... executed)
and fi ... ring orders
that

The divi ... but is
actually ... titioners of
automat ... alysis of the
divide h ... points out,
also in t ... 016). When

standard parts of sociology's disciplinary repertoire could be applied to trading (as, e.g. in the classic application of social network analysis by Baker, 1984). What, however, might it mean – theoretically, methodologically – to apply economic sociology to algorithms trading with other algorithms? In the wake of Callon's and Latour's actor-network theory (with its major influence on economic sociology via the work of Muniesa and many others: see, e.g. Callon et al., 2007; MacKenzie et al., 2007), it hardly seems satisfactory to say that we sociologists will study the human beings who program and supervise the algorithms, while leaving to others the investigation of the algorithms themselves and of how they interact – even if, as noted below, that investigation involves methodological difficulties. The second contribution of the research reported here is thus its identification of four distinct styles of algorithmic 'taking', each associated with a distinctive form of making/taking interaction. Only one of these forms of interaction – the 'picking-off' of 'stale quotes': see below – has previously been researched in any depth (by Budish et al., 2015).

The paper's third contribution is its empirical investigation of the material nature of making/taking interaction. Although the authors of the May 2016 special issue would all agree that HFT algorithms interact materially, attention to materiality in the existing sociological literature on HFT has been limited. (The researcher on HFT most sensitive to materiality is the anthropologist, publisher and graphic designer Alexandre

Laumoni ... rope by
HFT's m ... ccess of HFT
firms, it ... and
technica ... years that I
came to ... ialism
comes, ...
anthropo ... a, 2015).
One e ... one might
call ... rds (the
years of ... lol's The
body mu ... eriality is not
given or ... (2010), a
material ... ed not
involve ... The
material ... es and

processes, via which materiality takes shape, that involve human beings as well as non-human ‘actants’.

An ‘enactment materialism’ is analytically suitable because it supports this paper’s fourth contribution: its investigation of what I will call the ‘material political economy’ of the interaction of trading algorithms. How HFT algorithms interact materially is strongly shaped by the technological systems within which interaction takes place, and how such a system is designed is ‘political’ in the sense of, for example, Law and Mol’s ‘material politics’: it involves ‘a material ordering of the world … that contrasts with alternative and equally possible modes of ordering’ (Law & Mol, 2008, p. 141).[3] Different possible orderings can have substantially differential effects on ‘making’ and ‘taking’ (there are, e.g. a number of influential efforts materially to favour ‘making’ algorithms). Those orderings can be matters of economic ‘life or death’ for HFT firms, says one interviewee, and are, as argued in the conclusion, of wider importance too. I use the term ‘material political economy’ here to refer to this issue: economically consequential material orderings to which there are alternatives.[4] The politics of economic life takes a large variety of forms (monetary, ideological, coercive, legal, regulatory, party-political, social movement, and so on), but among them – perhaps increasingly so – are these material orderings. They remain underexplored, even in the actor-network inspired literature on ‘performativity’: the latter term’s origins in the

linguisti … eive of it as
a discurs
simultar

Precisely … olitical’ in
the abov … sputes can
take plac … ot take a
position … ng’ and
‘taki … s (e.g.
Foroo … alternative
material … s follows.
After thi … I
introduc … tions on
each of … pe
making/ … section, the

Data sources

As already suggested, it is not straightforward to find high-frequency traders prepared to be interviewed in any depth about HFT's material practices. One of my interviewees, for example, tried unsuccessfully to persuade an acquaintance to speak to me: 'even though he left over a decade ago, he signed paperwork going in and out of the company to keep quiet and also he (nor anyone) wants to get back on [X]'s radar because he has the money and ability to create legal issues for former employees that speak' (email from interviewee MI, 26 June 2017; X is a founder of the HFT firm for which my interviewee's acquaintance had worked). Gradually, however, I identified, primarily via snowballing, 72 practitioners of HFT – mostly in the world's main centres of the activity: Chicago, New York, London and Amsterdam – who were prepared to be interviewed in varying degrees of technical depth (14 on more than one occasion; seven of them three or more times), along with 29 suppliers of technology or communications links to HFT. Other interviewees included exchange staff, regulators, etc. Interviewees are anonymized in what follows via two-letter labels.

Interviewing has limitations when it comes to understanding HFT algorithms and how they interact. When human beings did deals on trading floors, sociologists could not

only qui ... nse see
algorith ... s can be
negotiat ... out their
understa ... uments).
For exan ... entify
arbitrage ... he exchange
more ch ... wered 'not
really' ... 'd just be
mak ... 'will move
down fo ... why.

Fortunat ... espect. In
contrast ... ransaction
betweer ... form of an
electron ... viewees'

Article contents

Related research

sell from each other also enables some aspects of this qualitative, sociological enquiry to be checked against the results of quantitative research on HFT by economists.

A brief introduction to high-frequency trading

HFT firms are typically recently established and small. Only a handful date from before 2000, and some firms that have a major presence in HFT have fewer than 150 staff; even an HFT firm with around 50 staff can be a significant player. To my knowledge, only two firms heavily engaged in HFT have more than 1,000 staff, and both also do things other than HFT. Some big banks used to be active in HFT, but their efforts were often less than fully successful: the rapid development of the necessary fast, highly specialized software systems can be difficult in a large, bureaucratic organization. Banks are still active as automated 'market-makers' – see below – in some classes of financial instrument (such as foreign exchange), albeit typically using systems that are slow by HFT standards, but 'taking' strategies in HFT by banks have effectively been ended by the post-crisis constraints on banks' proprietary trading.

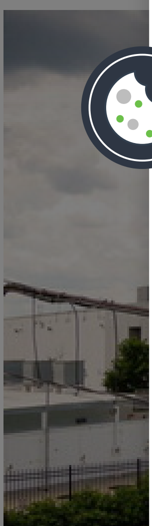
The HFT firms I have visited vary widely. Some had offices in bland or even scruffy buildings; others had spectacular views over Lake Michigan, Manhattan or London. Most
of their ... lly have
somethi ... are mostly
young a ... one wears a
business ... aring a tie –
and the ... s is rare. The
internal ... ies. Some
operate ... rader's
profit ... its traders
and ... ta that
informs ... other HFT
firms are ... rs to
commun ... ng a row of
administ ... noise
between ... ng what is
said by ... ung trader

(interviewee AC), ‘you … could get in trouble for being in the next room talking to someone you’re not supposed to talk to’.[6]

High-frequency materially happens not in HFT firms’ offices, but in exchanges’ computer datacentres.[7] Around two dozen datacentres globally host the vast bulk of the world’s financial trading. For example, almost all US financial futures trading happens in the datacentre shown in Figure 1, while nearly all the automated trading of other financial instruments (shares, currencies, Treasury bonds, etc.) takes place in a further seven datacentres in northern New Jersey. Four datacentres in the United Kingdom – in Slough, Basildon, the City of London, and London’s Docklands – host major exchanges; a fifth, Interxion’s datacentre on London’s Brick Lane, is popular with HFT firms because of its central location and proximity to the London Stock Exchange’s systems. The most important datacentre for HFT on the Continent is FR2 in Frankfurt am Main. These datacentres are huge warehouses, largely windowless, packed with many thousands of computer servers, powerful cooling systems to extract the heat the servers generate, mile upon mile of cabling, and almost no human beings beyond a few maintenance and security personnel. (Because of tight security, visits to datacentres are hard to arrange, but I have been able to visit two of them.)

Figure 1 The datacentre of the Chicago Mercantile Exchange, the most important in global fin… travel to New Jers… e to the datacen… ght of the picture.

Source: … s-edition-2018/.

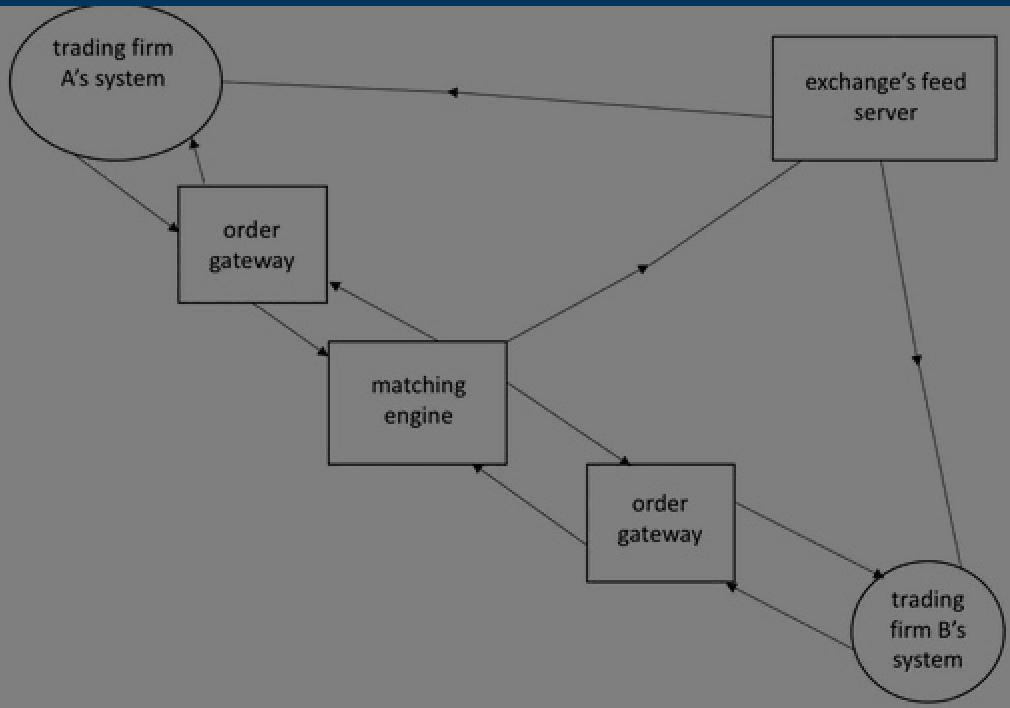


Display full size

Although the internal spatial layout of datacentres varies, there is considerable structural similarity among exchanges' technical systems (see Figure 2). The heart of any modern electronic exchange is its 'matching engines'. These are computer systems that maintain the 'order book' for each financial instrument that the exchange trades. For a 'human-eyes' visual representation of an order book, see Figure 3, but all modern order books are simply data files: ordered lists of all the bids to buy and offers to sell the financial instrument being traded that have not yet been executed. HFT firms normally 'co-locate' their trading servers: install them in the same datacentre as the exchange's matching engines. Bids to buy and offers to sell by the algorithms running on HFT firms' servers (and their cancellations of bids and offers) take the form of electronic messages to the exchange's systems, and arrive at the matching engines via exchange computers known as 'order gateways' (see Figure 2). An exchange's 'feed servers' or 'market data publishers' are computers that receive streams of order-book updates – transactions, new orders, cancellations of orders – from the matching engines, and dispatch them in anonymized form as a datafeed, sold to trading firms, that enables them to synthesize their own constantly updated mirrors of the exchange's order books.

Figure 2 n in which
electron s (and
cancella em a
'confirm system to
learn as ges) not
involvin , and an
ultrafast

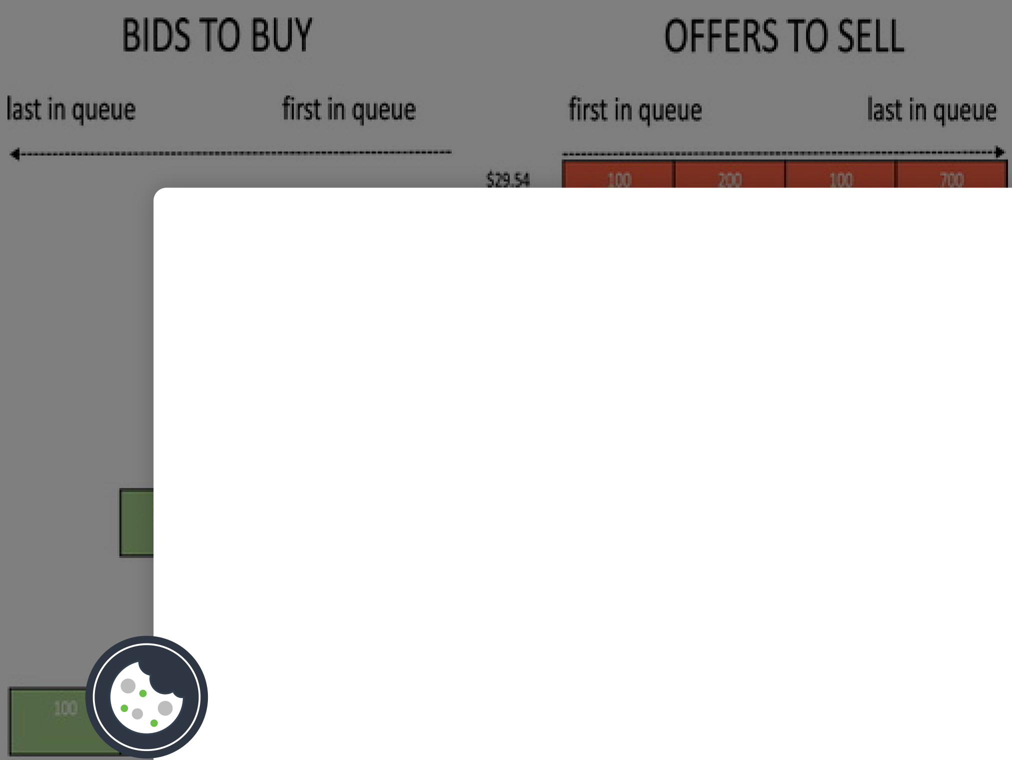
Article contents | Related research



Display full size

Figure 3 An order book.

Source: Author's interviews and observations of trading.



Display ful

Makin

Article contents
Related research

Most of the direct and indirect interaction of trading algorithms is mediated by order books – for exceptions, see MacKenzie (forthcoming) – and what differentiates a ‘making’ from a ‘taking’ order is its price relative to that of the existing orders in the book. Consider the order book in Figure 3. A bid to buy shares at $29.49 would be a ‘making’ order. The matching engine cannot execute it immediately, because there are no offers to sell at that price to match it with. Instead, the matching engine would simply add it to the order book’s queue of bids at $29.49. In most exchanges, that queue is a time-priority list: a new bid to buy at $29.49 will be executed only when all earlier bids at that price have been executed or cancelled. In contrast, a bid to buy at $29.50 would be a ‘taking’ order. The matching engine can execute it straightaway (perhaps only partially if it is large), because there are offers to sell at that price. Doing so removes these existing orders from the book: hence the terminology of ‘taking’.

In an exchange of the sort in which HFT is prevalent, most ‘making’ and most ‘taking’ orders are placed by algorithms. The core mechanism of direct interaction among trading algorithms is this straightforward process of matching: ‘taking’ orders being matched with (executed against) ‘making’ orders at the same price. That mechanism is so simple that it is hard to imagine that much pivots on it, and the difference between the prices of a ‘making’ and a ‘taking’ order on a modern electronic exchange is normally very small (the one-cent difference in Figure 3 between a bid that ‘makes’ and
a bid tha … ughly that
size are … nced by
some pa …
intervie… nique: ‘I tend
to want … herent evil in
the “tak…

The ‘mo… ematic form:
‘ma… o buy and
offers … st offer
price. In … o buy 100
shares a… 0 might
both hav… ne goal is
economi… with any
paymen… mic ‘making’
inherits … r’, who

Article contents
Related research

constantly stood ready both to buy the financial instrument being traded and to sell it (at a somewhat higher price).

Because other market participants' bids and offers arrive only sporadically, market-makers – whether human or algorithmic – provide a service to market participants who want to transact immediately. Interviewee OH highlights the continuing potency of that source of legitimacy when she recounts an episode in her algorithmic market-making firm at the height of the global financial crisis of 2007–2008. A software developer had left her firm, saying: 'I couldn't look my grandmother in the face anymore and say I worked in finance'. The firm's chief executive called a trading-room meeting of all its employees, and (as my interviewee recollects) told them, 'I'm going to explain to you why you should be able to look your grandmother in the face: because we're market-makers and we provide liquidity'. Another interviewee (OG, who managed to shift another algorithmic market-making firm towards 'taking' strategies) describes the resistance he faced from the firm's traders: 'ask them, do we market-take? "No, no, no", as if you asked them if they would stab their sister, really strongly against that. But we had to change'.

Specialists in 'taking' reject this 'moralization' of making (as indeed do some specialists in the latter). They (e.g. interviewees BY and CU) cite taking's central role in what economists call 'price discovery': its role (via arbitrage, as mentioned above) in keeping
prices in … s to those
who wis… cheaper
than 'ta… ave no
trading. … g able to
'look yo… cessful
market-… gorithm
repeate… odically get
run … , or sells
when …

The risk … mall gains)
has two … ntory' (its
aggrega… l your
inventor… ill 'shade'
its bids … e been

that fails, it may begin to 'take': in this example, reducing its inventory by executing against existing bids in the order book. (That occasional need for a market-making algorithm to 'take' is one of the ways in which the divide between 'making' and 'taking' is not absolute).

Second, almost all market-making algorithms make predictions of near-future price movements, and use those predictions to minimize the risk of being 'run over'. As BL says: 'markets move and you need to know when they're going to move because [otherwise] you'll be inventorying at a terrible price'. In all the markets in which HFT is active there are a number of classes of 'signal' that algorithms employ to predict price changes: see Table 1 for the main classes used in share trading. These signals need 'squashed', as BM put it: to inform how an algorithm trades, they need reduced to a single indicator. Although a variety of mathematical forms of 'squashing' are in use, HFT interviewees consistently report that by far the most common is for algorithms to combine signals via what is essentially a linear regression equation, in which a set of predictor variables (here, signals) are each 'weighted' so that in combination they best predict the value of a single 'dependent variable'. In HFT, that variable is a near-term prediction of the price of the financial instrument being traded, based on signals of the kind listed in Table 1. One market-making HFT firm, London-based XTX Markets, even advertises the salience of regression. I assumed its name was one of the quasi-

acronym that it was ,

a pervas atrix by its

transpos

Table

Downl

Noth d my

interview ediction is

between utside them.

Blending t is more

usual to making' or

'taking': s'

(intervie up of

separate trading groups reported that those groups focused either on making or on taking, not both:

> I think there is just something that's so different about having to have an opinion all the time [a market-making algorithm has constantly to be making decisions about its bids and offers] versus occasionally having an opinion [a taking algorithm needs only to identify the intermittent circumstances in which taking will be profitable] … for some reason those two things can't really be married without somehow ruining an aspect of the other one (AG).

The specialization in either making or taking reported by interviewees is confirmed by the literature of financial economics on HFT. There are large differences among firms in the proportions of their algorithms' trades that are making and taking, differences that are broadly stable through time: it is unusual for a firm mostly to 'make' in one month, then mostly 'take' in the next.[8] A preference for 'making' or for 'taking' can indeed be 'hard-wired' into an HFT firm's technical systems. Interviewee CE, for example, reports discovering this when he experimented with implementing 'taking' algorithms in a leading 'making' firm:

> [I]f you're trying to do something different than the system was conceived and built in the first place, you spend an awful lot of time and energy trying
> nd the first
> educe
> can't do
> code … Very,

Tak
(int

'Taking' … scussion of
differenc … ng situations
in which … er book will
be profit … s and the
next thr … er amounts

Article contents Related research

are mathematically more sophisticated. If, by doing this, a ‘taking’ algorithm can improve on ‘making’ algorithms’ price predictions, then there will be profit opportunities. These are not there continuously, but interviewees (e.g. BY) report that when they arise ‘taking’ algorithms typically buy or sell substantially larger quantities of the financial instrument being traded than ‘making’ algorithms do.

Interviewee CU gave the example of a ‘taking’ algorithm trading 10-year US Treasury bond futures in the Chicago Mercantile Exchange’s datacentre, shown in Figure 1. The algorithm will take into account the pattern of bids, offers and trades in those futures, and patterns in the trading of the other Treasury bond and interest-rate futures also traded in that datacentre. The algorithm will receive, via microwave links, data on the buying and selling of the underlying Treasury bonds, which are traded in two datacentres in New Jersey. Via Hibernia Atlantic’s new, ultrafast transatlantic cable, it will receive data on UK gilt futures (traded in the datacentre in Basildon) and German sovereign-bond futures, traded in Frankfurt’s FR2. Data on Japanese government bonds will come from a transpacific cable and yet more microwave links. The algorithm will continuously fuse all this information into a prediction of the price of the futures it is trading, ‘taking’ when it looks profitable to do so.

All of this information is also available to the ‘making’ algorithms of at least the larger market-making firms. The latter’s algorithms, though, have to be ultrafast (and

therefor ead of the
time-pric stale and
being pi arket-making
firm, put er words
very fast contrast
seldom a ue position’,
therefor at the
mark

That spe g’ than in
‘making consistent
with the CU,
however aking firm
‘begins redictive
pattern. ophisticated

‘taking’ discussed in this section is at one end of a spectrum; at the other end is the ‘taking’ discussed in the next section.

Taking II: picking-off stale quotes

The web, touched on in the previous section, through which the world’s financial information flows is strongly structured: some places – some ‘centres of calculation’ in the sense of Latour (1987) – are much more important than others; what happens in them has direct, highly predictable, and largely unidirectional effects. I chose the Chicago Mercantile Exchange’s (CME’s) datacentre for Figure 1 because it is the single most important such place worldwide. For reasons explored in MacKenzie (2018) large transactions on the CME, or significant changes in the contents of its most crucial order books, typically presage changes, both locally in that datacentre and worldwide, that immediately render many market-making algorithms’ bids or offers out-of-date (‘stale’). If that happens, a ‘taking’ algorithm has no need for complex modelling: it can simply ‘pick off’ – profit by trading against – knowably stale bids or offers. The archetype of this simple, ultrafast, form of taking (discussed by many interviewees and by Budish et al., 2015) is when the price of one of the share-index futures traded in the Chicago Mercantile Exchange’s datacentre – especially the most important such future, the ES, which co[...]es or falls. As discusse[...]edth of a second I[...]g shares (especia[...], which are composi[...]kets in those shares a[...]a ‘taking’ algorith[...] universally unde[...]nilar ‘picki[...]

‘Picking-[...]cancel stale bids or o[...]quotes. In Decemb[...]time needed from an [...]nds (milliont[...] now 300 now feasible.[9] (A nanosecond is a billionth of a second, the time it takes the fastest physically possible signal – light in free space – to travel a mere 30 centimetres.) Picking-off is one of the two most important material drivers of what interviewee CR calls 'an endless race' (Budish et al. [2015] call it an 'arms race' in speed); the other driver is the competition among 'making' algorithms to be at the front of queues. Given the current material arrangements of trading, the speed race imposes unavoidable costs on almost all HFT firms. It requires them, for example, to use microwave, millimetre wave or atmospheric laser links – via which signals travel at almost their speed in free space – rather than fibre-optic cable, the material of which slows light to around two-thirds of its free-space speed.

Hence the influence of rain on the interaction of algorithms. The microwave links that carry futures prices from Chicago Mercantile Exchange's datacentre to the share-trading datacentres in New Jersey can fail when it rains. Consequent effects on the interaction of HFT algorithms have had two distinct phases. Traces in price data of the first phase, in 2011–2012, were found by economists Shkilko and Sokolov (2016). In that phase, a number of HFT firms had created microwave links between Chicago and New Jersey, and seem to have used them above all for 'picking-off' the stale prices of market-making algorithms still dependent on fibre-optic cables. When rain interrupted the microwave links, those 'making' algorithms were able to resume market-making without ... d measures
of liquidi ...

The seco ... created a
new mic ... stest
available ... eodesic, or
great cir ... points).
McKay h ... any of the
priva ... naking firms)
has g ... his second
phase, t ... ersed. Now,
if it rains ... ns cannot
know fo ... failed. So,
reports ... articipants
put it: re ... so lowering
the risk ... of

Note that – in line with late ANT's 'enactment materialism' – the vulnerability of microwave transmission to rain is not a fixed physical effect: it increases as higher frequencies are used. Of the frequencies available in the United States, microwave engineers prefer the most reliable: 6 GHz. Unfortunately, reports SJ, that band is 'crowded' near the Chicago-New Jersey geodesic (microwave signals at the same frequency can interfere with each other), so keeping close to the geodesic requires use of higher frequencies more vulnerable to rain: 11, 18 and sometimes even 23 GHz. The influence of rain on the interaction of algorithms is, furthermore, not found in Europe. The European analogue of the Chicago-New Jersey geodesic is the microwave route from London to Frankfurt's FR2. (Perhaps fortunately for the generally unappealing prospects for UK finance post-Brexit, Hibernia's undersea cable – via which the fastest signals arrive in Europe from Chicago and the other US datacentres – makes landfall in the United Kingdom, near Brean on the Bristol Channel. The signals arrive in Greater London before transmission to Frankfurt.) McKay Brothers was able to build its London-Frankfurt link using only 6 GHz, so rain has little effect and 'making' algorithms in Europe therefore do not need to widen spreads when it rains as their US counterparts need to (SJ).

Taking III: market impact trading

The abo… …action
between… …rms of
'taking' … …e future
actions … …algorithm
reflexive… …s. One
version … …tuations in
whic… … will 'cut
their … …ble price) if
prices m… …ed firm's
algorith… …swipe' (CR)
the orde… …ce levels, so
driving t… …ories at
tempora… …e scale of
the trad… … in the

It’s amazing, you see those swipes and they’re huge swipes, millions and millions and millions of dollars underlying value, and if you look at it, the actual profit of one of these trades is $2,000 or something like that. (CR)

Taking IV: cat and mouse

‘Swiping’ is a crude, aggregate way of exploiting predictable behaviour by other algorithms, but ‘taking’ algorithms can also do this far more subtly. Predictability can, for example, arise from ‘making’ algorithms’ pervasive use of linear regression equations to combine widely-used signals (of the kind in Table 1) into a price prediction. As interviewee AJ said, ‘taking’ can involve an algorithm predicting other algorithms’ predictions: ‘What do you think the [price prediction] will be in a minute, in 30 seconds, in a millisecond, in 10 minutes?’ If a taking algorithm can anticipate the typical prediction, it can anticipate how other algorithms will react. If, for example, market-making algorithms are trading the ‘ES’ (the index future corresponding to the S&P500 share index), they will very likely be receiving ‘signals’ from the market for the ‘NQ’ (the index future, also traded in the Chicago Mercantile Exchange’s datacentre, corresponding to the Nasdaq-100 share index). A ‘taking’ algorithm can predict movements in the market for the NQ (for example, by analysis of the balance of bids and offe[illegible] predictions of the al[illegible]e moveme[illegible]ook imbalan[illegible]om which it can prof[illegible]

Even mo[illegible]ecific marke[illegible] of cat and mou[illegible]entified, and observe[illegible]nventory limit and[illegible]can then take on [illegible]a profit against [illegible] trade, will typically[illegible]e, one cent per shar[illegible]een

A ‘taking’ algorithm successfully playing a ‘game of cat and mouse’ with a specific ‘making’ algorithm is perhaps the most demanding computationally of all the forms of taking. The volumes of data generated by financial markets are huge (and anonymous), and established statistical techniques such as linear regression are not well suited for identifying the ‘signatures’ of specific algorithms in these masses of data: more recent machine-learning techniques are needed. Also required is a powerful grid of multiple computers on which to implement these techniques. This grid can run ‘offline’ (with programs running overnight or at weekends if necessary) when ‘signatures’ are being searched for; the ‘taking’ algorithms that are the result of this research have to be simpler to run – as they have to – on a single computer and fast. They are, however, not very simple. Here, the state-of-the-art technologies that are a result of the speed race are used not to achieve nanosecond reaction times but to permit more complex computation. As CG puts it: ‘speed allows you to do complicated things in the same time’ in which ‘others do simple things’.

The game of algorithmic ‘cat and mouse’ traditionally relied on human intelligence – ‘one of our traders has a friend who works on that [firm’s trading] desk’ (BM) – and the human capacity to spot ‘hints of [order] size, timing, what price levels, how they hedge’ that are characteristic of a firm’s algorithms (BM). More recently, however, machine learning techniques have, as noted above, started being applied to the ‘game’. This is
facilitate … st people’s
[comput … taken by an
HFT firm … change a
new ord … reasonably
constant … sly masked
by incon … ’ in
exchang … . Precise
atomi …
dete … allows
fuller co … ave,
however …

Altern…

As far as I can tell, this ‘unmasking’ is an inadvertent material effect, not one sought by those who run exchanges. They are, however, by no means always neutral observers of how ‘making’ and ‘taking’ algorithms interact. When they intervene it is most usually to encourage ‘making’. There is no evidence in my interviews that this is because they regard ‘making’ as ‘more moral’ than ‘taking’. Their fear, rather, is of ‘empty screens’ (interviewee GI) – order books devoid of bids and offers – which make an exchange fatally unattractive to traders and institutional investors. Sometimes, exchanges encourage ‘making’ with economic incentives: for example, small payments (known as ‘rebates’) to those who place ‘making’ orders that subsequently are executed against. Sometimes, too, exchanges protect making algorithms from HFT ‘takers’ by having rules that constrain the latter. For example, the new European stock exchange, Aquis, has a rule banning proprietary trading firms from ‘taking’. Its chief executive told the Financial Times that ‘aggressive predatory trading’ was damaging ‘posted liquidity’, that is, the numbers of ‘making’ orders in its order books (Stafford, 2016).[10]

From the viewpoint of this paper, however, the most interesting intervention by exchanges in making/taking interaction is their use of material devices. The most famous such device (highlighted in Michael Lewis’s 2014 best-seller Flash boys) is a 60-kilometre coil of fibre-optic cable installed by the new US stock exchange, IEX, through which all incoming orders to IEX (and all market data from IEX) have to pass, slowing
them do ... r’s famous
example ... r, 1999, pp.
187–188 ... en ‘making’
and ‘tak ... hat did not,
however ... pants in the
United S

Also dee ... osal from
anot
imple ... naking’
orders a ... ff of the US
stock ma ... pproved the
proposal ... sion, which
was ther ... tre of a
furore a ... bought by
the Inter ... it remains

As a result, the introduction of material devices and procedures to shape making-taking interaction has mostly been found in foreign exchange trading, in which there is no need to seek regulatory approval and in which banks, with their slow technical systems, are still important market-makers and retain considerable power and influence. The most sophisticated of these devices is a module, described by interviewee GS, that was added to the Thomson Reuters trading system in 2016. The module examines incoming buy and sell orders for each of the currency pairs being traded, classifies them as either 'taking' or 'making', and adds them to the corresponding buffer.[12] The first order to enter an empty buffer starts a 'timer' that runs for three milliseconds (thousandths of a second), at which point the buffer is emptied by sending the bids or offers it contains to the matching engine in a random order.[13] Randomization stops, e.g. the fastest market-making algorithm always getting to the head of queues, and, crucially, cancellations of orders are not placed in a buffer, but sent to the matching engine immediately. This gives substantial protection to market-making algorithms: if the market moves, they have three milliseconds (a long time, by HFT standards) to cancel their stale quotes before they are picked off.

Conclusion: material political economy

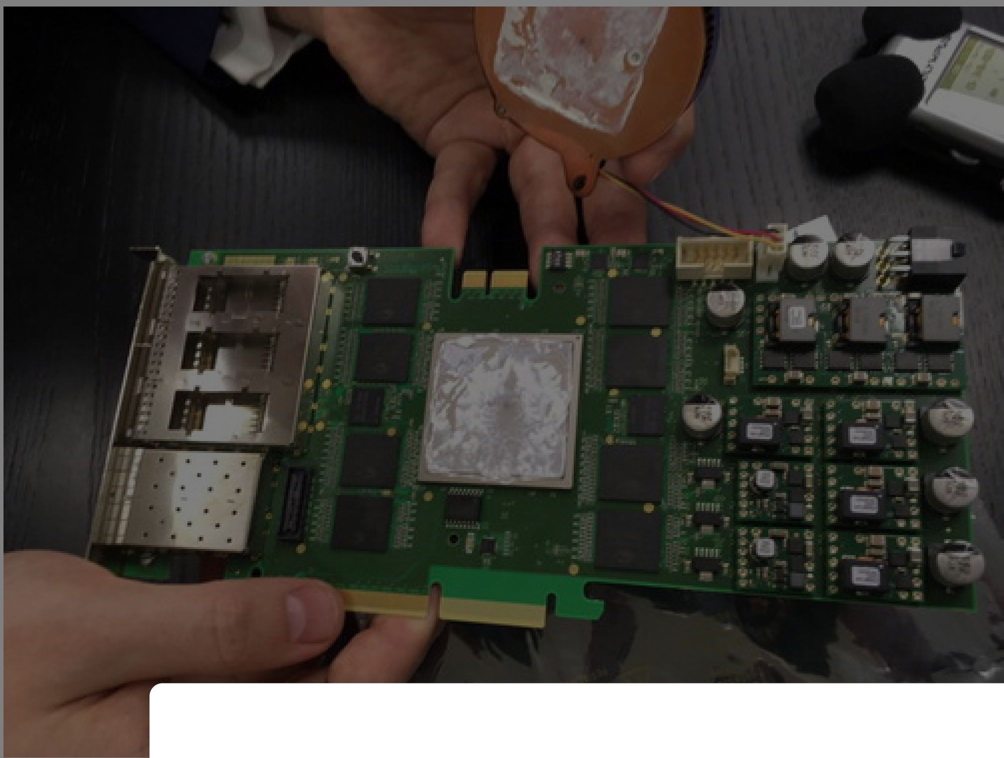
The inst… …ertheless
exempli… …he
possibili… …equential
ways. In… …ms race in
speed in… … any one
system …

That a… …so often, my
inter… … For
example… …s are no
longer i… …ecialized
silicon c… …).[15] In
February… …ow
sophistic… …have 5–10
nanosec…

> Those engineers that spend day and night on this, it’s ridiculous. It’s quite ridiculous … mind-numbing … a lot of people with extended training … shaving nanoseconds … you could put that brainpower to something else … something different. (Interviewee UC)

Figure 4 A field-programmable gate array (FPGA) in a ‘development kit’ for programming and testing. The FPGA is the large central chip with white paste on it.

Source: Author’s fieldwork photograph.



Display ful

The net between
making noted above,
one of th (Budish,
2017). M t takes the
form might
conce r other
speed-ra hat disturbs
some ins ed: either
simply t sources.

Just occa formal
political sses the east

companies owned by HFT firms applied for planning permission to build two huge – 10-foot wide, 1000-foot tall – microwave masts there. (Microwave transmission requires a direct ‘line-of-sight’ path from source to receiver, and the sea crossing from Richborough to the Continent is sufficiently long that a tall mast is needed. Without the latter, microwave links have to cross further south, where the English Channel is narrower, and that deviation from the geodesic means a transmission time that is around 10 microseconds longer: interviewee SJ.) The economic value of even an apparently minor speeding-up of an important microwave link is indicated by the promise of one of the companies to pay at least £100,000 a year to a community-managed project fund.[16] Considerable opposition was, however, sparked, involving not just those who live close to the proposed masts but also, e.g. Historic England, guardians of the remains of Richborough Fort, an important Roman administrative/military base. After much local debate, Dover District councillors voted in January 2017 to refuse planning permission for the masts.

In the case of the Richborough masts, the material political economy of algorithmic trading would have been all too visible. Such cases, however, are likely to remain rare. We are going to have to dig beneath the surface of the financial system to unearth that material political economy. One of its effects, for example, is what may become a substantial shift in Europe away from exchanges’ anonymous order books, which can

be ‘seen ... rithmic
participa ... ving webs of
bilateral ... er. In order
books, a ... vulnerable
to being ... thers’ links);
they suf ... ed if
market-... e, receiving
electr ... tutional
inves ... ng benefits
(there is ... the shift
said tha ... teral
relations ... orm of price
formatio ... executed
bilateral ... ne wants’
[intervie ... political

above. As random fluctuations in processing time are reduced, the algorithms of HFT firms without the fastest technology will ‘win the trade’ less and less often. Deterministic material systems are thus likely to be ‘winner-takes-all’ systems, with the potential to lead to growing dominance of trading by a diminishing number of ultra-high-tech firms.

The particular material political economy of HFT is new and esoteric. Even other forms of algorithmic trading do not yet manifest the extremity of HFT’s speed race, either because slow human beings remain in the loop, or technical systems and material procedures have features that limit the advantages that speed brings.[17] The underlying phenomenon of the importance of material orderings to economic life is, however, not new: slavery, after all, rested upon guns and whips, manacles and slave ships. Nor, indeed, is material political economy a novelty: volume one of Capital, with its detailed attention to the changing material orderings of production, can be read as in this genre (MacKenzie, 1984). As economic life becomes ever more algorithmic, and takes place to an ever-increasing extent in giant datacentres (let us not forget, for example, the elementary but environmentally important fact that datacentres consume huge amounts of electricity), material political economy is a tradition that urgently needs revivified.

Disclo

No poter

ORCID

Dona

Addit

Fundin

Council, under grant 291733.

Notes on contributors

Donald MacKenzie

Donald MacKenzie is a Professor of Sociology at the University of Edinburgh. His most recent book, written jointly with Diane-Laure Arjaliès, Philip Grant, Iain Hardie and Ekaterina Svetlova, is Chains of finance: How investment management is shaped (Oxford University Press, 2017).

Notes

1 The term ‘algorithm’ is used here to refer not just to a set of instructions sufficiently precise that they can be implemented as a computer program, but to that program running on a physical computer system and having material effects on other systems. For wider research in ‘critical algorithm studies’, which cannot be reviewed here for reasons of space, see the evolving bibliography at https://socialmediacollective.org/reading-lists/critical-algorithm-studies/.

2 See La … NJ, is the
location …

3 See al… Barry (2002)
on how ‘… ical’ effects
in closin…

4 A diffe… MacKenzie
(201… e ‘signals’
(pattern…

5 Practit…
‘passive… erring to
‘making… cally has to
be conti…

Article contents Related research

6 Trading teams in compartmentalized firms often welcome the separation, not wanting others, even within the same firm, to profit from ‘their’ ideas. Other reasons for strict compartmentalization include avoiding concentrations of risk caused by teams imitating each other’s trading, and persuading exchanges and regulators to allow one team’s algorithms to trade with another’s. This can easily happen accidentally, and ‘self-trading’ is normally prohibited, because it can be used to create a manipulative ‘false price’.

7 The need to limit this paper’s length means occasional inexact formulations, such as ‘exchange’: not all the trading venues in which HFT is active are registered exchanges, despite having exchange-like roles.

8 See, e.g. Baron et al. (2012); Hagströmer and Nordén (2013); Benos and Sagade (2016). Benos and Sagade, for example, use regulatory data to classify HFT participants in the London Stock Exchange as ‘passive’ (makers), ‘neutral’ or ‘aggressive’ (takers): ‘aggressive HFTs take liquidity 82% of the time, whereas the passive do so only 11% of the time’ (2016, p. 63).

9 These are what in HFT are called ‘wire-to-wire’ or ‘tick-to-trade’ times: the delay between the arrival of a price signal and the dispatch of an order or cancellation.

10 It see [illegible] er book
(intervie [illegible] d discussed
above is [illegible]

11 The r [illegible] Much trading
on IEX is [illegible] point of the
highest [illegible] ’ algorithm
detected [illegible] ight be able
profit [illegible] the midpoint
do no [illegible] ng’ order
has eme [illegible]

12 There [illegible]

13 The r [illegible] firm are
grouped [illegible] to an order
submitte [illegible] etail on the

Article contents Related research

14 In particular, Budish et al. (2015) argue that the underlying cause of the arms race is continuous trading, and propose replacing it with frequent but discrete auctions.

15 Even with the best current technology, says CR, it would take far too long (around a microsecond) to send an incoming signal from a network interface card to a conventional computer central processing unit and back again.

16 See http://www.richboroughmast.co.uk/community-benefits/community-benefit-fund, accessed 30 April 2018.

17 For example, the automated advertising auctions triggered by users' Google searches are discrete, single-point-in-time, auctions, in which, e.g. the algorithm that bids first has no advantage. There is an echo here of the material reordering proposed by Budish et al. (2015): see note 14 above.

References

1. Austin, J. L. (1962). How to do things with words. Oxford: Clarendon.

2. Baker, [...] American Journa[...]

3. Baro[...] requency tra[...]

Googl[...]

4. Barry, [...] 268–284. doi: 1[...]

5. Benos, E. & Sagade, S. (2016). Price discovery and the cross-section of high-frequency trading. Journal of Financial Markets, 30, 54–77. doi: 10.1016/j.finmar.2016.03.004

Web of Science ® | Google Scholar

6. Borch, C. (2016). High-frequency trading, algorithmic finance and the flash crash: Reflections on eventalization. Economy and Society, 45(3–4), 350–378. doi: 10.1080/03085147.2016.1263034

Web of Science ® | Google Scholar

7. Brogaard, J., Hagströmer, B., Nordén, L. & Riordan, R. (2015). Trading fast and slow: Colocation and liquidity. Review of Financial Studies, 28(12), 3407–3443. doi: 10.1093/rfs/hhv045

Web of Science ® | Google Scholar

8. Budish, E. (2017). Will the market fix the market? Speech at American Economic Association and American Finance Association. Retrieved from https://www.aeweb.org/conference/webcasts/2017

Googl

9. Budis s race:
Freque nal of
Econo

10. Ca lackwell.

Googl

11. de La luid
techn
10.11

12. Foroohar, R. (2016). Makers and takers: The rise of finance and the fall of American business. New York, NY: Crown.

Google Scholar

13. Hagströmer, B. & Nordén, L. (2013). The diversity of high-frequency traders. Journal of Financial Markets, 16(4), 741–770. doi: 10.1016/j.finmar.2013.05.009

Web of Science ® | Google Scholar

14. Lange, A.-C. (2016). Organizational ignorance: An ethnographic study of high-frequency trading. Economy and Society, 45(2), 230–250. doi: 10.1080/03085147.2016.1220665

Web of Science ® | Google Scholar

15. 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. doi: 10.1080/03085147.2016.1213986

Web of Science ® | Google Scholar

16. Latour ... ress.

Googl

17. Latour ... s.
Camb

Go

18. Latour ... ublic. In B.
Latour ... y (pp. 14–
41). C

Googl

Article contents | Related research

19. Law, J. (2010). The materials of STS. In D. Hicks & M. C. Beaudry (Eds.), The Oxford handbook of material culture studies (pp. 173–188). Oxford: Oxford University Press.

Google Scholar

20. Law, J. & Mol, A. (2008). Globalisation in practice: On the politics of boiling pigswill. Geoforum, 39(1), 133–143. doi: 10.1016/j.geoforum.2006.08.010

Web of Science ® | Google Scholar

21. Lewis, M. (2014). Flash boys: Cracking the money code. London: Penguin.

Google Scholar

22. MacKenzie, D. (1984). Marx and the machine. Technology and Culture, 25(3), 473–502. doi: 10.2307/3104202

Web of Science ® | Google Scholar

23. MacKenzie, D. (2017). A material political economy: Automated Trading Desk and price prediction in high-frequency trading. Social Studies of Science, 47(2), 172–194. doi: 10.1177/0306312716676900

24. MacKe … uency
tradin … 697318

25. Ma … tion order'
in a …

Web o…

26. MacKe … markets? On
the pe … .

Googl…

27. Melton, H. (2017). Market mechanism refinement on a continuous limit order book venue: A case study. ACM SIGecom Exchanges, 16(1), 72–77. doi: 10.1145/3144722.3144729

Google Scholar

28. Menkveld, A. J. (2016). The economics of high-frequency trading: Taking stock. Annual Review of Financial Economics, 8(1), 1–24. doi: 10.1146/annurev-financial-121415-033010

Web of Science ® | Google Scholar

29. Miller, D. (Ed.). (2005). Materiality. Durham, NC: Duke University Press.

Google Scholar

30. Mol, A. (2002). The body multiple: Ontology in medical practice. Durham, NC: Duke University Press.

Google Scholar

31. Parikka, J. (2015). A geology of media. Minneapolis, MN: University of Minnesota Press.

32. Seyfer … emic regim … . doi: 10.10…

33. Seyfer … eaning, perfor…

34. Shkilk … ng,

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2848562

Google Scholar

35. Stafford, P. (2016, February 3). Aquis Exchange bans 'predatory' high-speed trading. Financial Times. Retrieved from https://www.ft.com/content/04944696-c9d9-11e5-a8ef-ea66e967dd44

Google Scholar