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CONSTRUCTING ENVELOPES: HOW INSTITUTIONAL CUSTODIANS CAN TAME DISRUPTIVE ALGORITHMS

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The infusion of algorithms into organizational fields—accelerated by advances in artificial intelligence—can have disruptive effects that trigger defensive responses. One important response involves establishing a boundary around an algorithm to delimit its interactions with its environment—in engineering terms, constructing an "envelope." Yet, we know little about the process through which such envelopes are constructed. We address this issue by exploring how institutional custodians construct envelopes around disruptive algorithms. We empirically examine custodians' responses to the high-frequency trading algorithms that disrupted the field of U.S. securities trading, focusing on the years 2009–2016. Our inductive analysis shows that custodians created an envelope with interconnected normative, governance, and practice "layers" that jointly constrained high-frequency trading. Each layer emerged as custodians "coupled" one element of the field (e.g., its values) to one aspect of the disruptive algorithms (e.g., their impacts). Our study contributes to research on the social dynamics of algorithms by generating novel theory of how envelopes around algorithms are constructed, and to research on institutional custodianship by highlighting the constructing of envelopes as a custodial response to a wide range of threats—including, but not restricted to, disruptive algorithms.

The infusion of algorithms into organizational fields can have disruptive, often unintended, impacts: transforming practices and routines (Christin, 2020; Glaser, 2017); unsettling prevailing forms of expertise, status, and authority (Beunza, 2019; Pachidi, Berends, Faraj, & Huysman, 2021); and challenging prevailing norms and values (Lindebaum, Moser, Ashraf, & Glaser, 2022; Pasquale, 2015). These disruptive effects often trigger defensive responses to algorithms by actors who seek to protect their interests, or valued elements of specific fields (Burrell & Fourcade, 2021; Kellogg, Valentine, & Christin, 2020). One important but underexplored response to disruptive algorithms involves constructing a boundary that surrounds the algorithm—an "envelope" (Floridi, 2011: 228)—that constrains how the algorithm interacts with its environment. Rather than directly altering the algorithm,

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which is often not feasible, an envelope works by delimiting the algorithm's inputs and outputs, allowing it to function while restricting its impacts on people and communities. Despite the potential importance of envelopes in defending fields (Robbins, 2020), which becomes more urgent in the midst of advances in machine learning and artificial intelligence (AI), we know little about the processes through which envelopes around disruptive algorithms are constructed.

To explore this process, we focus on the role of institutional custodians. Custodians seek to preserve valued elements of organizational fields (Montgomery & Dacin, 2020; Wright, Meyer, Reay, & Staggs, 2021; Zilber, 2009), such as traditions (Dacin, Munir, & Tracey, 2010; Shils, 1981), identities (Howard-Grenville, Metzger, & Meyer, 2013), or values (DeJordy, 2010; Selznick, 1957). Because algorithms can disrupt these valued elements of a field (Burrell & Fourcade, 2021; Zuboff, 2019), we expect custodians to be particularly motivated to construct envelopes around disruptive algorithms to limit their influence. Focusing on the potential role of custodians in constructing envelopes also offers the opportunity to advance research on custodianship, as constructing envelopes poses distinct and underexplored challenges for custodianship—not least because the opacity and velocity of algorithms make it difficult for custodians to understand and respond to them (Beer, 2017; Kellogg et al., 2020). The likely involvement of custodians in constructing envelopes—together with the distinct challenges involved—leads us to ask: How do custodians construct envelopes around algorithms that threaten to disrupt valued elements of organizational fields?

We explore this question by studying custodial responses to the rise of high-frequency trading in the United States. High-frequency trading involves algorithms that trade securities in a fully automated way and at high speed (MacKenzie, 2018, 2021; Marti & Scherer, 2016). Around the year 2000, small startup firms began to use high-frequency trading algorithms for securities trading. By 2009, high-frequency trading accounted for more than 60% of transactions on U.S. stock markets (Vlastelica, 2017). High-frequency trading threatened to disrupt the traditional practices, governance, and values of the field of U.S. securities trading—outpacing human traders, bypassing traditional regulatory approaches, and upsetting the idea that retail (nonprofessional) investors should enjoy "fair" trading conditions. Focusing on the years 2009–2016, we draw on newspaper articles, Congressional hearings, and in-depth interviews to inductively analyze how custodians in the field of U.S. securities trading constructed an envelope around high-frequency trading algorithms.

Based on our analysis, we develop an empirically grounded process model of how custodians construct envelopes around disruptive algorithms. We show that custodians constructed an envelope made up of three interconnected "layers": a normative layer, a governance layer, and a practice layer. Each layer emerged as one type of custodian "coupled" one element of the field (e.g., its values) to one aspect of disruptive algorithms (e.g., their impacts). We further show that layers constructed in one phase motivated and resourced custodians in subsequent phases to construct further layers of the envelope. Jointly, the three layers of the envelope allowed high-frequency trading algorithms to operate while mitigating their potentially harmful impacts, thereby transforming high-frequency trading from a disruptive threat to the field of U.S. securities trading into an unproblematic part of the field.

Our study contributes to two literatures. First, we contribute to research on the social dynamics of algorithms (e.g., Glaser, 2017; Kellogg et al., 2020) by developing novel theory regarding how envelopes around algorithms are constructed. While prior research has highlighted the challenges associated with algorithmic opacity (e.g., Burrell, 2016; Pasquale, 2015), we show how an array of actors can jointly work around opacity by coupling aspects of the algorithm to elements of the field about which they are already knowledgeable. By drawing on their different forms of expertise, actors can construct envelopes without any actor completely understanding the inner workings of the algorithms. Second, we contribute to research on institutional custodianship (e.g., Lok & de Rond, 2013; Montgomery & Dacin, 2020) by identifying the custodial construction of envelopes as an important but unexamined custodial response to threats—including, but not limited to, disruptive algorithms. We thereby show that the range of custodial responses to threats is not limited to either buffering institutions (e.g., Siebert, Wilson, & Hamilton, 2017) or intervening in threats (e.g., Dacin et al., 2010). By constructing envelopes, institutional custodians may be able to steer institutional change—and preserve valued elements of fields—when threats make significant changes unavoidable.

THEORETICAL BACKGROUND

To develop our research question, we engage with two main bodies of work. First, we review the emerging organizational and sociological literature on the

social dynamics of algorithms (Glaser, Pollock, & D'Adderio, 2021; Hinings, Gegenhuber, & Greenwood, 2018) to map the disruptive potential of algorithms and actors' defensive responses. Here, we highlight the importance of constructing envelopes as a defensive response to disruptive algorithms, and the need to understand the process through which envelopes are constructed (Floridi, 2019; Robbins, 2020). Second, we draw on the institutional custodianship literature (Dacin et al., 2010; DeJordy, 2010), to explore how custodians—in particular—may construct envelopes around disruptive algorithms. From this literature, we surface the importance of the heterogeneity of custodians' responses to institutional threats, and the variety of resources on which they draw.

The Social Dynamics of Algorithms in Organizational Fields

An emerging organizational and sociological literature—galvanized by advances in machine learning and AI—has explored the social dynamics through which algorithms trigger and shape the renegotiation of practices, decision-making, knowledge, and identities (Burrell & Fourcade, 2021; Glaser, 2017). An important theme in this research is the disruptive effects of algorithms on whole arenas of social life, including industries such as ride-hailing (Cameron, 2022; Davis & Sinha, 2021) and finance (Beunza, 2019; MacKenzie, 2018), institutional domains such as policing (Brayne, 2017; Brayne & Christin, 2021), and fields such as digital advertising (Alaimo, 2022; O'Neil, 2016). We use "organizational field" as an umbrella term for such arenas, and draw on this emerging literature to understand the disruptive potential of algorithms on fields and actors' responses to such disruptions.

The disruptive potential of algorithms. Algorithmic disruptions of organizational fields can be relatively direct, as practices are recalibrated to incorporate algorithms (Constantiou, Joshi, & Stelmaszak, 2023; Gillespie, 2018; Murray, Rhymer, & Sirmon, 2021); and more indirect, as algorithms unsettle prevailing forms of expertise, status, and authority (Alaimo & Kallinikos, 2021; Anthony, 2021; Moulaï, Islam, Manning, & Terlinden, 2022) or violate prevailing norms and values (Moser, Hond, & Lindebaum, 2022; Newman, Fast, & Harmon, 2020; Scherer, Neesham, Schoeneborn, & Scholz, 2023). Such disruptions often flow from the cumulative efforts of actors to make fields more intelligible, accessible, and predictable to algorithms (Alaimo, 2022; Burrell & Fourcade, 2021; Zuboff, 2019). These efforts can involve actors recrafting practices and technological infrastructures to provide algorithms with relevant and processable data (Glaser et al., 2021; Jaton, 2021; Schildt, 2020) or making themselves more recognizable to algorithms in pursuit of algorithmically allocated status and resources (Fourcade & Healy, 2017; Gillespie, 2017). Such transformations strengthen the grip of algorithms—rendering them more impactful and better positioned to challenge human expertise (Brayne & Christin, 2021; Burrell & Fourcade, 2021).

These dynamics are illustrated by recent changes in the field of policing in the United States. Through the rise of predictive policing, algorithms direct attention and resources to specific people, or to places where crime is predicted to occur (Brayne, 2021; Glaser, 2017). Fueling the efficacy of these algorithms is an expanding web of surveillance practices and technologies (Brayne, 2017, 2021): predictive policing algorithms draw on information from a wide range of databases—including some not traditionally associated with crime control—to generate risk assessments for people and places, which are used to guide patrol decisions, information-gathering, and other police routines (Brayne, 2017, 2021; Glaser, 2017). Such changes make the world increasingly intelligible and responsive to predictive policing algorithms—while diminishing the status of police officers' local knowledge and "street smarts" (Brayne, 2021; Brayne & Christin, 2021). These changes may also have extensive and unexpected reverberations: with past arrests and convictions used to predict future criminality, predictive policing risks amplifying historical biases by over-policing specific communities (Harcourt, 2007; Jefferson, 2020).

Responses to disruptive algorithms. The disruptive impact of algorithms can prompt resistance. In the field of policing, for instance, the disruptions described above are often contested: the potentially surveilled try to evade databases used for profiling (Brayne, 2014), police officers sometimes ignore their algorithms (Brayne & Christin, 2021), and civil society actors raise awareness of the extent and impacts of algorithmic surveillance (Harcourt, 2007; Jefferson, 2020). More generally, research on the social dynamics of algorithms has highlighted a range of defensive strategies through which actors work to resist algorithmic disruption in defense of their own interests or of morally and emotionally significant elements of the status quo (Cameron & Rahman, 2022; Christin, 2017; Kellogg et al., 2020).

Perhaps the most visible defensive strategies are rhetorical or regulative. Rhetorical strategies rely, for

example, on building opposition to algorithms by framing them as unfair, biased, unjust, or intrusive (Harcourt, 2007; Noble, 2018). Regulative strategies, in turn, involve developing new laws that set limits on the collection, storage, and use of data, or the scope of algorithmic decision-making (Burrell & Fourcade, 2021; Kellogg et al., 2020). In practice, however, the opacity of algorithms—stemming from commercially driven secrecy or technical complexity—often insulates algorithms from effective critique and regulation (Buhmann, Paßmann, & Fieseler, 2020; Burrell, 2016; Pasquale, 2015). Moreover, rhetorical and regulative strategies can be difficult to pursue in the face of widely resonant discourses of technological inevitability and rationalization, as well as powerful vested interests (Davis & Sinha, 2021; Zuboff, 2019).

Other responses to disruptive algorithms focus on shaping their relationships with everyday practice (Anthony, Bechky, & Fayard, 2023; Steele, 2016; Velkova & Kaun, 2021). People may seek to insulate their everyday activities from algorithms by refusing to engage with their outputs, by challenging their validity, or by exiting contexts in which they are used (Lebovitz, Lifshitz-Assaf, & Levina, 2022; Rahman, 2021). For example, Christin (2017: 9) observed a criminal court system that offered risk-assessment instruments to guide decision-making—only to find that "none of the judges, prosecutors, or attorneys ever mentioned the scores during the hearings I observed." Efforts to shape the relationship between algorithms and everyday practice may also involve work to manipulate algorithmic outputs by starving algorithms of relevant data so they cannot function (Brayne, 2021; Brayne & Christin, 2021), producing contradictory and messy data that generate junk-like outputs (Harcourt, 2015), or curating data to produce specific desired outputs (Cameron, 2022; Curchod, Patriotta, Cohen, & Neysen, 2020; Gillespie, 2017).

Implicit in many of these strategies is an underlying dynamic that has been underexplored in sociological and organizational research: the construction of a boundary around disruptive algorithms—an envelope (Floridi, 2011; Robbins, 2020)—that delimits the interactions of an algorithm with its environment. The strategies described above tend to intervene in a localized and patchwork fashion, as when individuals manipulate specific inputs to obtain desired decisions, but these local efforts may wittingly or unwittingly contribute to more comprehensive shifts in the kinds of inputs an algorithm may receive and the kinds of outputs it can effect. When such shifts are cohesive and interdependent, they effectively construct an envelope around algorithms: they construct "physical and virtual" boundaries around algorithms that delimit their interactions with the broader environment, thus restricting their disruptive impacts (Robbins, 2020: 391). In a rare empirical study of this process, Asatiani, Malo, Nagbøl, Penttinen, Rinta-Kahila, and Salovaara (2021) showed how a Danish government agency constructed an envelope around its machine-learning algorithms by engineering technical mechanisms that established limits on its sphere of application, training data, and inputs and outputs. Beyond these initial insights, given that envelopes represent a potentially important means of constraining disruptive algorithms (Asatiani et al., 2021; Floridi, 2011; Robbins, 2020), there remains an urgent need to flesh out our understanding of the process through which actors construct such envelopes.

Institutional Custodians and the Construction of Envelopes around Disruptive Algorithms

To explore the process through which envelopes are constructed around disruptive algorithms, we focus on the role of institutional custodians. We expect that custodians may be particularly motivated to construct envelopes around disruptive algorithms because doing so can help them defend valued elements of a field (Lawrence & Phillips, 2019; Lok & de Rond, 2013; Steele, 2021), such as traditions (Dacin et al., 2010) or values (DeJordy, 2010), while still reaping the benefits of algorithms. In the field of higher education, for example, a range of actors are responding to the rapid rise of generative AI by quickly reshaping the practices and rules that mediate between the technologies and the field—in an attempt to reap the benefits of such algorithms while avoiding potential harms (Heaven, 2023). Constructing envelopes can also be a promising option for custodians because alternative defensive strategies may face significant constraints: scorched earth strategies, for example, may be tempting, but are likely to be challenged by the functional and economic benefits of algorithms, and a technocratic discourse that defends them as embodiments of rational, data-driven decision-making (Beer, 2017; Burrell & Fourcade, 2021; Schildt, 2020).

In exploring how custodians construct envelopes around disruptive algorithms, an important issue concerns the variety of ways in which custodians work to protect fields (Lok & de Rond, 2013; Steele,

2021; Wright et al., 2021) and the cumulative effects of those distributed efforts (Dacin, Dacin, & Kent, 2019; Kroezen & Heugens, 2019). Montgomery and Dacin (2020), for example, described how different types of custodians sought to preserve public water services in Detroit by engaging in different forms of work, including linking the institution to broader moral concerns, enlisting supporters through coalition-building, and surfacing new practices that could help preserve the institution's valued core. Although research on institutional custodians has addressed complex, uncertain threats (Montgomery & Dacin, 2020; Wright et al., 2021), it has tended not to focus on complex technologies like algorithms that—through their opacity and velocity, for example—may pose new and distinctive challenges (Beer, 2017; Borch & Min, 2022; Kellogg et al., 2020). These challenges may call for novel types of custodians to effectively map the boundaries of an algorithm in action and isolate its potentially damaging effects.

A second issue concerns the heterogeneous resources on which different types of custodians draw. The custodial work of regulation and punishment, for example, relies on social resources such as formal or informal authority (Crawford & Dacin, 2021; DeJordy, 2010; Lok & de Rond, 2013). When actors lack such resources, they may need to rely on rhetorical resources to motivate conformity or shame deviation from established paths (Creed, Hudson, Okhuysen, & Smith-Crowe, 2014; Heaphy, 2013). The distinct challenges posed by disruptive algorithms may mean that custodians constructing envelopes need resources distinct from those associated with more familiar settings. Custodians may, for instance, require distinct forms of expertise that allow them to understand the behavior of algorithms.

To summarize, recent writing on the social dynamics of algorithms and institutional custodianship leads us to argue that constructing envelopes represents an important but underexplored defensive response to disruptive algorithms that may be particularly relevant for custodians. Research on institutional custodianship has highlighted the importance of distributed forms of custodial work and heterogeneous resources, though there may be novel varieties of both required for custodians to effectively construct envelopes around disruptive algorithms. Against this background, we explore how custodians construct envelopes around algorithms that threaten to disrupt valued elements of organizational fields.

METHODS

Research Context

Our study focuses on the contestations around high-frequency trading that occurred in the field of U.S. securities trading between 2009 and 2016. This context is appropriate to address our research question because custodians' responses to high-frequency trading were observable and collectively successful in constraining the disruptive algorithms. To illuminate how high-frequency trading disrupted the field of U.S. securities trading, we highlight three elements of the field—practices, governance, and values—that prior research has identified as key elements of organizational fields (e.g., Hinings, Logue, & Zietsma, 2017; Lounsbury, Steele, Wang, & Toubiana, 2021).

We begin with trading practices. Prior to around the year 2000, algorithms were used to determine the prices at which investors placed orders (i.e., asset pricing) and match orders (i.e., electronic order book), but the placing of orders (e.g., buying 500 shares of IBM for $50 per share) was done exclusively by humans on trading floors, where as many as 2,000 traders operated simultaneously (MacKenzie, 2015). Around the year 2000, small startup firms began using algorithms to trade securities in what came to be known as "high-frequency trading" in public discourse and "HFT" among finance insiders (Borch & Lange, 2017). By 2009, high-frequency trading had expanded its market share of transactions on U.S. stock markets to more than 60% (Vlastelica, 2017), as its greater speed and information-processing capacity allowed previously impossible trading practices, including trading based on slight and fleeting price differences of the same security (e.g., shares of IBM) across multiple trading venues (e.g., New York Stock Exchange [NYSE] and Nasdaq).

Despite these dramatic changes in trading practices, high-frequency trading did not initially disrupt the field's governance—the "formalized systems that ensure control and compliance within a field" (Hinings et al., 2017: 176). The governance of the field of U.S. securities trading was primarily the responsibility of the Securities and Exchange Commission (SEC) and the Commodity Futures Trading Commission (CFTC), both of which traditionally focused on preventing and punishing collusion between human market-makers (Beunza, MacKenzie, Millo, & Pardo-Guerra, 2011). Such collusion occurred regularly: in the 1990s, for example, market-makers at Nasdaq fixed prices with each other to increase transaction costs for retail investors

(Christie & Schultz, 1994). As a result, the use of algorithms for trading was initially welcomed by regulators because it helped resolve the problem of collusion through the explicit paper trail it produced (Beunza et al., 2011).

Moving to the values of the field, the controversy that marks the beginning of our study initially focused on the impact of high-frequency trading on a "particular conception of fairness that is widely shared in US financial markets" (Garten, 2001: 7). This conception of fairness, established in the 1930s and still a fundamental value of the field (Bradley, 2000), focuses on ensuring retail investors have equal access to information and trading opportunities (Angel & McCabe, 2013; MacKenzie, Beunza, Millo, & Pardo-Guerra, 2012). The emphasis on retail investors is based on the idea that they represent the "weakest" market participants and that fairness to these investors gives them confidence, thereby increasing their capital inflows into financial markets, which benefits the broader economy (Garten, 2001). The value of fairness for retail investors is a distinctly American concern: the regulation of securities markets in European countries, for example, assumes that the wealth of individuals is managed primarily by large investors rather than directly by individuals, and thus focuses on creating good trading conditions for those large investors (MacKenzie et al., 2012).

Data Collection

To understand how custodians constructed an envelope around high-frequency trading, we collected data from four sources. Table 1 provides an overview of these data sources.

First, we collected a set of newspaper articles to identify who publicly responded to the rise of high-frequency trading and understand how they did so. To select relevant newspapers, we started with the 16 highest-circulation U.S. daily and weekly newspapers. For each newspaper, we counted articles that included the keyword "high-frequency trading" or synonyms ("high-speed trad*," "algorithmic trad*," "algo trad*," "computerized trad*," "flash trad*"). We then focused on the five outlets with the greatest number of articles on high-frequency trading: the *Chicago Tribune*, *Los Angeles Times*, *New York Times*, *Wall Street Journal,* and *Washington Post*. From each, we collected articles that mentioned high-frequency trading between January 2009 and December 2016 through LexisNexis, Factiva, and newspaper websites. This produced 1,512 articles, which we refer to as the "primary newspaper dataset."

Second, we collected 1,185 pages of transcripts from nine U.S. Congressional hearings on high-frequency trading. The questions of politicians and the answers provided by experts in these hearings allowed us to identify additional actors who responded to the rise of high-frequency trading and provided an in-depth, real-time account of how these actors described, evaluated, and supported or opposed high-frequency trading.

Third, we conducted semi-structured interviews with two sets of actors. Our main interviews were with 24 actors we identified (through the newspaper articles and the hearings data) as having been particularly active in responding to the rise of high-frequency trading. We were able to interview most of the actors we contacted, except for politicians, of whom we could only interview one former senator; our understanding of the work of politicians was, however, covered by the hearings data. We also interviewed two radical critics of high-frequency trading from Occupy Wall Street to understand alternative views that received less mainstream newspaper coverage. Interviews focused on how interviewees and other actors responded to the rise of high-frequency trading. In addition to our main interviews, we interviewed five regulatory experts to understand the regulatory issues around high-frequency trading. In total, we conducted 39 interviews with 29 individuals. All interviews were recorded and transcribed.

Fourth, we collected a larger set of newspaper articles (hereafter: the "secondary newspaper dataset") to explore what resources allowed individuals to respond to the rise of high-frequency trading. Based on the primary newspaper dataset and the hearings data, we identified 140 individuals who publicly responded to the rise of high-frequency trading. We then searched LexisNexis to collect all articles in U.S. newspapers that referred to any of these individuals in the period 2009–2016 (i.e., once high-frequency trading had become a public issue) and in the period 2004–2008 (to understand the social positions of actors before high-frequency trading became a public issue).[1]

[1] For the four most prominent actors (Hillary Clinton, Timothy Geithner, Bernie Sanders, and Charles Schumer), we sampled between two weeks and two months of each year and then multiplied results accordingly to make them comparable to the results of actors for which we downloaded all available articles. Without this partial sampling, the secondary newspaper data set would have been at least 10 times larger.

TABLE 1
Data Sources

Data Sources	Use in Analysis[a]
1. **Newspaper articles on high-frequency trading ("primary newspaper dataset")**	Step 1 (+++)
(1) *Chicago Tribune* (106 articles), **(2)** *Los Angeles Times* (74 articles), **(3)** *New York Times* (366 articles), **(4)** *Wall Street Journal* (823 articles), **(5)** *Washington Post* (143 articles)	Step 2 (+) Step 3 (++)
Total: 1,512 articles	Step 5 (++)
2. **Congressional hearings**	
(1) October 28, 2009: "Dark pools, flash orders, high-frequency trading, and other market structure issues" (112 pages), **(2)** December 8, 2010: "Examining the efficiency, stability and integrity of the U.S. capital markets" (195 pages), **(3)** September 20, 2012: "Computerized trading: What should the rules of the road be?" (112 pages), **(4)** December 18, 2012: "Computerized trading venues: What should the rules of the road be?" (81 pages), **(5)** April 29, 2014: "Oversight of the SEC' agenda, operations, and FY 2015 budget request" (261 pages), **(6)** May 13, 2014: "High frequency and automated trading in futures markets" (76 pages), **(7)** June 17, 2014: "Conflicts of interest, investor loss of confidence, and high speed trading in U.S. stock markets" (134 pages), **(8)** June 18, 2014: "High frequency trading's impact on the economy" (86 pages), **(9)** July 8, 2014: "The role of regulation in shaping equity market structure and electronic trading" (128 pages)	Step 1 (+) Step 2 (+++) Step 3 (+) Step 4 (++) Step 5 (+)
Total: 9 hearings (1,185 pages)	
3. **Semi-structured interviews**	
Actors who responded to the rise of high-frequency trading: **(1)** Broker (58'[b] in New York; 34' by phone), **(2)** CEO of financial data company (32' and 28' by phone), **(3)** CEO of high-frequency trading firm (55' by phone), **(4)** CEO of market research firm (53' by phone), **(5)** Entrepreneur (30' by phone), **(6)** Finance professor 1 (64' and 40' by phone), **(7)** Finance professor 2 (49' in New York), **(8)** Finance professor 3 (27' by phone), **(9)** Finance professor 4 (42' by phone), **(10)** Former executive of high-frequency trading advocacy group (55' by phone), **(11)** Former CEO of high-frequency trading firm (83' and 34' by phone), **(12)** Former chief economist of the CFTC and the SEC (60' by phone), **(13)** Former commissioner of the CFTC (63' by phone), **(14)** Former exchange executive (95' in New York; 103' by phone), **(15)** Former chair of the SEC (62' by phone), **(16)** Former high-frequency trader (148' in Connecticut area; 60' by phone), **(17)** Former Democratic senator (45' and 39' by phone), **(18)** Journalist from leading U.S. newspaper (25' by phone), **(19)** Market structure activist (84' in Philadelphia; 41' by phone), **(20)** Market structure consultant (90' by phone), **(21)** Occupy Wall Street activist 1 (49' in New York), **(22)** Occupy Wall Street activist 2 (69' in New York; 45' by phone), **(23, 24)** Two partners of a brokerage firm (58' in New Jersey area; 43' by phone)	Step 1 (+) Step 2 (+++) Step 3 (++) Step 4 (+++) Step 5 (+++)
Experts on financial regulation: **(25)** Finance professor 5 (42' in the United Kingdom), **(26)** Professor of securities law (47' by phone), **(27)** Professor of sociology of finance 1 (42' in the United Kingdom; 27' by phone), **(28)** Professor of sociology of finance 2 (49' in the United Kingdom), **(29)** Professor of sociology of finance 3 (45' by phone)	
Total: 39 interviews with 29 actors (total length of 33 hours)	
4. **Newspaper articles on key actors who responded to the rise of high-frequency trading ("secondary newspaper dataset")**	Step 1 (+++)
90,322 newspaper articles from 639 U.S. newspapers that refer to the 140 individuals whom we identified as key actors in the response to the rise of high-frequency trading	Step 3 (++)

[a] The steps of the data analysis are explained in the subsection "Data analysis." The number of plus signs indicates how heavily each data source informed each step of the data analysis.
[b] Apostrophe indicates minutes, as in 58' = 58 minutes.

This produced our secondary newspaper dataset of 90,322 articles.

Data Analysis

Our data analysis followed the tradition of grounded theory (Corbin & Strauss, 2008). All our concepts emerged inductively, but we further explored some of our emerging insights through dictionary-based content analysis of our secondary newspaper dataset (Schreier, 2012). The authors had complementary roles in the data analysis, which increases the credibility of the emerging insights (Lincoln & Guba, 1985): while the first author conducted the open coding and subsequent rounds of coding, all decisions regarding the data analysis were jointly made by the first two authors, with the third author helping to refine the analysis through critical questions (Gioia, Price, Hamilton, & Thomas, 2010). Although our data analysis involved

back-and-forth iteration between different steps, for the sake of clarity, we present our analysis in five sequential steps.

Step 1: Identifying individuals who responded to the rise of high-frequency trading. In the first step of our data analysis, we read the articles in our primary newspaper dataset to identify individuals who publicly evaluated high-frequency trading in terms of its social and economic impacts in the United States. We identified 133 such individuals and coded the 260 statements they made in terms of whether they highlighted positive or negative social and economic impacts of high-frequency trading. We used the hearings data to identify additional individuals who responded to the rise of high-frequency trading by participating in Congressional hearings. We thereby established a list totaling 140 individuals who publicly responded to the rise of high-frequency trading. Although we were concerned there may have been other actors working behind the scenes, no further names came up in our interviews to suggest that was the case.

Our interviews suggested that three resources were key to understand the position from which individuals acted: (a) public prominence, (b) specialization in the area of high-frequency trading, and (c) prior participation in public discussions of financial markets. We therefore examined the degree to which each of the 140 individuals was endowed with each resource based on our secondary newspaper dataset. We analyzed this data using dictionary-based content analysis (Krippendorff, 2012) executed with the software WordStat.[2] To measure public prominence, defined as an actor's "large-scale collective recognition" (Rindova, Williamson, Petkova, & Sever, 2005: 1035), we counted the number of newspaper articles that mentioned the individual between 2009 and 2016; higher numbers indicated higher prominence. To measure specialization in the area of high-frequency trading, we calculated the percentage of articles about an individual that mentioned high-frequency trading (based on a dictionary we created that included 18 keywords that describe high-frequency trading, e.g., "high-frequency trad*" or closely related issues, e.g., "order type*"): a high ratio indicated that the individual appeared in the media primarily in relation to high-frequency trading, which suggested a high degree of specialization. To measure prior participation in public discussions of financial markets, we restricted our analysis to the five years prior to when an actor was first mentioned in an article in relation to high-frequency trading: for this period, we calculated the percentage of articles mentioning that actor in relation to financial markets (based on a dictionary with five keywords that signaled financial market content, e.g., "capital market*" or "financial market*"): a high percentage indicated that the actor had intensively engaged in discussions of financial market issues before responding to the rise of high-frequency trading.

Step 2: Grouping individuals into five types of actors. Our main focus in this step of the data analysis was on identifying how the 140 individuals identified in Step 1 responded to the rise of high-frequency trading. To do this, we inductively coded, in the software NVivo, the newspaper, hearings, and interview data, including both the public work that actors did, often by expressing ideas in newspapers and public hearings, and their less public work, such as work to create a new trading venue. Our analysis led us to distinguish between custodians and noncustodians. Based on the idea that custodians seek to preserve valued elements of a field (Dacin et al., 2019; Montgomery & Dacin, 2020), we identified actors as custodians if they worked to protect the value of fairness for retail investors from high-frequency trading. Noncustodians resisted or opposed the work of custodians.

We identified three types of custodians. First, "guardians" were high-profile politicians, journalists, and pundits who publicly criticized high-frequency trading as unfair, which suggested intentional efforts to protect the value of fairness for retail investors.[3] Guardians were highly prominent actors with a low specialization in high-frequency trading, which explains why they problematized high-frequency trading based on its impacts without diagnosing the causes of those impacts. Second, "reformers" focused on diagnosing why high-frequency trading produced impacts that undermined fairness for retail investors, which again suggested intentional efforts to protect the value of fairness for retail investors. Reformers

[2] We added exclusion terms to disambiguate individuals with namesakes (e.g., "Michael Lewis"), and excluded lists of bestselling books as they did not contain relevant information.

[3] Whereas DeJordy (2010: 98) used the term "guardian" to describe any actors engaged in "actively working to preserve different valued aspects" of a field, we use the term more narrowly, roughly consistent with DeJordy's (2010: 86) notion of "Value-Restorative Guardianship." In line with more recent writing, we use the concept of "custodian" as the broader term to encompass different approaches to preserve valued elements of a field.

were highly specialized actors with low prior participation in public discussions of financial markets. Third, "regulators" aimed to ensure that high-frequency trading did not undermine fairness for retail investors, which suggested intentional efforts to live up to their regulatory mandate to guarantee "fairness for 'average,' small investors" (Pardo-Guerra, 2019: 257). Regulators included members of the SEC and CFTC who tended to be less specialized in high-frequency trading than reformers, and less prominent in public discourse than guardians.

We also identified two types of noncustodians. First, "high-frequency traders" tried to evade custodial efforts to problematize and constrain high-frequency trading, and included actors working for high-frequency trading firms or advocacy groups. Second, "challengers" used the controversy around high-frequency trading to promote alternative governance arrangements that would not privilege fairness for retail investors: this included, for example, actors proposing governance arrangements favoring pension funds and other large investors.

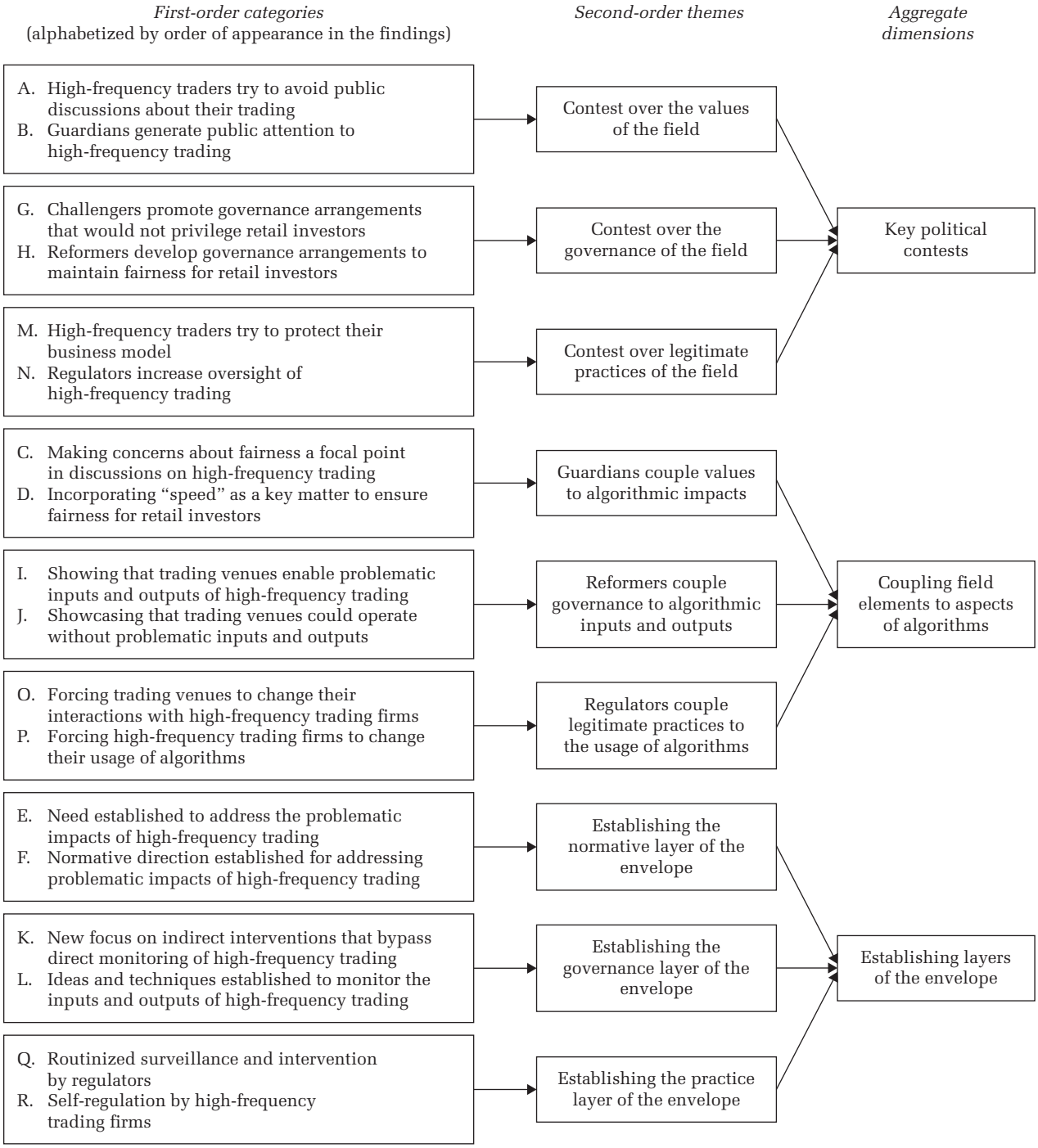
Step 3: Identifying key political contests. Using all data sources, we were able to categorize 56 of the 140 individuals into the five identified types of actors (guardians, reformers, regulators, high-frequency traders, and challengers). The noncategorizable individuals were mostly those who made only a single statement in the primary newspaper dataset and who did not appear in our other data sources. For example, the *Los Angeles Times* reported a statement on high-frequency trading by "Christopher Mroz, a 32-year-old day trader in Manhattan's financial district who invests his own money" (*Los Angeles Times*, June 22, 2013). This statement led us to include Christopher Mroz in the 140 individuals identified in Step 1 of the data analysis, but because this individual did not appear again in any of our data sources, he remained noncategorizable.

We subsequently analyzed when the different types of actors were active and how they interacted. Our coding unfolded in an iterative process from open coding to first-order categories, second-order themes, and aggregate dimensions (Gioia, Corley, & Hamilton, 2013). Our analysis showed that different types of actors were active at different points and that political contests occurred between distinct custodians and noncustodians. We thus engaged in temporal bracketing (Langley, 1999), identifying three phases. Each phase was characterized by a key political contest between one type of custodian and one type of noncustodian, as captured in the first aggregate dimension of our data structure (see Figure 1). We also identified three attention-increasing events (e.g., the arrest of Sergey Aleynikov in July 2009) that reinforced the transition from one phase to the next.

Step 4: Identifying commonalities in the work of the three types of custodians. Our analysis showed that in each of the three political contests, the work of custodians produced larger and more enduring effects than that of noncustodians. We therefore analyzed in depth the work of each type of custodian, and searched for commonalities across the work of the three types of custodians. By again moving from open codes to more theoretical concepts, we uncovered that each custodian adapted one element of the field of U.S. securities trading (its values, governance, or practices) and made this adapted element bear on one aspect of high-frequency trading (its impacts, its inputs and outputs, or its usage). We theorized this as a "coupling" between elements of the field and aspects of high-frequency trading (see the second aggregate dimension in Figure 1). For example, in Phase 1, rhetorical work coupled the value of fairness for retail investors to the impacts of high-frequency trading, thereby establishing a normative reference point for discussions of the impact of high-frequency trading.

Step 5: Identifying how coupling constrained high-frequency trading. Finally, we drew on all our data sources to analyze how the three types of coupling constrained the impacts, inputs and outputs, or usage of high-frequency trading. The coupling of the value of fairness for retail investors to the impacts of high-frequency trading, for example, established a widely shared distinction between desirable and problematic impacts of high-frequency trading, which constrained the impacts high-frequency trading could produce without raising concerns. We theorize these constraints as "layers" of an envelope (see the third aggregate dimension in Figure 1). Together, the three layers we identified constituted a boundary that constrained the disruptive algorithms and thus delimited their interaction with the field. Our analysis also showed that establishing one layer of the envelope motivated and resourced work by subsequent custodians. The gradual construction of three layers of an envelope helps explain how custodians constrained high-frequency trading.

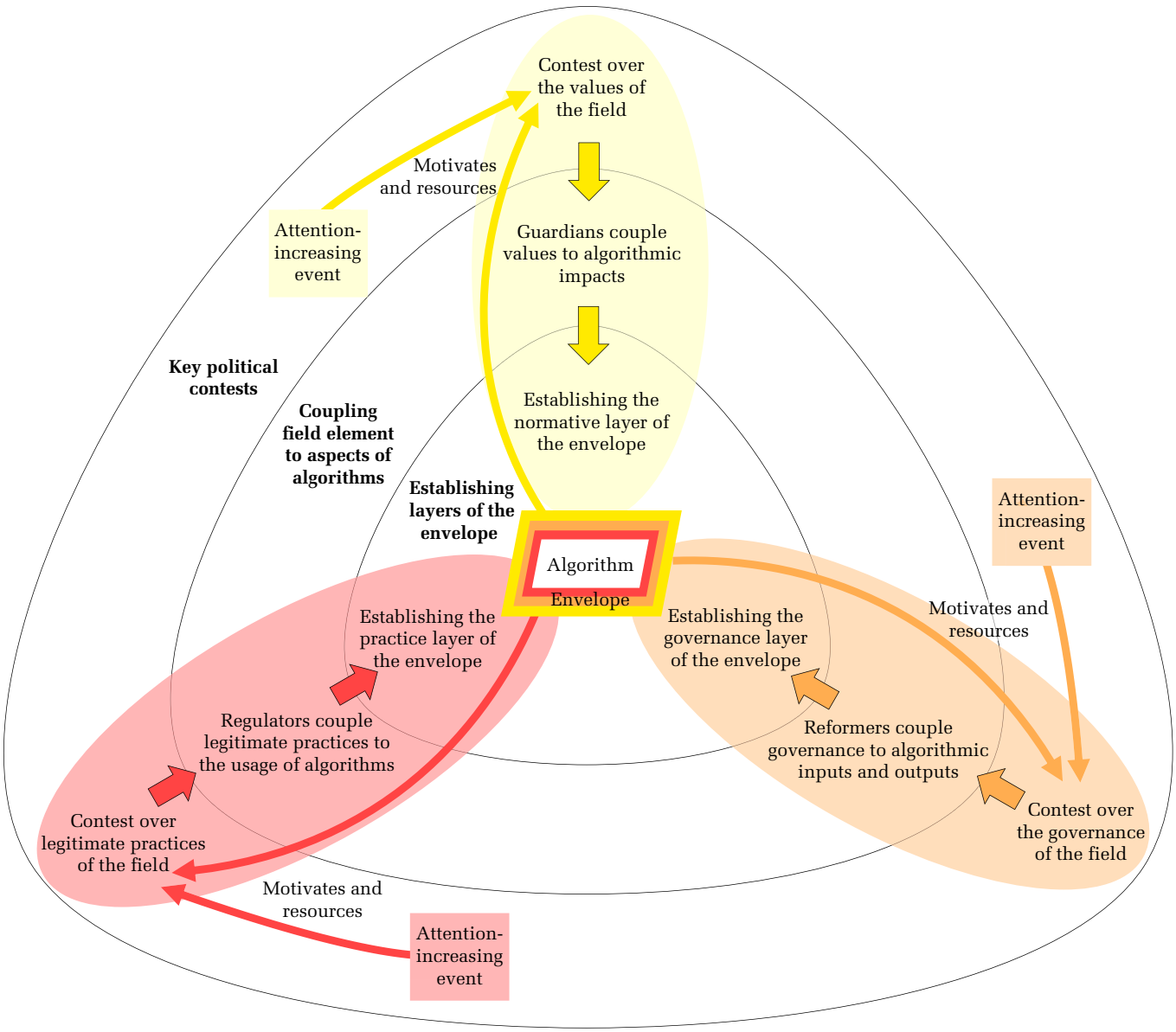
FIGURE 1
Data Structure



FINDINGS

We develop an empirically grounded process model of how custodians in the field of U.S. securities trading constructed an envelope around high-frequency trading algorithms. This process occurred over three phases, depicted by the yellow, orange, and red shaded areas in Figure 2. In each phase, custodians constructed one of three interconnected "layers" of the envelope: a normative layer in Phase 1, a governance layer in Phase 2, and a practice layer in Phase 3. The construction of each layer started with an attention-increasing event that heightened anxiety around high-frequency trading in the field of U.S. securities trading and fueled a political contest between one type of custodian and one type of noncustodian (e.g., guardians vs. high-frequency traders in Phase 1). In each phase, custodians were more successful than noncustodians, which led us to focus on how each type of custodian coupled one

FIGURE 2
How Custodians Constructs Envelopes around Disruptive Algorithms



element of the field of U.S. securities trading to one aspect of high-frequency trading algorithms (e.g., coupling the value of fairness for retail investors to the impacts of high-frequency trading). Through these couplings, custodians established distinct layers of the envelope, with layers established in one phase motivating and resourcing custodians in subsequent phases. Jointly, the three layers transformed high-frequency trading from a disruptive threat to the field of U.S. securities trading into an unproblematic part of the field. Table 2 provides additional evidence for each phase.

Phase 1 (2009–2010): Establishing the Normative Layer of the Envelope

The attention-increasing event that triggered Phase 1 happened on July 3, 2009, when the FBI arrested Sergey Aleynikov, a former Goldman Sachs programmer, for stealing proprietary high-frequency trading code. In a country still shaken by the 2007–2008 financial crisis, in which financial innovations had led to an economic depression, the arrest generated significant media attention: on July 23, 2009, a *New York Times* article declared, "It is called high-frequency trading—and it is suddenly one of the most talked-about and mysterious forces in the markets" (Duhigg, 2009b: A1). As a consequence of the arrest, some high-profile politicians, journalists, and pundits—whom we refer to as guardians—became concerned that regulators were paying insufficient attention to high-frequency trading and its potentially problematic impacts. This combination of an attention-increasing event and the awareness it created for a lack of control of high-frequency trading (see the two thin yellow arrows in Figure 2) triggered a political contest over whether high-frequency trading threatened the value of fairness for retail investors, a key value of the field of U.S. securities trading. In this contest, high-frequency traders tried to avoid public discussions about their trading, including whether it threatened this key value, while guardians worked to generate public attention to high-frequency trading. Guardians were the more successful group: their rhetorical work coupled the value of fairness for retail investors to the impacts of high-frequency trading, thereby establishing the normative layer of the envelope around high-frequency trading.

Contest over the values of the field. The key political contest in Phase 1 revolved around the question of whether high-frequency trading threatened the value of fairness for retail investors. In this contest, high-frequency traders tried to avoid public discussions about their trading, including whether it was fair, while guardians succeeded in generating public attention to high-frequency trading and questions about its fairness. High-frequency trading firms were mostly specialized startups with between 10 and 250 employees, and typically founded after the year 2000 (Bowley, 2011). A former executive of a high-frequency trading advocacy group described these firms as "basically small, scrappy, upstarts … In many senses they resemble Silicon Valley firms" (Interview). Guardians, in contrast, were high-profile actors such as Paul Krugman, a Nobel laureate economist, and senators (Democratic and Republican), including Democratic Senator Charles Schumer and Republican Senator Jim Bunning.

In this phase, high-frequency traders tried to avoid public discussions about their trading practices so they could focus on their business. The CEO of a high-frequency trading firm explained that he did not talk to journalists because, "the only way you can survive [as a startup] is to be completely focused on that business" (Interview). High-frequency traders ignored criticism, which they described as coming from a "community of ex-floor traders who used to make a lot of money as overpaid intermediaries" and had "largely been put out of business because they don't trade electronically" (Interview, former CEO of high-frequency trading firm). An important implication of high-frequency traders' low profile was that the "debate in the media was very one-sided" (Interview, former CEO of high-frequency trading firm). This one-sidedness is reflected in our primary newspaper dataset, in which 77% of statements evaluating high-frequency trading highlighted its negative social and economic impacts, while only 13% highlighted its positive impacts (10% highlighted both positive and negative impacts).

Guardians, in contrast, actively worked to generate public attention to high-frequency trading and questions about its fairness, after it had been "growing in the shadows for years" (*New York Times*, July 23, 2009). A central concern of guardians was that high-frequency trading was not being dealt with adequately by regulators. A former Democratic senator explained that he became active because, "both the major regulators, Securities and Exchange Commission and the CFTC, had not really done anything about it" (Interview). Regulators remained passive in this period because they had "no instruction [from] lawmakers in the U.S. … to deal with automated trading" (Interview, former commissioner of the CFTC) and "had no tools to monitor what was

TABLE 2
Additional Evidence

Phase 1 (2009–2010): Establishing the Normative Layer of the Envelope	
Contest over the values of the field	
A. High-frequency traders try to avoid public discussions about their trading	A1. "For a long time the view of many in the HFT industry was to put your head in the sand and hope nobody found you." (Interview, former commissioner of the CFTC)
	A2. "Sometimes when there's a debate with a very vocal crowd and there's nobody out there taking the other side of the debate, people start to believe what this very vocal minority are saying, even if it's nonsense. This is what compelled me to become part of the debate, because my peers really weren't responding to these ridiculous statements or allegations." (Interview, former CEO of high-frequency trading firm)
B. Guardians generate public attention to high-frequency trading	B1. "We made a rather dramatic change in digital trading and all of a sudden thousands of shares are being traded in a second, and the Securities and Exchange Commission and the CFTC … had really done not a whole lot to examine what [high-frequency traders] were doing and what the impact was of what they were doing." (Interview, former Democratic senator)
	B2. "Electronic trading has evolved dramatically over the last decade, and it is important that regulators keep up. For example, trading technology today is measured not in seconds or even milliseconds, but it in microseconds, or one-millionth of a second." (Hearing transcript, October 28, 2009, Senator Jack Reed)
Guardians couple values to algorithmic impacts	
C. Making concerns about fairness a focal point in discussions on high-frequency trading	C1. "I said at the time that democracy and our financial markets are the two crown jewels that make America great, and if you don't have credibility in your markets it's going to hurt your markets because it's gonna [be] perceived to be unfair." (Interview, former Democratic senator)
	C2. "High-speed trading, nothing wrong with it. It is good. To stop it would be Luddite. But it can produce certain problems in the market in terms of equality, that the little guy and the big guy have the same shake. And that is what we have to guard against." (Hearing transcript, October 28, 2009, Senator Charles Schumer)
D. Incorporating "speed" as a key matter to ensure fairness for retail investors	D1. "Some market participants are able to game the system using repeated and lightning-fast orders to quickly identify other traders' positions and take advantage of that information, potentially disadvantaging retail investors." (Hearing transcript, October 28, 2009, Senator Jack Reed)
	D2. "The major regulators … were operating at speeds [that were too low, compared to high-frequency traders] and were not collecting the information they needed to actually monitor what was happening in the marketplace." (Interview, former Democratic senator)
Establishing the normative layer of the envelope	
E. Need established to address the problematic impacts of high-frequency trading	E1. "'We want to know if people are utilizing technology for illicit purposes such as gaming the markets and getting advance knowledge of trades,' said Senator Charles E. Schumer, Democrat of New York, who had threatened to introduce legislation banning flash orders. 'Chairman Schapiro is going to attempt to separate innovations, which are good, from taking advantage of people, which must be prohibited.'" (*New York Times*, August 5, 2009)
	E2. "The term 'fair' has … been used as a dog whistle to try to get people up in arms" (Interview, former executive of high-frequency trading advocacy group)
F. Normative direction established for addressing problematic impacts of high-frequency trading	F1. "New York Sen. Charles Schumer last month said use of such orders 'creates a two-tiered system where a privileged group of insiders receives preferential treatment,' and he urged the SEC to ban them." (*Wall Street Journal*, August 31, 2009)
	F2. "Our financial markets are one of the keys to United States success … What I tried to do is talk to folks who were involved in the markets—members of Congress and also people on Wall Street—about the fact that we were risking one of the things that made America great if we didn't deal with some of these issues." (Interview, former Democratic senator)
Phase 2 (2010–2014): Establishing the Governance Layer of the Envelope	
Contest over the governance of the field	
G. Challengers promote governance arrangements that would not privilege retail investors	G1. "Who cares if you can get a great execution on 100 shares of stock—it doesn't matter, because the market won't function on 100 share executions." (Interview, former NASDAQ executive)

TABLE 2
(Continued)

Phase 2 (2010–2014): Establishing the Governance Layer of the Envelope	
	G2. "What you need to do to get a better experience for the larger investors is have a slower market with wider spreads that accumulates more liquidity … which by definition, if you create a market that's better for the Fidelitys and the Putnams and the larger institutional investors of this world, by and large it's not going to be good for the individual investor." (Interview, CEO of market research firm)
H. Reformers develop governance arrangements to maintain fairness for retail investors	H1. "I view the role of the exchange as that of a referee where their role is to understand the rules of the game, to honor those rules and to let the teams sort out who wins and loses. And in many ways the integrity of the game is destroyed if the referees are biased or are selling advantages to one of the teams or serving a purpose that goes beyond simply ensuring fairness in how that game is played." (Interview, entrepreneur)
	H2. "It should be a national public policy issue how to construct a proper, functioning, I'll say fair, national market system." (Interview, former high-frequency trader)
Reformers couple governance to algorithmic inputs and outputs	
I. Showing that trading venues enable problematic inputs and outputs of high-frequency trading	I1. "If you go look at the order type statistics, about 40% of the trades that occur in the U.S. equities market … occur through the order types that were first exposed by me … Most people who are non-HFT had never heard of those order types before I came onto the market." (Interview, former high-frequency trader)
	I2. "The attorney general [Eric Schneiderman] has zeroed in on the exchanges, including the New York Stock Exchange and Nasdaq, that permit high-frequency traders to pay to put their computer servers within the exchanges' data centers. … A number of other services provided by exchanges to high-frequency traders, including extra network bandwidth, special switches and fast connection cables, are also being examined by Mr. Schneiderman, who said the services gave the traders a 'leg up on the rest of the market.'" (*New York Times*, March 19, 2014)
J. Showcasing that trading venues could operate without problematic inputs and outputs	J1. "There are two major innovations that IEX has brought; the first is the speed bump. So, the first is a technological innovation and I think that has been disruptive, that does directly impact some trading strategies, some high-frequency trading strategies and mitigates the effects and makes them unprofitable … [Second,] they're not a maker-taker venue, they charge fees for both sides of the trade, so that's a pretty dramatic difference that reduces conflict of interest." (Interview, market structure activist)
	J2. "If you look at these traditional exchanges, most of their money is not being made from transactions; it's being made from sales of market data and market data-related services. That's not IEX's model. So it's an entirely different way of looking at what a stock exchange is, and it is a utility … Their role is to help match buyers and sellers, that's an exchange, right?" (Interview, partner of a brokerage firm)
Establishing the governance layer of the envelope	
K. New focus on indirect interventions that bypass direct monitoring of high-frequency trading	K1. "I think that … the real party to blame in this entire corruption of the stock market are the stock exchanges themselves. So, if you view the high-speed traders as capitalists who are pilfering a broken system, I view the exchanges as the actors who have purposely broken the system to sell advantages to people who are looking to pilfering." (Interview, entrepreneur)
	K2. "Exchanges accommodated HFT strategies and eliminated the diversity from the marketplace and allowed … They basically created a situation where certain types of strategies had an edge over the market that was created artificially by exchange venues that understood how to court those strategies." (Interview, former high-frequency trader)
L. Ideas and techniques established to monitor the inputs and outputs of high-frequency trading	L1. "I think IEX was the lynchpin, IEX was the biggest of all changes, it changed everything, just the way you think about markets, the way things are done, the way regulators react, has now set the tone I think for more changes to come." (Interview, partner of a brokerage firm)
	L2. "I'm not gonna try to take all the credit here, but I'm basically saying that the order type scandal and the work I did, I definitely can say that that had the most impact on changing the regulation of anything with the HFT space." (Interview, former high-frequency trader)
Phase 3 (2014–2016): Establishing the Practice Layer of the Envelope	
Contest over legitimate practices of the field	
M. High-frequency traders try to protect their business model	M1. "The HFT community has decided to finally speak out and defend their position, where I think for a number of years they decided to remain quiet and they really wouldn't say much." (Interview, partner of a brokerage firm)
	M2. "The [high-frequency traders] are finally beginning to stand up and let their voices be heard." (Interview, former commissioner of the CFTC)

TABLE 2
(Continued)

Phase 3 (2014–2016): Establishing the Practice Layer of the Envelope	
N. Regulators increase oversight of high-frequency trading	N1. "SEC Chairman Mary Jo White has vowed to ratchet up oversight of computer trading. In June, she said in a speech in New York that while technology has increased market efficiency, 'it can also allow severe problems to develop very quickly.'" (*Wall Street Journal*, December 27, 2014) N2. "[*Flash Boys*] was useful because it created a huge reception within the regulator. … Basically, it created a pressure for these organizations which had already had investigations into this area to strengthen the resources put into those investigations and to come out with results." (Interview, former high-frequency trader)
Regulators couple legitimate practices to the usage of algorithms	
O. Forcing trading venues to change their interactions with high-frequency trading firms	O1. "What did you see post-*Flash Boys*, you saw at least 20 significant market structure enforcement actions come to conclusion, including the Barclays and Credit Suisse one, I think it was $130 million total, I mean it was an enormous, an enormous result. And that result would not have been possible … prior to *Flash Boys* coming out." (Interview, former high-frequency trader) O2. "So probably the climax, I'd say, of the high-frequency trading [controversy] was in 2014 when in April, or whatever, when the Michael Lewis book came out, because now it was being marketed to the masses. You've got Hollywood actors reading it, you've got senators reading it, *everyone's* reading it and they're all coming to the same conclusion that, 'Wow, this is really messed up, <*laughs*> this is not fair and orderly.' And that public reaction has created the move by the regulators to expose a lot of the bad actors and the bad processes and to help it along." (Interview, market structure consultant)
P. Forcing high-frequency trading firms to change their usage of algorithms	P1. "To improve the oversight of high-speed traders, Ms. White said she had asked the S.E.C. staff to draft a rule requiring such trading companies to register with the agency. She also is seeking to close a loophole that allows trading companies to avoid registering with the Financial Industry Regulatory Authority, Wall Street's self-regulator, if they do their trading off traditional exchanges." (*New York Times*, June 6, 2014) P2. "There's certainly been much greater transparency in their order types and how they [i.e., trading venues] display their order types and how they define and instruct traders on how to use their order types." (Interview, CEO of market research firm)
Establishing the practice layer of the envelope	
Q. Routinized surveillance and intervention by regulators	Q1. "We just saw the Alternative Trading System Rule that was published, that's likely get effected, that requires much more disclosure from an alternative trading system about how they're matching engine works, how they're pricing orders, what conflicts of interests they have, where previously that had to report none of that." (Interview, market structure consultant) Q2. "Eventually in U.S. equities the so-called HFT players took the place of the old dealers that used to provide liquidity on a proprietary basis, but there was this in-between period where a lot of weird stuff was happening, and things got worse before they got better." (Interview, broker)
R. Self-regulation by high-frequency trading firms	R1. "I've always said that I thought [high-frequency traders] needed to be registered, that they needed to test their programs before they were used in the market production environment, and that they needed kill switches. … the HFT industry, at least some of them, are now in support of these regulations." (Interview, former commissioner of the CFTC) R2. "The SEC [got] in the minds of everybody who is trading and writing algorithms [to] think twice before they code something that might start to be at the edges of manipulation because they know they might be punished" (Interview, finance professor 4)

actually going in the markets that they were supposed to regulate" (Interview, former Democratic senator). A key resource that allowed guardians to generate public attention to high-frequency trading was their prominence in public discourse. In our analysis of the secondary newspaper dataset, guardians had the highest prominence of all actors (see Table 3). At the same time, guardians lacked expertise in relation to high-frequency trading, as suggested by their low level of specialization (see Table 3) and reflected by the former senator's statement that, "nobody knew what was going on" (Interview).

Guardians couple values to algorithmic impacts. Although fairness for retail investors was a central

TABLE 3
Resources of Different Types of Actors

	Prominence	Specialization (%)	Prior Participation (%)
11 high-frequency traders: Mean (median)	**101 (16)**	**55 (71)**	**33 (3)**
Example 1: CEO of trading firm Manoj Narang	37	100	100
Example 2: CEO of trading firm Ari Rubenstein	7	71	0
Example 3: CEO of advocacy group Bill Harts	6	100	0
8 guardians: Mean (median)	**4,279 (1,382)**	**3 (1)**	**18 (11)**
Example 1: Nobel Laureate Paul Krugman	4,495	0	11
Example 2: Democratic Senator Charles Schumer	21,294	1	9
Example 3: Republican Senator Jim Bunning	1,521	0	16
21 challengers: Mean (median)	**112 (39)**	**42 (42)**	**52 (50)**
Example 1: Market structure activist David Lauer	46	52	3
Example 2: Former NASDAQ executive David Weild	23	57	67
Example 3: Broker Joe Saluzzi	130	50	96
7 reformers: Mean (median)	**1,553 (686)**	**33 (15)**	**6 (4)**
Example 1: Entrepreneur Brad Katsuyama	101	95	0
Example 2: Former high-frequency trader Haim Bodek	6	100	0
Example 3: Attorney General Eric Schneiderman	5,927	2	4
9 regulators: Mean (median)	**546 (247)**	**23 (11)**	**29 (31)**
Example 1: SEC Chairwoman Mary Jo White	1,736	12	24
Example 2: SEC Commissioner Kara Stein	239	6	31
Example 3: CFTC Commissioner Bart Chilton	247	17	38
84 nonclassified actors: Mean (median)	**2,692**[a] **(32)**	**18 (3)**	**28 (18)**

[a] The average prominence of nonclassified actors is high because two presidential candidates (Hillary Clinton and Bernie Sanders) referred to high-frequency trading once in passing; without these outliers, the average prominence would be 382.

value in the field of U.S. securities trading (Bradley, 2000; Garten, 2001), it had remained disconnected from high-frequency trading prior to Phase 1 because the few insiders who knew about high-frequency trading tended to evaluate it in purely technical terms. Through their rhetorical work, guardians generated public attention to questions of fairness, thereby establishing fairness for retail investors as an important basis for evaluating the impacts of high-frequency trading. We describe this connection as a coupling of the value of fairness for retail investors (a key element of the field of U.S. securities trading) to the impacts of high-frequency trading (a key aspect of the algorithms). This coupling made the value of fairness for retail investors central to assessing the impacts of high-frequency trading.

The first way in which guardians established this coupling was by making concerns about fairness a focal point of public discussions of high-frequency trading. To this end, guardians made statements in public media criticizing high-frequency trading. One day after the *New York Times* first reported on high-frequency trading, Senator Schumer sent a letter to the SEC that he shared with the media. In it, he criticized high-frequency trading as unfair, writing that he "intended to introduce legislation barring the technique, if the agency failed to act" (Duhigg, 2009a). Similarly, Paul Krugman (2009) criticized high-frequency trading in his widely read *New York Times* column: on August 2, 2009, he wrote that some market participants "have been using superfast computers to get the jump on other investors." To a similar end, senators from both parties organized the first Congressional hearing on high-frequency trading on October 28, 2009. There, senators interrogated representatives from the SEC, trading venues, and asset managers. Also at the hearing, Democratic Senator Ted Kaufman warned that, "only … clear and enforceable rules can maintain the integrity of U.S. capital markets, which we all know is an essential component of our Nation's success" (Hearing transcript); and Senator Bunning argued that principles from the past still apply to high-frequency trading:

> Historically, the way we have tried to make our markets safer and fairer is by increasing transparency and access, and I think that it has worked. But in order for those principles to continue to work, the SEC must stay on top of the changing markets and update its rules as necessary. (Hearing transcript)

The second way in which guardians established this coupling was by incorporating "speed" as a key concern for ensuring fairness for retail investors. Although speed had always been a competitive concern for securities traders, with technological and

manual tactics regularly adapted to facilitate faster trading, the pursuit of speed was not previously considered a moral issue (Banner, 1997). Prior to the rise of high-frequency trading, market participants and the broader public conceived threats to fairness for retail investors primarily in terms of bad behavior, such as insider trading (Scheppele, 1993) or collusion between market-makers (Goslings, 1997). In contrast, a moral evaluation of speed was evident in the hearing of October 28, 2009: in his opening statement, Senator Jack Reed described high-frequency trading as problematic because it was a "lightning-fast computer-based trading technique" (Hearing transcript). Through their rhetorical work, guardians established speed as a moral concern, asking, "Does one firm have a right to be faster than the others?" (Interview, former high-frequency trader).

Establishing the normative layer of the envelope. Coupling the value of fairness for retail investors to the impacts of high-frequency trading established a moral basis for actors in the field of U.S. securities trading to respond to high-frequency trading. We refer to the moral ideas and arguments that guardians brought into the controversy as the "normative layer" of the envelope around high-frequency trading because they helped enact a boundary between desirable and problematic impacts of high-frequency trading. These ideas and arguments represent a "layer" of the envelope both because they worked to assert a degree of protection between high-frequency trading algorithms and the field in which they operated, and because they acted as a foundation upon which other layers of the envelope could be constructed.

The first part of the normative layer of the envelope was a need established in public discourse to address the problematic impacts of high-frequency trading. By coupling the value of fairness for retail investors to the impacts of high-frequency trading, guardians established a problem that needed to be addressed. For example, Senator Schumer opened the hearing of October 28, 2009 by arguing that the success of U.S. financial markets was due to "regulation that has historically ensured that the little guy … can be sure when he puts in an order, the price he gets is fundamentally fair" and warning that high-frequency trading may "erode the confidence in the fundamental fairness of our markets" (Hearing transcript). The mainstream media disseminated these concerns. The *New York Times* (July 25, 2009), for example, interviewed Senator Schumer, who noted that the "hallmark of our markets are that … the little guy has as much of a chance as the big guy" and that high-frequency trading "takes a dagger to the heart of that concept."

The second part of the normative layer of the envelope was a normative direction, again established in public discourse, for addressing problematic impacts of high-frequency trading. This guidance primarily came, at least initially, from establishing that speed was the problem to be addressed, an idea widely shared in newspaper articles that reported, for example, that high-frequency trading firms were "putting wicked fast computer servers next to exchanges so they can have an edge" (*Wall Street Journal*, November 2, 2009). Similarly, a 2010 cartoon depicted a race between a puzzled looking person in a tracksuit labeled "Investors" and a racecar labeled "High-frequency traders" (Schillerstrom, 2010). Our interviews show that these accounts influenced market participants. A reformer who later played a key role, for example, described how:

> Senator Schumer talking about flash trading … to me [it] created a picture of the market where certain people, based on their speed, had optionality on where to trade and where not to trade. And that started to trigger a deeper research on my part about why they were able to do that. (Interview)

Given that guardians lacked the technical expertise to propose solutions, a key contribution of their rhetorical work was providing the motivation and guidance that would allow other custodians to develop technical solutions.

Phase 2 (2010–2014): Establishing the Governance Layer of the Envelope

The normative layer of the envelope established in Phase 1 motivated and resourced other custodians—reformers—by inducing them to mitigate problematic impacts of high-frequency trading and guiding them in how to do so. This shift was amplified by an attention-increasing event—the "flash crash" of May 6, 2010, in which U.S. stock markets fell by more than 9% in less than 13 minutes before recovering nearly as quickly. The flash crash triggered a "large jump in … media coverage" of high-frequency trading (Interview, former executive of high-frequency trading advocacy group), with commentators asking whether high-frequency trading had exacerbated or even caused the crash. Together, the normative layer of the envelope and the attention-increasing event fueled a political contest over the governance of the field of U.S. securities trading (see the two thin orange arrows in Figure 2). This contest unfolded between challengers who promoted alternative

governance arrangements that would not privilege the interests of retail investors and reformers who worked to develop governance arrangements that would maintain fairness for retail investors in the context of high-frequency trading. Reformers were more successful in their pursuit: by coupling the governance of U.S. securities trading to the inputs and outputs of high-frequency trading, they established the governance layer of the envelope around high-frequency trading.

Contest over the governance of the field. The key political contest in Phase 2 was between challengers who promoted governance arrangements that would not privilege retail investors and reformers who developed governance arrangements that would maintain fairness for retail investors as a central value in U.S. securities trading. Challengers included David Lauer, the founder of Healthy Markets, a nonprofit organization advocating changes in market structure—which describes the infrastructure that underpins securities trading, including trading rules and order types (Hasbrouck, 2007)—in order to better serve large investors. Other challengers were two New Jersey brokers, Sal Arnuk and Joseph Saluzzi, who published a book detailing their concerns over issues such as the fragmentation of trading venues (Arnuk & Saluzzi, 2012). Like guardians, most challengers were critics of high-frequency trading, but in contrast to guardians, challengers sought to establish governance arrangements that would replace—rather than maintain—the value of fairness for retail investors. Reformers, in turn, worked to develop governance arrangements to maintain the value of fairness for retail investors spearheaded by guardians. Reformers included Brad Katsuyama, a former bank executive who launched the new trading venue IEX; Haim Bodek, a former high-frequency trader who became an SEC whistleblower; and Eric Schneiderman, the New York attorney general who investigated services offered by trading venues to high-frequency traders.

Challengers used the attention to issues of market structure created by the controversy over high-frequency trading to promote governance arrangements that would not privilege retail investors. Rather than supporting the value of fairness for retail investors championed by guardians, challengers argued that the rules governing securities trading unduly privileged retail investors. They proposed governance arrangements that would realize alternative values, including regulation focused on creating liquidity for large investors—because they "are the people managing retirements and massive savings" (Interview, market structure activist)—and regulation focused on the growth of small capitalization stocks to create more jobs (Weild, Kim, & Newport, 2013). Challengers were able to quickly enter the controversy over high-frequency trading because they possessed expertise, as indicated by their high degree of specialization, and had extensive prior participation in public discussions of financial market issues (see Table 3). Their prior participation made challengers known to journalists and ready to communicate their already formed views. The two New Jersey brokers (Arnuk and Saluzzi), for example, had criticized high-frequency trading in a 2005 media release largely ignored at the time; once the controversy over high-frequency trading erupted, they found a wide audience for their views, including coverage in the *New York Times* and the *Wall Street Journal*. However, despite their head-start over reformers, challengers were too heterogenous as a group to create coherent alternative governance arrangements, and thus ended up having less influence on the field of U.S. securities trading than did reformers.

Reformers, in contrast, extended the custodial work of guardians by developing governance arrangements that would maintain fairness for retail investors as a central value in U.S. securities trading. Katsuyama, for example, promoted IEX as a trading venue "dedicated to institutionalizing fairness in the market … through the use of cutting-edge technology" (Hearing transcript, June 17, 2014). Reformers were well-placed to continue the work of guardians because of the expertise they had gained through direct exposure to the problematic impact of high-frequency trading. Former high-frequency trader Bodek, for example, encountered problems because he used "the wrong order types": "I got faster and faster and faster and I was just the first guy to fall into the trap" (Bodek, 2013: 84). Similarly, Katsuyama experienced problems when trading shares that he later associated with high-frequency trading:

> In 2006, if I saw 100,000 shares of AMD offered, and I wanted it, I could go out and buy it. It was as simple as that. In 2007, if I tried to buy 100,000 shares, I would get 80,000. Then in 2008 I would get 60,000. … I can't buy or sell what I see on my screen. (Popper, 2015)

Table 3 shows that reformers had a much higher specialization in the area of high-frequency trading than guardians, which indicates their higher expertise. Table 3 also shows that reformers had much lower prior participation in financial market discussions than challengers, which helps explain why reformers were slower to enter the controversy.

Reformers couple governance to algorithmic inputs and outputs. Though reformers entered the controversy more slowly than challengers, their custodial work was nonetheless the more influential in Phase 2. Reformers worked in a setting in which regulators were unable to intervene in high-frequency trading in a way that responded to the concerns raised by guardians. A market structure activist noted that "regulators don't feel that they are able to intervene, know enough to intervene" (Interview). In 2010, SEC Chair Mary Schapiro publicly acknowledged that "we need the tools that will enable us to keep up with market participants who are placing thousands of orders per second" (Hearing transcript, December 8, 2010). In this setting, the key achievement of reformers was to diagnose how high-frequency trading was undermining fairness for retail investors and identify how the governance of securities trading (trading rules, etc.) could overcome this problem by controlling the inputs and outputs of high-frequency trading algorithms. Through this work, reformers coupled the governance of U.S. securities trading (a key element of the field of U.S. securities trading) to the inputs and outputs of high-frequency trading (key aspects of the algorithms).

The first way in which reformers established this coupling was by showing that trading venues enabled problematic inputs and outputs of high-frequency trading. Problematic inputs included new order types offered by trading venues to high-frequency traders. Traditionally, order types were limited to "market orders" to buy or sell at the current price and "limit orders" to buy or sell when a security reaches a certain price. Nonstandard order types could advantage high-frequency traders: "price-slide order types," for example, adjusted the bid or ask price depending on the price traded on different trading venues, which allowed high-frequency trading algorithms to optimize pricing more effectively than human traders (Mackintosh, 2014: 12). Trading venues catered to high-frequency traders because the latter generated high trading volume and paid high trading fees. In mid-2011, former high-frequency trader Bodek became a whistleblower for the SEC: he alleged that trading venues were providing preferential order types to high-frequency traders, claiming that "he was offered one himself when he ran a high-speed trading firm" (*Wall Street Journal*, September 19, 2012). Similarly, in March 2014, New York Attorney General Schneiderman began to investigate whether "U.S. stock exchanges and alternative trading platforms provide high-frequency traders with unfair technological advantages" (Freifeld, 2014). Problematic outputs included executing trades that were impossible for regular traders to execute. The relationships between trading venues and high-frequency traders facilitated, for instance, the execution of trades based on privileged access to data that allowed high-frequency traders to send orders before other traders and thereby "jump ahead of other investors" (*Wall Street Journal*, October 24, 2012).

The second way in which reformers established this coupling was by showcasing that trading venues could operate without problematic inputs and outputs. IEX, the new trading venue that Katsuyama launched in October 2013, played a key role in this regard. The new trading venue introduced a "speed bump" that slowed the transmission of information between the trading venue and traders by 350 milliseconds—a delay that prevented high-frequency trading from "front-running," wherein high-frequency trading orders are made ahead of other large orders to take advantage of their market effects. Furthermore, in contrast to other trading venues that rented out space in their data centers so high-frequency traders could locate their servers right next to those of the trading venue—thus receiving information slightly more quickly than other traders—IEX offered no "colocation." Through such activities, IEX showcased an alternative business model for trading venues that avoided catering to high-frequency trading. A partner at a brokerage firm noted that IEX

> is a different model. Not only the speed bump but they don't have colocation, right, they don't have all these perks that all the other changes do. There's no [colocation], there's no rebates, there's no special order types. All the toys or the benefits that [high-frequency trading firms] normally get from an exchange … are no longer there. So, it's a major change in how a market operates. (Interview)

Establishing the governance layer of the envelope. Coupling trading governance to the inputs and outputs of high-frequency trading algorithms established a technical basis for actors in the field of U.S. securities trading to manage the impacts of high-frequency trading. We refer to these technical ideas and techniques as the "governance layer" of the envelope around high-frequency trading because they provided actors with a basis for governance—by identifying and providing responses to problematic inputs and outputs of high-frequency trading. These ideas and techniques represent a layer of the envelope because, like the normative layer, they protected the field of U.S. securities trading from

the impacts of high-frequency trading algorithms and acted as a foundation for further layers of the envelope.

The first part of the governance layer of the envelope was a new focus on indirect intervention, which bypassed reliance on directly monitoring high-frequency trading. Traditionally, the governance of securities trading focused on monitoring the behavior of traders, especially potential collusion among market-makers. The concerns raised by guardians in Phase 1 about the speed of high-frequency traders resonated with this traditional concern, as it located the problem in the behaviors of (now automated) traders. The work of reformers in Phase 2 both built on and challenged this focus on speed, showing that speed in and of itself was not the problem—indeed, one former high-frequency trader went so far as to argue that "speed was a red herring. It was smoke and mirrors" (Interview). Instead, reformers showed that it was the features of market structure and the activities of trading venues that gave high-frequency trading its advantage. By the end of Phase 2, reformers had established the idea that "the stock exchanges were the biggest enablers of high-frequency trading" (Interview, entrepreneur).

The second part of the governance layer of the envelope was to establish ideas and techniques that enabled monitoring and controlling the inputs and outputs of high-frequency trading algorithms. While the new exchange IEX only ever achieved a tiny market share, it reflected a "change in philosophy" in thinking about markets (Interview, partner at a brokerage firm) by highlighting the potentially problematic role of trading venues. Similarly, the work of Bodek and Schneiderman mattered less in terms of the monetary fines against trading venues in Phase 2 (which were insignificant in size compared to fines levied in Phase 3), and more because their work shifted thinking among market participants concerning the role of trading venues in creating a level playing field. One reformer who became a whistleblower recounted how a journalist told him that, "You've changed the entire stock market by getting the regulators onto these issues" (Interview). In sum, the work of reformers made clear to regulators the possibility of intervening in high-frequency trading by constraining its problematic inputs and outputs.

Phase 3 (2014–2016): Establishing the Practice Layer of the Envelope

Along with the existing normative layer, the governance layer of the envelope that reformers established in Phase 2 motivated and resourced regulators to intervene in high-frequency trading. This shift was amplified by an attention-increasing event: the publication of Michael Lewis's *Flash Boys* on March 31, 2014. In *Flash Boys*—which was widely discussed in the media, and remained at the top of the *New York Times* bestseller list for four weeks—Lewis disseminated the idea established by reformers that regulating trading venues, rather than high-frequency traders, was key to maintaining the value of fairness for retail investors. In a television panel discussion featuring Lewis and Katsuyama, which was so widely watched in the financial community it "stopped NYSE trading" (CNBC, 2014), their opponent was not a high-frequency trader but the president of a trading venue. Together, the existing layers of the envelope and the attention-increasing event fueled a political contest over legitimate practices of the field of U.S. securities trading (see the two thin red arrows in Figure 2). This contest unfolded between high-frequency traders trying to protect their business models, and regulators, who were ultimately more successful, working to increase oversight of high-frequency trading. Regulators achieved this through enforcement work that coupled legitimate practices in the field of U.S. securities trading to high-frequency trading firm's usage of high-frequency trading algorithms, thereby establishing the practice layer of the envelope around high-frequency trading.

Contest over legitimate practices of the field. The key political contest in Phase 3 was between high-frequency traders and regulators. While high-frequency traders tried to protect their business model, regulators succeeded in increasing oversight of high-frequency trading algorithms.

High-frequency traders tried to protect their business model in various ways, most notably by forming an advocacy group. In late 2013, four leading high-frequency trading firms founded the Modern Markets Initiative, "dedicated to educating the public about high-frequency trading and modern equities" (Rubenstein, 2014). A former executive of this advocacy group explained that it tried to ensure that high-frequency trading firms would "have the same access as everybody else" given that "some of these dark pools had begun to exclude electronic trading firms, high-frequency trading firms" (Interview). Beyond this advocacy group, high-frequency traders also became more active in public discussions about high-frequency trading in Phase 3. A former commissioner of the CFTC noted that through such

efforts, high-frequency traders tried to influence potential regulatory interventions:

> [high-frequency trading firms] may not like it but they're going to be regulated and they should have a voice in how that regulation is done because after all nobody knows better than the actual people and firms that would be impacted by the regulation how they do their work. (Interview)

Notwithstanding these efforts, regulators successfully increased oversight of high-frequency trading in Phase 3. Part of what helped regulators succeed was the public pressure for regulatory interventions created by reformers and guardians. As the most prominent reformer, Michael Lewis constructed a "narrative for people to connect with who are not part of the industry, really outsiders and the public," which increased pressure on regulators (Interview, former high-frequency trader). Guardians also became active again by organizing four hearings in 2014 in which they created a sense of urgency around intervening in problematic trading venues. Katsuyama was invited as a witness to one of these hearings, and another witness described Senator John McCain as "enamored" with Katsuyama's IEX (Interview). Another senator portrayed IEX as a "free market" solution to fairness problems and noted that, "maybe this hearing will help out and more investors will take a look at finding companies like yours" (Hearing transcript, June 17, 2014). The alignment that emerged in Phase 3 between the three custodians—guardians, reformers, and regulators—helps explain why regulators successfully increased oversight of high-frequency trading.

Regulators couple legitimate practices to the usage of algorithms. As in the previous two phases, custodians—regulators, in this case—were the more influential group. In this phase, regulators' enforcement work redefined what practices were considered legitimate in the field of U.S. securities trading, thus delimiting how high-frequency trading firms could use high-frequency trading algorithms. A former chair of the SEC noted that while there had been no "change in the concept of fairness," what had emerged were "new standards and tests" to assess whether specific trading activities were fair (Interview). The enforcement work of regulators thus coupled legitimate trading practices (a key element of the field of U.S. securities trading) to the usage of high-frequency trading algorithms (a key aspect of the algorithms).

The first way in which regulators established this coupling was by forcing trading venues to change how they interacted with high-frequency trading firms. In Phase 3, regulators pursued at least 20 enforcement actions against trading venues related to high-frequency trading, while there were none in the prior phases. The SEC and other regulators, for instance, levied an $84 million fine against Credit Suisse and a $70 million fine against Barclays for claiming to protect customers from high-frequency traders on their trading platforms, while actually selling proprietary customer information to high-frequency traders (Moyer, 2016). The SEC also issued a $14 million fine against the trading venue operator BATS for failing to "accurately describe the order types being used on the exchanges" (SEC, 2015b). The massive fines led trading venues to reduce the variety of order types they offered in Phase 3. The NYSE, for example, eliminated 15 order types in July 2014 (Mackintosh, 2014). Trading venues also implemented other changes. Some trading venues, for example, copied IEX's speed bump, including the NYSE in some of its smaller trading venues. As *Bloomberg* noted in August 2016, "Speed bumps are the hot new thing for exchanges" (Levine, 2016). These constituted important changes in the immediate practical context in which high-frequency trading algorithms had to operate.

The second way in which regulators established this coupling was by forcing high-frequency traders to change how they used algorithms. In Phase 3, regulators issued fines against high-frequency trading firms, including an $8 million fine against Latour Trading for sending approximately 12.6 million illegal orders to trading venues (SEC, 2015a). Regulators also closed loopholes used by high-frequency traders. For example, regulators closed a loophole that, under certain conditions, gave traders one second to decide whether to trade against an order, which high-frequency traders used for "cherry-picking"—a move that a finance professor who testified in a Congressional hearing described as "totally legal but not right" (Interview, finance professor 3; see also McInish & Upson, 2013). A key reformer also acknowledged that "Some loopholes have closed" (Interview). These regulatory activities forced high-frequency traders to change their usage of algorithms. As a market structure consultant noted, the result was that "a lot of these really aggressive strategies that [high-frequency traders] were using quite a bit in the 2008 to 2012 timeframe have by and large really disappeared" (Interview).

Establishing the practice layer of the envelope. Coupling legitimate trading practices to the usage of high-frequency trading algorithms established a

practical basis for mitigating potentially unfair impacts of high-frequency trading. We refer to the altered definitions of legitimate practices as the "practice layer" because they acted as a boundary delimiting problematic usages of high-frequency trading algorithms. Like the other two layers, this represents a "layer" of the envelope because it served to protect the field of U.S. securities trading both on its own and in conjunction with the normative and governance layers. The effects of the practice layer were amplified by the consistency it enjoyed with the normative layer established by guardians and the governance layer established by reformers.

The first part of the practice layer of the envelope was routinized surveillance and intervention by regulators. By Phase 3, based on the work of reformers, regulators had developed a clear approach to regulating high-frequency trading that led to a "mature stage where markets are finally … becoming a little fairer" (Interview, partner of a brokerage firm). A market structure consultant noted that

> regulators have [become] much more attuned into going into firms and looking at their practices and as a result of that we're just really now starting to see some of the fines come about for issues caused back in 2010, for example. And as those things happen though, they help to correct a lot of the bad actors in the marketplace. (Interview)

Similarly, a former commissioner of the CFTC acknowledged "previously lax regulation" around high-frequency trading, and noted that "that's changing and that's a good thing" (Interview). The former high-frequency trader argued that these "enforcement actions" reduced "the honeypots of the HFT business" (Interview), which could explain why the profits of high-frequency trading had gone down substantially by the end of Phase 3 (Worstall, 2017).

The second part of the practice layer of the envelope was self-regulation by high-frequency trading firms. Regulatory pressure led "industry associations and working groups," such as the FIA Principal Traders Group, to become active in establishing "best practices" related to high-frequency trading (Hearing transcript, May 13, 2014). This industry association also supported a proposal by the Financial Industry Regulatory Authority "to require registration of associated persons who are involved in the design, development or significant modification of algorithmic trading strategies" (FIA Principal Traders Group, 2015). A former commissioner of the CFTC noted that the high-frequency traders became "willing to take their medicine and be regulated like the rest of the world" (Interview). With this, high-frequency trading had become a "boring and unprofitable part of the basic infrastructure of the markets" (Worstall, 2017). By establishing normative, governance, and practice layers, custodians created an envelope around high-frequency trading that transformed the new algorithms into a widespread but unproblematic part of the field.

DISCUSSION

We have sought to understand how custodians construct envelopes around algorithms that threaten to disrupt valued elements of organizational fields—an increasingly important question as advances in machine learning and AI gather pace. Based on an inductive, qualitative study, we developed a process model of how custodians in the field of U.S. securities trading constructed an envelope around high-frequency trading algorithms. To deepen our understanding of this process, we follow writing on grounded theory that distinguishes between substantive and formal theory (Burgelman, 2011; Glaser & Strauss, 1967). Whereas substantive theory provides an account of an empirical case, formal theory extrapolates from this to provide a more general and abstract account. In this section, we move toward a more formal theorization of the process through which custodians construct envelopes around disruptive algorithms and then discuss how our study contributes to research on the social dynamics of algorithms and to research on institutional custodianship.

Toward a Formal Theory of How Custodians Construct Envelopes Around Algorithms

To move toward a more formal theory of how custodians construct envelopes around disruptive algorithms, we introduce three ideas that extend the substantive formulation articulated in our findings. First, we elaborate on the idea that envelopes are made up of different "layers," to make the concept more portable and powerful. Second, we suggest that the construction of envelopes is a "conjunctive" process (Cloutier & Langley, 2020: 14), rather than a linear one. Third, we argue that the process through which custodians construct envelopes is open-ended, with closures—such as the one observed in Phase 3 of the Findings—being merely temporary. The three moves toward a more formal theory clarify

that our Figure 2 serves as a hinge that connects our substantive and formal theorizing: it presents a substantive theorization of our case if we read it as a complete and ordered sequence (beginning with the yellow oval to the orange and ending with the red); it moves toward a formal theory if we step away from a specific order and end point.

Our first move toward a more formal theory of how custodians construct envelopes around algorithms is to elaborate on properties shared by the different layers of an envelope. The first common property is that layers are built from specific "materials" sourced from the field in which they are constructed. For example, the guardians in our study produced a normative layer that drew on moral ideas and arguments prominent in the field of U.S. securities trading. Custodians mobilize these materials by coupling them to distinct aspects of disruptive algorithms. Second, each layer delimits interactions between the algorithms and a field in a distinctive fashion. The normative layer in our case, for instance, established fairness as a basis for evaluating the impacts of high-frequency trading (see Harmon, 2019; Kraatz, Flores, & Chandler, 2020; Ocasio, Mauskapf, & Steele, 2016). Third, each layer can motivate and resource subsequent custodians, thus leading to the production of further layers of an envelope, as when the normative layer provided motivation and guidance for the subsequent work of reformers. Together, these three properties provide a template for future studies of envelopes and how they are constructed.

As a second move toward a formal theory, we argue that the construction of envelopes around algorithms constitutes a "conjunctive" process (Cloutier & Langley, 2020: 14). While our findings describe a specific sequence in which custodians constructed layers of the envelope, we argue that in more general terms the construction of envelopes only requires the conjunction of complementary layers, without any necessary sequence, such that they together delimit the interactions between algorithms and fields. In terms of the model we propose in Figure 2, this suggests its primary dynamic moves from outside to inside—from political contests to couplings to layers of the envelope—rather than in any specific sequence of layer construction. Although our case began with guardians establishing a normative layer, other cases could begin with regulators establishing practice-based constraints on a disruptive algorithm, even in the absence of an explicit moral foundation; the resulting practical constraints on algorithms may then spark objections from advocates of the algorithms, prompting guardians to establish a retrospective normative foundation for regulators' actions; alternatively, the practical constraints may motivate reformers to work on field governance to reinforce or redirect those practical constraints. Conceptualizing our model as conjunctive, rather than linear, allows for these indeterminate possibilities and allows its use in a broader set of empirical contexts.

As a third move toward a more formal theory, we suggest that the process of constructing envelopes around disruptive algorithms is open-ended (Reinecke & Lawrence, 2023); moments of closure, such as we observed at the end of Phase 3, are likely temporary pauses rather than final endpoints. This open-endedness stems, we suggest, from at least two sources. Advocates and owners of algorithms may adapt their algorithms to counter the effects of existing or emerging envelopes (Shapiro & Varian, 1999; Wagner, 2004), thereby necessitating changes in the normative, governance, or practice layers of the envelope. Exogenous shocks may also alter the impacts of algorithms or reduce the effectiveness of existing envelopes in delimiting those impacts, which may trigger new cycles of work by custodians to maintain or update envelopes around algorithms.

Contribution to Research on the Social Dynamics of Algorithms

Our first contribution is to research on the social dynamics of algorithms (e.g., Glaser, 2017; Kellogg et al., 2020) by generating novel, empirically grounded theory of how envelopes around algorithms are constructed. We have argued that envelopes around disruptive algorithms emerge through a conjunctive process in which different actors construct normative, governance, and practice layers that jointly constrain disruptive algorithms. Although our study focused on the role of custodians, we posit that such envelopes may be constructed by a broader range of actors, including those driven primarily by self-interest rather than the protection of fields. Owners, designers, and proponents of algorithms, for instance, may construct envelopes around algorithms to constrain their disruptive impacts and make them more legitimate, thus avoiding the uncertainty of constraints stemming from envelopes constructed by antagonists or field custodians. Our theory of how envelopes are constructed has two main implications.

First, our theory of how envelopes are constructed responds to writing on algorithmic opacity (Burrell, 2016; Curchod et al., 2020; Rahman, 2021), which

has warned of the dangers of a "black box society" (Pasquale, 2015: 10) and suggested that a lack of transparency means that "using AI for judgments with serious individual or societal consequences may be problematic" (Lebovitz et al., 2022: 129). While prior research has highlighted the challenges associated with algorithmic opacity, we show how actors can jointly work around this opacity by coupling aspects of disruptive algorithms to elements of fields about which they already have expertise. Our study thus suggests that actors may be able to shape the impacts of algorithms even without understanding their inner workings. Guardians, for example, focused on coupling the impacts of high-frequency trading algorithms to the values of the field with which they were already familiar—thus playing to their strengths. Collectively, this approach allowed existing, distributed expertise to generate a cohesive envelope without any actor completely understanding the inner workings of the algorithms. This dynamic leads us to a more optimistic stance: it suggests that interested actors can respond to opacity by developing an understanding of algorithms in action—leveraging their existing field-specific expertise, rather than having to learn the intricacies of code.

Second, our theory of how envelopes are constructed implies that responses to disruptive algorithms (e.g., Christin, 2017; Rahman, 2021) may be more interdependent than previously theorized and thus more important than previously recognized. Our study shows that responses to algorithms can motivate and resource subsequent responses, as seen when the normative layer of the envelope that guardians established inspired reformers to become active. This insight suggests that many of the responses to disruptive algorithms previously studied as separate strategies may affect algorithms indirectly by motivating and resourcing subsequent strategies. For example, framing strategies that position algorithms as unfair (Burrell & Fourcade, 2021; Harcourt, 2007) may seem to have limited impacts if viewed in isolation, but our study suggests that these strategies may motivate or resource other forms of work, potentially inspiring and shaping governance or practice layers of envelopes, thereby playing a profound role in reshaping the societal impacts of algorithms.

Contribution to Research on Institutional Custodianship

Our second contribution is to research on institutional custodianship (e.g., Lok & de Rond, 2013; Montgomery & Dacin, 2020) by introducing the construction of envelopes as an important but unexamined response custodians may adopt in response to a wide range of phenomena—including, but not restricted to, disruptive algorithms—that threaten to disrupt valued elements of fields. Key to this possibility is the ability of custodians to identify and control the channels of interaction between the threat and the field in which it is embedded. If we consider, for instance, the construction of an envelope to mitigate the environmental threat of mining to a surrounding ecology, this would require custodians to identify the biophysical channels through which mining activity affects the local ecology and establish social and technical mechanisms to control those channels by delimiting inputs (e.g., water or employees) and outputs (e.g., waste and resource extractions). Constructing an envelope in such cases involves reshaping the field around a threat rather than attempting to reshape the threat itself. Recognizing the construction of envelopes as an important custodial response to threats has two main implications.

First, recognizing the construction of envelopes as an important custodial response to threats implies that the range of custodial responses is broader than has been previously suggested in the literature. Prior custodianship research has focused on two broad approaches: buffering institutions and intervening in threats. Buffering occurs when custodians erect material or symbolic boundaries around institutions to preempt disruptions from potential threats (Siebert et al., 2017; Wright et al., 2021): students at Texas A&M University, for example, protected their traditional bonfire from "detractors" by "limiting access to and knowledge about the construction of Bonfire" (Dacin & Dacin, 2008: 346). Constructing envelopes is distinct from buffering by virtue of what each contains: whereas buffers surround institutions to protect them from diverse and unpredictable threats, envelopes surround specific, identified threats to limit their impact on institutions. The second prevalent approach—intervening in threats—involves efforts to rid the field of threatening practices by controlling actors through socialization (Dacin et al., 2019; Lok & de Rond, 2013), directly manipulating practices (Dacin et al., 2010; Lok & de Rond, 2013), or punishing actors for noncompliance (Crawford & Dacin, 2020, 2021). In contrast to direct interventions, constructing envelopes is distinct by virtue of its focus on reshaping the fields in which threats are embedded.

Second, the custodial construction of envelopes implies that custodians may be able to steer ongoing

institutional change when threats make significant changes unavoidable. Institutional change may be unavoidable when threats are so complex or unpredictable that directly intervening is beyond the ability of even distributed custodians, or when threats are accompanied by important benefits, such as the local economic benefits of mining or the increased efficiency of high-frequency trading algorithms. In such cases, stopping institutional change may be impossible or undesirable. By constructing envelopes, custodians may be able to steer institutional change in ways that maintain valued elements of fields—in a managed form of drift (Micelotta, Lounsbury, & Greenwood, 2017; Steele, 2021; Voronov, Glynn, & Weber, 2022). In sum, while buffering institutions and intervening in threats are primarily oriented toward preserving the status quo (Dacin et al., 2010; Siebert et al., 2017), the custodial construction of envelopes may be distinctively concerned with steering ongoing institutional change.

CONCLUSION

Asking how custodians construct envelopes in response to disruptive algorithms led us to understand this process as centered on the production of multiple layers achieved through custodial work coupling aspects of disruptive algorithms to elements of fields. Although high-frequency trading in the field of U.S. securities trading provided a transparent and important case, it also brought with it two important limitations. The first arises from the relatively passive role played by the firms that developed and used high-frequency trading algorithms. During most of the period we studied, these firms did little to resist or counter custodial efforts, perhaps because they were mostly small startups with limited resources. Future research should address this limitation by exploring how proponents of algorithms work to counteract custodial efforts to construct envelopes. The second limitation concerns the relatively tightly bounded field we examined. Unlike disruptive algorithms that span multiple fields (e.g., Google search algorithms), high-frequency trading was contained within the field of U.S. securities trading, in which custodians were well-connected and had clear roles. Future research should explore how custodians can construct envelopes to constrain algorithms that threaten to disrupt less well-bounded fields, or that traverse multiple fields.

The incorporation of algorithms into nearly every domain of life brings with it significant risks, along with its potential benefits, particularly as advances in machine learning and AI accelerate the evolution of algorithms. Without custodial responses to disruptive algorithms, the future of fields and the societies in which they exist will be left to technologists, technology firms, or technologies. Constructing envelopes around algorithms thus represents an important way in which institutional custodians can tame unbridled technological change. Though this form of custodial work is far from open to all, it offers important opportunities for actors without deep technological expertise or access to proprietary algorithms to influence the ongoing algorithmic transformation of society.

REFERENCES

Alaimo, C. 2022. From people to objects: The digital transformation of fields. ***Organization Studies***, 43: 1091–1114.

Alaimo, C., & Kallinikos, J. 2021. Managing by data: Algorithmic categories and organizing. ***Organization Studies***, 42: 1385–1407.

Angel, J. J., & McCabe, D. 2013. Fairness in financial markets: The case of high frequency trading. ***Journal of Business Ethics***, 112: 585–595.

Anthony, C. 2021. When knowledge work and analytical technologies collide: The practices and consequences of black boxing algorithmic technologies. ***Administrative Science Quarterly***, 66: 1173–1212.

Anthony, C., Bechky, B. A., & Fayard, A.-L. 2023. "Collaborating" with AI: Taking a system view to explore the future of work. ***Organization Science***, 34: 1672–1694.

Arnuk, S., & Saluzzi, J. 2012. ***Broken markets: How high frequency trading and predatory practices on Wall Street are destroying investor confidence and your portfolio***. Upper Saddle River, NJ: FT Press.

Asatiani, A., Malo, P., Nagbøl, P., Penttinen, E., Rinta-Kahila, T., & Salovaara, A. 2021. Sociotechnical envelopment of artificial intelligence: An approach to organizational deployment of inscrutable artificial intelligence systems. ***Journal of the Association for Information Systems***, 22: 325–352.

Banner, S. 1997. What causes new securities regulation? 300 years of evidence. ***Washington University Law Quarterly***, 75: 849–856.

Beer, D. 2017. The social power of algorithms. ***Information Communication and Society***, 20: 1–13.

Beunza, D. 2019. ***Taking the floor: Models, morals, and management in a Wall Street trading room***. Princeton, NJ: Princeton University Press.

Beunza, D., MacKenzie, D., Millo, Y., & Pardo-Guerra, J. P. 2011. Impersonal efficiency and the dangers of a fully

automated securities exchange. ***Foresight Driver Review 11***. London, U.K.: Government Office for Science.

Bodek, H. 2013. ***The problem of HFT: Collected writings on high frequency trading & stock market structure reform***. Stamford, CT: Decimus Capital Markets.

Borch, C., & Lange, A.-C. 2017. High-frequency trader subjectivity: Emotional attachment and discipline in an era of algorithms. ***Socio-economic Review***, 15: 283–306.

Borch, C., & Min, B. H. 2022. Toward a sociology of machine learning explainability: Human–machine interaction in deep neural network-based automated trading. ***Big Data & Society***, 9.

Bowley, G. 2011, July 18. Fast traders, in spotlight, battle rules. ***New York Times***: A1.

Bradley, C. 2000. Disorderly conduct: Day traders and the ideology of fair and orderly markets. ***Journal of Corporation Law***, 26: 63–96.

Brayne, S. 2014. Surveillance and system avoidance: Criminal justice contact and institutional attachment. ***American Sociological Review***, 79: 367–391.

Brayne, S. 2017. Big data surveillance: The case of policing. ***American Sociological Review***, 82: 977–1008.

Brayne, S. 2021. ***Predict and surveil: Data, discretion, and the future of policing***. Oxford, U.K.: Oxford University Press.

Brayne, S., & Christin, A. 2021. Technologies of crime prediction: The reception of algorithms in policing and criminal courts. ***Social Problems***, 68: 608–624.

Buhmann, A., Paßmann, J., & Fieseler, C. 2020. Managing algorithmic accountability: Balancing reputational concerns, engagement strategies, and the potential of rational discourse. ***Journal of Business Ethics***, 163: 265–280.

Burgelman, R. A. 2011. Bridging history and reductionism: A key role for longitudinal qualitative research. ***Journal of International Business Studies***, 42: 591–601.

Burrell, J. 2016. How the machine 'thinks': Understanding opacity in machine learning algorithms. ***Big Data & Society***, 3: 1–12.

Burrell, J., & Fourcade, M. 2021. The society of algorithms. ***Annual Review of Sociology***, 47: 213–237.

Cameron, L. D. 2022. "Making out" while driving: Relational and efficiency games in the gig economy. ***Organization Science***, 33: 231–252.

Cameron, L. D., & Rahman, H. 2022. Expanding the locus of resistance: Understanding the co-constitution of control and resistance in the gig economy. ***Organization Science***, 33: 38–58.

Christie, W. G., & Schultz, P. H. 1994. Why do NASDAQ market makers avoid odd-eighth quotes? ***Journal of Finance***, 49: 1813–1840.

Christin, A. 2017. Algorithms in practice: Comparing web journalism and criminal justice. ***Big Data & Society***, 4: 1–14.

Christin, A. 2020. ***Metrics at work: Journalism and the contested meaning of algorithms***. Princeton, NJ: Princeton University Press.

Cloutier, C., & Langley, A. 2020. What makes a process theoretical contribution? ***Organization Theory***.

CNBC. 2014, April 1. "Flash Boys" fight that stopped NYSE trading. ***CNBC***.

Constantiou, I., Joshi, M. P., & Stelmaszak, M. 2023. Organizations as digital enactment systems: A theory of replacement of humans by digital technologies in organizational scanning, interpretation, and learning. ***Journal of the Association for Information Systems***, 24: 1770–1798.

Corbin, J., & Strauss, A. 2008. ***Basics of qualitative research***. London, U.K.: SAGE.

Crawford, B., & Dacin, M. T. 2020. Punishment and institutions: A macrofoundations perspective. In C. W. J. Steele, T. R. Hannigan, V. L. Glaser, M. Toubiana, & J. Gehman (Eds.), ***Macrofoundations: Exploring the Institutionally situated nature of activity***, vol. 68: 97–119. Leeds, U.K.: Emerald Publishing.

Crawford, B., & Dacin, M. T. 2021. Policing work: Emotions and violence in institutional work. ***Organization Studies***, 42: 1219–1240.

Creed, W. E. D., Hudson, B. A., Okhuysen, G. A., & Smith-Crowe, K. 2014. Swimming in a sea of shame: Incorporating emotion into explanations of institutional reproduction and change. ***Academy of Management Review***, 39: 275–301.

Curchod, C., Patriotta, G., Cohen, L., & Neysen, N. 2020. Working for an algorithm: Power asymmetries and agency in online work settings. ***Administrative Science Quarterly***, 65: 644–676.

Dacin, M. T., & Dacin, P. A. 2008. Traditions as institutionalized practice: Implications for deinstitutionalization. In R. Greenwood, C. Oliver, R. Suddaby, & K. Sahlin-Andersson (Eds.), ***The SAGE handbook of organizational institutionalism***: 327–351. Thousand Oaks, CA: SAGE.

Dacin, M. T., Dacin, P. A., & Kent, D. 2019. Tradition in organizations: A custodianship framework. ***Academy of Management Annals***, 13: 342–373.

Dacin, M. T., Munir, K., & Tracey, P. 2010. Formal dining at Cambridge colleges: Linking ritual performance and institutional maintenance. ***Academy of Management Journal***, 53: 1393–1418.

Davis, G. F., & Sinha, A. 2021. Varieties of Uberization: How technology and institutions change the organization(s) of late capitalism. ***Organization Theory***, 2: 1–17.

DeJordy, R. 2010. ***Institutional guardianship: The role of agency in preserving threatened institutional arrangements***. Unpublished doctoral dissertation. Carrol Graduate School of Management, Boston College, Chestnut Hill, MA.

Duhigg, C. 2009a, July 24. Senator wants restrictions on high-speed trading. ***New York Times.***

Duhigg, C. 2009b, July 23. Stock traders find speed pays, in milliseconds. ***New York Times***: A1.

FIA Principal Traders Group. 2015. Letter sent to FINRA. Retrieved from https://www.finra.org/sites/default/files/notice_comment_file_ref/15-06_FIA_comment.pdf

Floridi, L. 2011. Children of the fourth revolution. ***Philosophy & Technology***, 24: 227–232.

Floridi, L. 2019. What the near future of artificial intelligence could be. ***Philosophy & Technology***, 32: 1–15.

Fourcade, M., & Healy, K. 2017. Seeing like a market. ***Socio-economic Review***, 15: 9–29.

Freifeld, K. 2014, March 18. New York's Schneiderman seeks curbs on high-frequency traders. ***Reuters***.

Garten, H. A. 2001. ***US financial regulation and the level playing field***. New York, NY: Palgrave.

Gillespie, T. 2017. Algorithmically recognizable: Santorum's Google problem, and Google's Santorum problem. ***Information Communication and Society***, 20: 63–80.

Gillespie, T. 2018. ***Custodians of the Internet: Platforms, content moderation, and the hidden decisions that shape social media***. New Haven, CT: Yale University Press.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. 2013. Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. ***Organizational Research Methods***, 16: 15–31.

Gioia, D. A., Price, K. N., Hamilton, A. L., & Thomas, J. B. 2010. Forging an Identity: An Insider-outsider Study of Processes Involved in the Formation of Organizational Identity. ***Administrative Science Quarterly***, 55: 1–46.

Glaser, B. G., & Strauss, A. L. 1967. ***The discovery of grounded theory: Strategies for qualitative research***. Chicago, IL: Aldine Publishing Company.

Glaser, V. L. 2017. Design performances: How organizations inscribe artifacts to change routines. ***Academy of Management Journal***, 60: 2175–2207.

Glaser, V. L., Pollock, N., & D'Adderio, L. 2021. The biography of an algorithm: Performing algorithmic technologies in organizations. ***Organization Theory***, 2: 1–27.

Goslings, J. H. W. 1997. Ethical behaviour and securities trading. ***Business Ethics***, 6: 147–152.

Harcourt, B. E. 2007. ***Against prediction: Profiling, policing, and punishing in an actuarial age***. Chicago, IL: Chicago University Press.

Harcourt, B. E. 2015. ***Exposed: Desire and disobedience in the digital age***. Cambridge, MA: Harvard University Press.

Harmon, D. J. 2019. When the FED speaks: Arguments, emotions, and the microfoundations of institutions. ***Administrative Science Quarterly***, 64: 542–575.

Hasbrouck, J. 2007. ***Empirical market microstructure: The institutions, economics and econometrics of securities trading***. Oxford, U.K.: Oxford University Press.

Heaphy, E. D. 2013. Repairing breaches with rules: Maintaining institutions in the face of everyday disruptions. ***Organization Science***, 24: 1291–1315.

Heaven, W. D. 2023, April 6. ChatGPT is going to change education, not destroy it. ***MIT Technology Review***.

Hinings, B., Gegenhuber, T., & Greenwood, R. 2018. Digital innovation and transformation: An institutional perspective. ***Information and Organization***, 28: 52–61.

Hinings, C. R., Logue, D., & Zietsma, C. 2017. Fields, institutional infrastructure and governance. In R. Greenwood, C. Oliver, T. B. Lawrence, & R. E. Meyer (Eds.), ***The SAGE handbook of organizational institutionalism***: 170–197. London, U.K.: SAGE.

Howard-Grenville, J., Metzger, M. L., & Meyer, A. D. 2013. Rekindling the flame: Processes of identity resurrection. ***Academy of Management Journal***, 56: 113–136.

Jaton, F. 2021. ***The constitution of algorithms: Ground-truthing, programming, formulating***. Cambridge, MA: MIT Press.

Jefferson, B. 2020. ***Digitize and punish: Racial criminalization in the digital age***. Minneapolis, MN: University of Minnesota Press.

Kellogg, K. C., Valentine, M. A., & Christin, A. 2020. Algorithms at work: The new contested terrain of control. ***Academy of Management Annals***, 14: 366–410.

Kraatz, M. S., Flores, R., & Chandler, D. 2020. The value of values for institutional analysis. ***Academy of Management Annals***, 14: 474–512.

Krippendorff, K. 2012. ***Content analysis: An introduction to its methodology***. Thousand Oaks, CA: SAGE.

Kroezen, J. J., & Heugens, P. P. M. A. R. 2019. What is dead may never die: Institutional regeneration through logic reemergence in Dutch beer brewing. ***Administrative Science Quarterly***, 64: 976–1019.

Krugman, P. 2009, August 2. Rewarding bad actors. ***New York Times***: A21.

Langley, A. 1999. Strategies for theorizing from process data. ***Academy of Management Review***, 24: 691–710.

Lawrence, T. B., & Phillips, N. 2019. ***Constructing organizational life: How social-symbolic work shapes selves, organizations, and institutions***. Oxford, U.K.: Oxford University Press.

Lebovitz, S., Lifshitz-Assaf, H., & Levina, N. 2022. To engage or not to engage with AI for critical judgments: How professionals deal with opacity when using AI for medical diagnosis. ***Organization Science***, 33: 126–148.

Levine, M. 2016, August 31. Speed bumps are the hot new thing for exchanges. ***Bloomberg***.

Lincoln, Y. S., & Guba, E. G. 1985. ***Naturalistic inquiry***. Thousand Oaks, CA: SAGE.

Lindebaum, D., Moser, C., Ashraf, M., & Glaser, V. L. 2022. Reading the technological society to understand the mechanization of values and its ontological consequences. ***Academy of Management Review***, 48: 575–592.

Lok, J., & de Rond, M. 2013. On the plasticity of institutions: Containing and restoring practice breakdowns at the Cambridge University Boat Club. ***Academy of Management Journal***, 56: 185–207.

Lounsbury, M., Steele, C. W. J., Wang, M. S., & Toubiana, M. 2021. New directions in the study of institutional logics: From tools to phenomena. ***Annual Review of Sociology***, 47: 261–280.

MacKenzie, D. 2015. Mechanizing the Merc: The Chicago Mercantile Exchange and the rise of high-frequency trading. ***Technology and Culture***, 56: 646–675.

MacKenzie, D. 2018. Material signals: A historical sociology of high-frequency trading. ***American Journal of Sociology***, 123: 1635–1683.

MacKenzie, D. 2021. ***Trading at the speed of light: How ultrafast algorithms are transforming financial markets***. Princeton, NJ: Princeton University Press.

MacKenzie, D., Beunza, D., Millo, Y., & Pardo-Guerra, J. P. 2012. Drilling through the Allegheny mountains: Liquidity, materiality and high-frequency trading. ***Journal of Cultural Economics***, 5: 279–296.

Mackintosh, P. 2014. Demystifying order types. ***KCG Market Insights***.

Marti, E., & Scherer, A. G. 2016. Financial regulation and social welfare: The critical contribution of management theory. ***Academy of Management Review***, 41: 298–323.

McInish, T. H., & Upson, J. 2013. The quote exception rule: Giving high frequency traders an unintended advantage. ***Financial Management***, 42: 481–501.

Micelotta, E., Lounsbury, M., & Greenwood, R. 2017. Pathways of institutional change: An integrative review and research agenda. ***Journal of Management***, 43: 1885–1910.

Montgomery, A. W., & Dacin, M. T. 2020. Water wars in Detroit: Custodianship and the work of institutional renewal. ***Academy of Management Journal***, 63: 1455–1484.

Moser, C., Hond, F. d., & Lindebaum, D. 2022. Morality in the age of artificially intelligent algorithms. ***Academy of Management Learning & Education***, 21: 139–155.

Moulaï, K., Islam, G., Manning, S., & Terlinden, L. 2022. "All too human" or the emergence of a techno-induced feeling of being less-able: Identity work, ableism and new service technologies. ***International Journal of Human Resource Management***, 33: 4499–4531.

Moyer, L. 2016, February 1. Barclays and Credit Suisse to settle "dark pool" inquiries. ***New York Times***.

Murray, A., Rhymer, J., & Sirmon, D. G. 2021. Humans and technology: Forms of conjoined agency in organizations. ***Academy of Management Review***, 46: 552–571.

Newman, D. T., Fast, N. J., & Harmon, D. J. 2020. When eliminating bias isn't fair: Algorithmic reductionism and procedural justice in human resource decisions. ***Organizational Behavior and Human Decision Processes***, 160: 149–167.

Noble, S. U. 2018. ***Algorithms of oppression***. New York, NY: New York University Press.

Ocasio, W., Mauskapf, M., & Steele, C. W. J. 2016. History, society, and institutions: The role of collective memory in the emergence and evolution of societal logics. ***Academy of Management Review***, 41: 676–699.

O'Neil, C. 2016. ***Weapons of math destruction: How big data increases inequality and threatens democracy***. New York, NY: Crown Books.

Pachidi, S., Berends, H., Faraj, S., & Huysman, M. 2021. Make way for the algorithms: Symbolic actions and change in a regime of knowing. ***Organization Science***, 32: 18–41.

Pardo-Guerra, J. P. 2019. ***Automating finance: Infrastructures, engineers, and the making of electronic markets***. Cambridge, U.K.: Cambridge University Press.

Pasquale, F. 2015. ***The black box society: The secret algorithms that control money and information***. Cambridge, MA: Harvard University Press.

Popper, B. 2015, July 2. Meet the man building a stock exchange that doesn't screw people over. ***The Verge***.

Rahman, H. A. 2021. The invisible cage: Workers' reactivity to opaque algorithmic evaluations. ***Administrative Science Quarterly***, 66: 945–988.

Reinecke, J., & Lawrence, T. B. 2023. The role of temporality in institutional stabilization: A process view. ***Academy of Management Review***, 48: 639–658.

Rindova, V. P., Williamson, I. O., Petkova, A. P., & Sever, J. M. 2005. Being good or being known: An empirical examination of the dimensions, antecedents, and consequences of organizational reputation. ***Academy of Management Journal***, 48: 1033–1049.

Robbins, S. 2020. AI and the path to envelopment: Knowledge as a first step towards the responsible regulation and use of AI-powered machines. ***AI & Society***, 35: 391–400.

Rubenstein, A. 2014, April 30. Thank you, Michael Lewis. ***CNBC***.

Scheppele, K. L. 1993. "It's just not right": The ethics of insider trading. ***Law and Contemporary Problems***, 56: 123–173.

Scherer, A. G., Neesham, C., Schoeneborn, D., & Scholz, M. 2023. New challenges to the Enlightenment: How twenty-first-century sociotechnological systems facilitate organized immaturity and how to counteract it. ***Business Ethics Quarterly***, 33: 409–439.

Schildt, H. 2020. ***The data imperative: How digitalization is reshaping management, organizing, and work***. Oxford, U.K.: Oxford University Press.

Schillerstrom, R. L. 2010. On your mark … !!! Investment News.

Schreier, M. 2012. ***Qualitative content analysis***. Thousand Oaks, CA: SAGE.

SEC. 2015a, September 30. Latour trading charged with market structure rule violations. Retrieved from www.sec.gov/news/press-release/2015-221.

SEC. 2015b, January 12. SEC charges Direct Edge exchanges with failing to properly describe order types. Retrieved from www.sec.gov/news/press-release/2015-2.

Selznick, P. 1957. ***Leadership in administration: A sociological interpretation***. New York, NY: Harper & Row.

Shapiro, C., & Varian, H. R. 1999. ***Information rules: A strategic guide to the network economy***. Cambridge, MA: Harvard Business Press.

Shils, E. 1981. ***Tradition***. Chicago, IL: University of Chicago Press.

Siebert, S., Wilson, F., & Hamilton, J. R. A. 2017. "Devils may sit here:" The role of enchantment in institutional maintenance. ***Academy of Management Journal***, 60: 1607–1632.

Steele, C. W. J. 2016. ***Analytics in action: The production of data, insight, and validation***. Doctoral dissertation. Kellogg School of Management, Northwestern University, Evanston, IL.

Steele, C. W. J. 2021. When things get odd: Exploring the interactional choreography of taken-for-grantedness. ***Academy of Management Review***, 46: 341–361.

Velkova, J., & Kaun, A. 2021. Algorithmic resistance: Media practices and the politics of repair. ***Information Communication and Society***, 24: 523–540.

Vlastelica, R. 2017, March 17. High-frequency trading has reshaped Wall Street in its image. ***MarketWatch***.

Voronov, M., Glynn, M. A., & Weber, K. 2022. Under the radar: Institutional drift and non-strategic institutional change. ***Journal of Management Studies***, 59: 819–842.

Wagner, R. P. 2004. On software regulation. ***Southern California Law Review***, 78: 457–519.

Weild, D., Kim, E., & Newport, L. 2013. ***Making stock markets work to support economic growth***. Working paper no. 10, OECD Corporate Governance Working Papers. Paris, France: OECD Publishing. Retrieved from https://www.oecd-ilibrary.org/governance/making-stock-markets-work-to-support-economic-growth_5k43m4p6ccs3-en;jsessionid=K3Lvu-pohAXcAGDwbNkpkhp3XVA0ClrYORsn-Sj6.ip-10-240-5-142

Worstall, T. 2017. Don't worry, be happy—High frequency trading is over, dead, it's done. Forbes.

Wright, A. L., Meyer, A. D., Reay, T., & Staggs, J. 2021. Maintaining places of social inclusion: Ebola and the emergency department. ***Administrative Science Quarterly***, 66: 42–85.

Zilber, T. B. 2009. Institutional maintenance as narrative acts. In T. Lawrence, R. Suddaby, & B. Leca (Eds.), ***Institutional work: Actors and agency in institutional studies of organizations***: 205–235. Cambridge, U.K.: Cambridge University Press.

Zuboff, S. 2019. ***The age of surveillance capitalism: The fight for a human future at the new frontier of power***. New York, NY: Public Affairs.

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