Making Markets: Infrastructures, Engineers, and the Moral Technologies of Finance

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This paper seeks to expand sociological accounts of markets by advocating an ‘infrastructural conception’ of finance. Through this, the paper addresses the role of agents previously understudied within the literature: ‘infrastructural workers’ involved in transforming markets and their embedding organizational fields. The paper indicates two consequences of adopting this infrastructural conception by analyzing two historical cases related to the invention and adoption of the electronic order book respectively, a device that is arguably central to the organization and operation of global financial capitalism. The first case reconsiders the extent to which markets are moral projects by studying the invention of the electronic order book as a device that sought to materialize brotherly love in American securities markets. The second case examines the process by which this moral technology was adopted by financial organizations in Britain, exploring the role played by technologists in shaping the trajectory of the London Stock Exchange, and identifying three processes through which infrastructural workers transformed this organization and which I refer to as *capture, revelation, and conversion*. 
1. Introduction

Within the growing literature on financial markets and despite stark theoretical disagreements, economists and sociologists converge on at least one point: they tender similar answers to the question of ‘who make markets’? Financial markets are made by ‘market makers’ who, economists tell us, are intermediaries that quote prices to buy and sell assets and in doing so aggregate supply and demand to determine a market-clearing price (O’Hara 1995: 4-10; Demsetz, 1968; Gould, 1980). Sociologists of finance concur: market makers, they argue, are agents at the center of exchange that ‘while trading for their own accounts’ provide liquidity ‘to a diffuse population of investors and speculators located throughout the world’ (Abolafia 1996, p. 2-3; Carruthers and Stinchcombe 1999; MacKenzie and Millo 2003; Beunza and Millo 2013).

There are two possible roots for this correspondence. The first is patently linguistic: since at least the early 1960s, the term ‘market maker’ has been native to Anglo-American finance where, as Abolafia writes, it denotes the ‘trader’s sense that he creates the market by his own action’ (Abolafia 1996, p. 6) and refers to a concrete, recognized role within financial organizations.

More importantly, however, economists and sociologists of finance coincide in their underlying imaginaries of markets, and it is this second point of correspondence that I address in this paper. Social scientists may profess contrasting understandings of the economy (Swedberg 2003; Smelser and Swedberg 2005), yet they nevertheless agree on a historically entrenched ontology of markets (Agnew 1986; Lie 1995; Mirowski 1988; O’Neill 2001): markets are spaces of transactions (Callon 1998), sequences of ephemeral associations that, through calculative means, facilitate the exchange of money
and goods (Weber 1978, p. 635; Muniesa and Callon 2004). What motivates similar answers is a common understanding: markets are made by agents that, like brokers, dealers, and other intermediaries, coordinate the double coincidence of wants between buyers and sellers, making exchange possible (Jevons 1875; Weber 1968; Roth, Sönmez and Ünver 2007); paraphrasing an old English proverb, three men and a stock make a market (Ray 1818, p. 33).

In this paper, I explore a distinct consequence of thinking of markets beyond this transactional conception, precisely by expanding the notion of who constitutes a market maker: while markets are certainly made by agents that exchange, they are also made by agents that engage in infrastructural work, and as I argue in the following pages, analyzing the dynamics of market-making associated to the latter furnishes novel insights on the location of markets and market organizations in modern capitalist societies (see Ahrne, Aspers and Brunsson 2014 for a discussion of market organizations and, in particular, stock exchanges). This article is therefore a provocations: what is lacking in our sociological imaginary is greater recognition of the varied infrastructures of markets and of the agents that constitute them. Three men and a stock may make a market, but they can only do so within specific material and institutional arrangements that provide the conditions of felicity (Austin 1968) that frame and support transactions. This recognition leads to an important corollary: making markets is not only the purview of brokers, dealer, and traders; as importantly, it is also the domain of the largely unnoticed builders of the infrastructures of exchange.

Focusing on financial markets, this paper contributes to the sociological literature by studying infrastructural work as a distinct form of market making.
Concretely, the paper presents some of the mechanisms that involved infrastructural actors in the transformation of global financial markets by exploring the creation and adoption of a singular set of infrastructures: electronic order books, technological devices that are central to the organization of modern, automated finance. The history of such family of devices, which at their core consist of electronic lists made up by the volumes and prices at which market participants are willing to trade financial instruments, is ostensibly a history of the re-making of finance. Electronic order books grounded the most important qualitative revolution in recent finance (Glostein 1994; Domowitz 1992, 1993; Clemons and Weber 1996): their adoption displaced trading from the floors of stock exchanges onto global electronic trading networks (Zaloom 2006; Muniesa 2003), changing the spatial scope and interactional character of the marketplace (Knorr Cetina and Bruegger 2002; Preda 2006). In short, order books became the places where markets are made, the infrastructural substrates of global financial transactions. Indeed, their adoption allowed for a change in the speed and politics of finance, as illustrated by the rise of automated trading strategies that exploit the affordances of computers and communication networks to generate profits in minute fractions of a second (Lenglet 2011; MacKenzie 2014; author ref). Statistics by the World Federation of Exchanges underscore this transformation. Between 2000 and 2009, the aggregate value of trading in global stock markets grew by 61% while the number of trades expanded by 700%. Trades today are much smaller than ten years ago and take place at higher speeds—turnover velocity\(^1\) in most mature markets is generally above 80% (the NYSE Euronex and NASDAQ are notable examples: their
turnover velocities are 138.5% and 300% respectively; World Federation of
Exchanges 2012).

What matters in this paper are not market infrastructures primarily but
rather the cultural and institutional processes that first brought them into
existence to then transform the organizational fields they inhabit². In addressing
such processes, this study contributes to the literature on markets, technologies,
and organizations in two important ways. First, it connects established
sociological discussions on the morality of markets (Zelizer 1979; Fourcade and
Healy 2007; Quinn 2008; Stehr, Henning and Weiler 2006) with research on the
politics of technologies and innovation (Bijker and Law 1992; Bijker, Hughes and
Pinch 2012). The electronic order book, for instance, was a distinct moral project
that sought to enact specific social and ethical orders within the marketplace by
means of a technological intervention. If markets are, indeed, moral projects in
their own right (Fourcade and Healy 2007), then further recognition of the
moralized infrastructures of markets and how they are created adds depth to
extant sociological accounts.

The moral valence of the electronic order book had an important
organizational consequence. While competition between stock exchanges
certainly played a role in promoting the adoption of electronic order books
between the late 1980s and early 2000s, the uptake of these devices was part of
larger organizational trajectories that resembled processes of moral reformation
whereby the designers, producers, and maintainers of market infrastructures
transformed market organizations from within. Innovation, in this sense, was not
exogenous but rather occurred in connection to longer-lived forms of moral
entrepreneurship taking place within market organizations. This was
particularly clear in regulated stock exchanges, historically the prime institutions of global finance, and where electronic order books confronted the cultural and economic interests of established market makers: as partial owners of their stock exchanges, market makers had very little interest in adopting technologies that reduced their material or symbolic control over the marketplace. These infrastructures were nevertheless embraced over time with great success—today, an electronic order book resides at the core the vast majority of registered stock trading venues. Herein lies a second contribution of this paper: outlining the processes through which infrastructural workers motivated the organizational field to adopt novel technologies and, in doing so, transformed twentieth-century finance. Combining insights from sociological studies of organizations, historical institutionalism, and science and technology studies, this paper analyzes a three-stepped process through which infrastructural workers captured their organization’s hierarchy, revealed the infrastructures of the market, to then convert their organizations into adopting a new generation of technologies. These three processes involved the co-production of moralized infrastructures and novel niches within market organizations. Although clearly relevant to how transactions occur within the marketplace, these three processes—capture, revelation and conversion—were not driven by ‘traditional’ market makers. On the contrary, these and other transactional actors were far detached from the activities of infrastructural work, serving as end-users of services and technologies rather than as primary developers3.
2. Markets, Infrastructures, and Organizational Change

In writing about the history of economic sociology, Stark (2009) highlights a jurisdictional division that structured how social scientists throughout the second half of the twentieth century understood their economic worlds: whilst economists laid claim on the economy, sociologists specialized on the cultures and social relations embedding economic institutions. Such division is profound, involving not only a partitioning of the empirical field but also recourse to different epistemologies when analyzing similar objects, as exemplified by what Dobbin identifies as the inductive approach of economic sociology as contrasted to the deductive logic of mainstream economics (Dobbin 2007), or the distinct models of agency and behavior invoked by these disciplines (Swedberg 2003; Granovetter 1985).

Despite divergences, sociologists and economists share what I call a transactional conception of markets. Within this conception, markets are understood as collections of symmetrical, short-lived transactions engaged in willingly by economic agents as a means for facilitating exchange and avoiding the difficulties of barter and gift economies where issues of commensurability and residual social ties create frictions (Jevons 1875; Hayek 1948; Weber 1978; Williamson 1981; Callon 1998). This conception is certainly relevant in economics, where Cournot’s definition of markets as areas ‘within which the price of a good tends to uniformity’ (Cournot in Stigler and Sherwins 1985, p. 555) contributes to understanding the type of substitutive transactions that buyers and sellers engage in to deal with changes in prices, preferences, and demands. Perhaps unexpectedly, though, the conceptual privilege of transactions is also dominant within sociology. Firmly grounded on the project of building a
*Wirtschaftssoziologie* in dialogue with the economic theory of his time, for instance, Weber thought of markets as archetypes ‘of all rational social action [...] a coexistence and sequence of rational consociations, each of which is specifically ephemeral insofar as it ceases to exist with the act of exchanging the goods’ (1976, p. 635). Durkheim similarly replicated an economistic definition, writing of markets as institutions geared ‘primarily towards exchange’ (Durkheim 1976). Decades later, White challenged the jurisdictional divide between economics and sociology, presenting markets not as surrounded by society but as formed by social relations (White 1981). Yet by defining markets as ‘self-reproducing social structures among specific cliques of firms’ (White 1985, p. 518), White retained the importance of transactions: markets are formed by agents that produce and exchange goods and services—that is, by agents whose identity and structural position is defined by their possibility to exchange. In his seminal work on the social embeddedness of economic interactions, Granovetter (1985) echoed this transactional conceptualization of markets: his is not a challenge to the exchange-oriented paradigm of markets but, rather, a proposal for explaining allocation outcomes in terms of ‘personal relations and networks of relations between and within firms’ (p. 502); note that his is a theory of the embeddedness of transactions in social relations, rather than a challenge to the classical conceptualization of markets as uniquely transactional institutions. The situation is similar in Fligstein’s (2001) work, which regards markets as ‘situations in which some good or service is sold to customers for a price that is paid in money’ (p. 8). Zelizer (1988) also writes of markets as ‘institutionalized type[s] of social relations involving consumption, production and exchange’ (p. 618). The transactional account is consistent
across sociological traditions: For Bourdieu (2005), markets are ‘the product of a twofold social construction [...]': the construction of supply [...] and the construction of demand’ (p. 16). Slater and Tonkiss’ (2001) review identifies markets as ‘the buyers and sellers of a particular good or service [comprised by] supply [...] demand [...] and price’ (p. 38). And Aspers’ (2011) recent work defines markets as social structures ‘for the exchange of rights in which offers are evaluated and priced, and compete with one another’ (p. 4).

Swedberg (2005) rightly observes that sociologists have ‘suggested new ways of conceptualizing how markets operate’ (p. 233; see also Krippner 2001). They have shown, through great empirical dexterity, that market transactions are embedded in, and shaped by, cultures, institutions, and interpersonal networks (Swedberg 2005; Beckert 2010; White 1981; Uzzi 1997; Baker 1990; Dobbin 1994; Fligstein 2001; Carruthers 1994; Carruthers 1999; Zelizer 1979). But sociologists, as other social scientists (e.g. Gudeman 2001; Bloch and Parry 1989; see Maurer 2014), haven’t entirely escaped what Bernard Barber (1977) memorably identified as the ‘absolutization’ of the market — that is, an intellectual settlement that privileges abstract, exchange-oriented transactional market processes over the varied and mundane dynamics of physical marketplaces. This occurs despite a strong analytical tradition within the social sciences that stresses the materiality of marketplaces as critical for understanding market exchange (particularly visible among anthropologists; see Geertz 1963; Mintz 1959, 1960; Palmeira 2014 [1971]). Markets may be mechanisms for trading. And they may be partly constituted by ephemeral sequences of transactions. But they are, too, places, objects, and durable infrastructures.
2.1. Making Markets, from Transactions to Infrastructures

The transactional conception has an important empirical consequence: from its vantage point, markets are made by those who ‘truck, barter and exchange’ (Smith 1776), and so to study markets requires scrutinizing the strategies, institutions, and cultures performed by such transactional agents. Consider, for example, recent work in the sociology of finance. Within the broader sociological imaginary, finance is represented as a field formed by more than only transactional agents (e.g. investors, stock brokers, dealers, specialists and market-makers); specifically, numerous authors recognize financial markets as intimately bound to technologies that structure action and communicate marketplaces across the globe. Writing little less than three decades ago, Bell considered that ‘teletext-radio-computer systems would breakup old geographical habits and locations’ to bring about a ‘change in the nature of markets from “places” to “networks”’ (Bell 1987, p. 12). In her discussion of the new geographies of finance, Sassen mentions the couplings between telematic technologies and social institutions that configure the new spatial organization of capital (Sassen 2001). And for Castells, information and communication technologies ‘allow capital to be shuttled back and forth between economies in very short time’, increasing the velocity, complexity and connectedness of global financial flows (Castells 2000, p. 103). Within the more recent specialized literature, Knorr Cetina and Preda’s Handbook of the Sociology of Finance (2012), mentions technologies as notable elements of financial markets in 12 of 29 chapters, including discussions of technology as enabling the autonomy of the financial sector (Davis 2012), its role in constituting structures of communication and coordination (Knorr Cetina 2012; also, Knorr Cetina and
Bruegger 2002), as an element shaping traders’ identities (Zaloom 2012), as a agent configuring market actions (Hardie and MacKenzie 2012, Beunza and Stark 2012; see also Beunza and Stark 2004), and as a facilitator of the production of financial instruments (Fligstein and Goldstein 2012; Poon 2012). Other reviews, such as Carruthers’ and Kim’s (2011), also recognize the importance of technology, for example, by presenting it as part of the cognitive devices of financial agents, as a means for creating new forms of sociality within the marketplace, or as linked to transformations in the practices of credit rating organizations. Indeed, a recent and important trend within the sociological literature on finance is acutely sensitive to what MacKenzie (2006, p. 25) calls the technicality of financial markets—that is, the overt recognition that systematic forms of knowledge and technological infrastructures are consequential to understanding markets (see, for example, Muniesa 2003; Preda 2009; MacKenzie 2006; Beunza and Stark 2004).

Clearly relevant in the literature, financial market technologies are nevertheless evaluated through a transactional conception: for the question of who makes markets, technologies matter in their use (as, for instance, elements in the cognitive apparatuses of market agents, or as a facilitator of commensuration and exchange), but not primarily in their production. Querying the literature, authors more often than not represent markets as ‘interpenetrating networks of exchange and competition’ (Quack 2009) made by firms, regulators, traders, auctioneers, trading desks, analysts, managers, and banks (see Knorr Cetina and Preda 2012), as opposed to artifacts crafted by scientists, engineers, designers, architects and other specialists and amateurs involved in creating the technological infrastructures of the marketplace. These
agents may produce instruments that make trading possible or facilitate competition but, in our current vocabulary and theoretical sensibility, they do not make markets.

A focus on traders, bankers and investors may nevertheless divert attention from processes that take place in market organizations and that are key to their status as sites of capitalist enterprise and exchange. Consider, for example, *The Engineers and the Price System*, where Veblen (1921) explored an interesting paradox of modern capitalism: while conventional accounts at the time located control over the economy on the owners of the means of production, Veblen noted that advanced industrial activity necessitates sophisticated forms of technical expertise to operate. These forms of knowledge and practice, however, neither reside among the capitalist elites nor among the working classes, but rather are embodied by engineers and other technical experts who, as Veblen writes, ‘determine, on technological grounds, what could be done in the way of productive industry, and to contrive ways and means of doing it’ (Veblen 1921). Without the acquiescence of such agents, without their technical and managerial capacities, capitalist industry could simply not be (see also Schumpeter 1934). Since Veblen, numerous studies equally emphasized the ‘corps of technological production specialists’ (Veblen 1921) that constitute modern societies; these include research on the heterogeneous formation of electrical networks in Western nations (Hughes 1993), the emergence of modern knowledge-based corporate forms (Nobel 1979), the making of the modern oil industry (Bowker 1994), and similar research that presents technical specialists as key agents of social change (e.g. Bijker and Law 1992; Bijker, Hughes and
Pinch 2012) and organizational transformation (Barley 1986; Yates 2005; Orlikowski and Scott 2008).

If capitalism is made as much by the captains of industry as it is by its engineers (and if so much has been gained by this observation), then similar theoretical leverage can be garnered by studying the specialists that, through technical means, constitute modern markets. Like power systems and corporations, marketplaces are, too, cultural artifacts (Hughes 1993, p. 2), and so to study the technical actors involved in their making may be a path for revealing novel mechanisms that articulate markets within organizations and with broader social fields (Fligstein 2001; Fligstein and Dauter 2002; Nathaus and Gilgen 2011). This entails a theoretical and methodological shift away from the transactional conception of markets: while accepting marketplaces as sites of exchange where transactions are embedded in cultural repertoires and networks of social relations, what I call an infrastructural conception places emphasis on how markets are made as material artifacts and organizational platforms for exchange, placing focus not only on such agents as traders, banks, and investors and their transactions, but also on lawyers, programmers, computer scientists, hackers, and self-made engineers who make markets in durable ways.

What is gained by an infrastructural conception? In this paper, I present two contributions that expand the sociological imaginary of markets in important ways. These are by no means exhaustive—focus on infrastructures may well reveal other facets of markets and market making that have been neglected by a transactional conception.

2.2. Infrastructures, Moralities and Markets
The first contribution is a change in how and where sociologists locate the morality of markets. Here, Zaloom provides what is perhaps the clearest example of the consequences of understanding markets beyond a transactional conception. While her ethnographic study of futures trading clearly examines a traditional category of transactional agents (futures traders in Chicago and London?), Zaloom (2006) nevertheless dedicates a chapter of her book to discuss the history of how the Chicago Board of Trade (CBOT) redesigned a key market infrastructure—the trading floor—in the tumultuous years surrounding the Great Depression. At the time, futures were traded face-to-face and changes to the structure of the trading floor had concrete effects on the quality of market transactions, altering ‘the daily paths of the traders and [configuring] whom they can see and hear, their access to information, and what communication technologies they can use instantly and which they must stretch to procure’ (Zaloom 2006, p. 39). The trading floor manifested what Latour (1992) would call the ‘strongly social and highly moral’ substance of technology: in addition to being a platform for interactions, the design of the floor could ‘bring the marketplace more closely in line with the ideals of commerce, shaping the [trading] pits to reflect market principles of individual competition and smooth circulation’ (Zaloom 2006, p. 40). The CBOT’s trading floor thus involved a specific vision of the marketplace, one that materialized situated forms of order and informational equality for the transactional agents making markets (Zaloom 2006, p. 15-50). Notably, the categories motivating the floor’s redesign were moral, reflecting not only ideals of what markets are but, particularly, distinct notions of how exchange should occur within the marketplace. In this, the CBOT’s trading floor had a dual character: it was, on the one hand, an infrastructure for
exchange, and on the other hand, a concrete moral and moralizing project (Fourcade and Healy 2007).

Observe that in Zaloom’s study, morality was situated partly within the infrastructures of the marketplace—for example, in the location of the hexagonal trading pits within the trading floor, or the placement of the telephone lines that communicated the floor with the world and provided some traders with informational advantages that others didn’t possess. By providing asymmetric access to resources (such as lines of sight on the trading floor, or the proximity of the telephones to some groups of futures traders) and assigning worth to certain competencies over others, these decisions involved a value judgment that was projected over the agents and the organizational forms of the market. Morality was not found only in the interactions between traders, but was located, too, in the design of the infrastructures used by dealers to trade. This constitutes a substantial, though subtle, contribution to extant approaches to morality within economic sociology. While morality is by no means new to sociological research on markets (e.g. Weber 1978; Zelizer 1978; Quinn 2008; for a review, see Stehr, Henning and Weiler 2006), scholars have often examined it as dovetailing the relational qualities of transactions: markets are moral largely because they entail classifications and ethical qualifications of both the objects of exchange (Appadurai 1988; Thomas 1991; Douglas and Isherwood 1996) and the relationships ‘create[d], define[d], affirm[ed and] challenge[d]’ in transacting (Zelizer 2009, p. 28; Quinn 2008; Healy 2007; Wherry 2012; Lainer-Vos 2013). This is, for example, a gap in Abolafia’s (1996) classical account of market making in New York, or indeed of more recent studies that suggest that the moral valence of stock exchanges resided within face-to-face transactions and
was diluted with the historical shift towards electronic trading (Beunza and Millo, 2013). Covering the same organizational field, both studies posit morality as located within the dense social environments of the trading floor, where ‘everyday rules about business contact[s]’ (Abolafia 1996, p. 49) constitute moral orders that constrain and enable action in the marketplace. But if we understand moralities as evaluations and categorizations of worth, permissibility, and appropriateness shared by groups within the marketplace (Hitlin and Vaisey 2013, p. 59; Abend 2008), then focus on how infrastructures are built also matters: as Edwards, Bowker, Jackson and Williams (2009) recognize, in their design, infrastructures distribute social qualities among people and things (p. 372). By reinforcing relations, preforming categories, and stressing differences (Star and Ruhleder 1996; Bowker and Star 1999), infrastructures partly encode the moralities of the market; they are ‘saturated with normativity’ (Fourcade and Healy 2007, p. 299) before transactions have even occurred.

2.3. Infrastructures and Market Change

Some of the recent literature on financial markets has been sensitive to matters of infrastructures (though not entirely to their moral content; research on credit ratings and credit scorings may be an exception; see Poon 2008; Fourcade and Healy 2013). In addition to Zaloom’s work, studies by Knorr Cetina on foreign exchange markets, Sassen on global financial centers, and MacKenzie on derivatives and stock markets directly acknowledge the importance of infrastructures—including global communication networks and commodities classification standards—as integral to the social, material, and cognitive ‘scaffolds’ that structure action in the marketplace (see Knorr Cetina 2012, p.
The usage of infrastructures in these studies, though, is closer to their everyday
definition as ‘substructures or foundations’ (Oxford English Dictionary 2014)
than to the more specific theorizations offered by science and technology studies
(e.g. Star and Ruhleder 1996; Star and Bowker 1999, Edwards 2012; Bowker
1996; Edwards, Bowker, Jackson and Williams 2009). This is a second
consequence of adopting an infrastructural conception: by specifying a sociology
of infrastructures, it offers novel accounts of the transformation of marketplaces
and market organizations as shaped by concrete forms of infrastructural, rather
than transactional, work.

Here, it is important to be specific about what is meant by infrastructures.
This paper builds on work in science and technology studies, where scholars
write of infrastructures as taken-for-granted collections of technological devices,
standards, classifications, protocols and material arrangements that are ‘often
[manifested] simply as a list of numbers of technical specifications, or black
boxes, wires and plugs’ (Star 2002, p. 1). Infrastructures, as Edwards notes, are
perhaps best defined in the negative ‘as those systems without which
contemporary societies cannot function’ (Edwards 2003, p. 187). Not all
technologies are infrastructural, and infrastructures are not primarily physical.
Rather, as Star and Ruhleder (1996) note, ‘infrastructure appears only as a
relational property, not a thing stripped of use’ (p. 113). Infrastructures thus
exist in practice, as heterogeneous arrangements that interconnect actions,
people and artifacts in what Edwards calls ‘a perpetual oscillation between the
desire of smooth, system-like behavior and the need to combine capabilities no
single system can yet provide’ (Edwards 2012). More specifically, Star and
Ruhleder (1996, p. 113) identify eight dimensions relevant to the study of infrastructures:

*Embeddedness.* Infrastructure is "sunk" into, inside of, other structures, social arrangements and technologies;

*Transparency.* Infrastructure is transparent to use, in the sense that it does not have to be reinvented each time or assembled for each task, but invisibly supports those tasks;

*Reach or scope.* This may be either spatial or temporal—infrastructure has reach beyond a single event or one-site practice;

*Learned as part of membership.* The taken-for-grantedness of artifacts and organizational arrangements is a sine qua non of membership in a community of practice [...];

*Links with conventions of practice.* Infrastructure both shapes and is shaped by the conventions of a community of practice [...];

*Embodiment of standards.* Modified by scope and often by conflicting conventions, infrastructure takes on transparency by plugging into other infrastructures and tools in a standardized fashion;

*Built on an installed base.* Infrastructure does not grow de novo: it wrestles with the "inertia of the installed base" and inherits strengths and limitations from that base [...];

*Becomes visible upon breakdown.* The normally invisible quality of working infrastructure becomes visible when it breaks [...].

The qualities identified by Star and Rudheler (1996) have significant implications on how making of infrastructures reshapes market organizations within and without. To paraphrase Woodrow Wilson on democracy,
infrastructures live in a world made safe for infrastructures (Edwards et al. 2009, p. 368). The creation of these environments, where infrastructures can seamlessly sink into the background of everyday expectancies (Pinch 2008), requires performing specific varieties of technological and organizational work. As a ‘set of organizational techniques (technical, governmental, and administrative) that create the conditions of possibility’ for exchange (Carse 2012), these forms of infrastructural work produce invisible yet embedded and durable connective relations that add to the routines, standards, and conventions of practice of market organizations and their organizational fields.

But how does infrastructural work transform market organizations? And, how do moral frames and moral horizons (Hitlin and Vaisey 2013, p. 63) shape the making of market infrastructures? As the literature suggests, infrastructural work is not a punctual, transactional, phenomenon nor is it necessarily constrained to narrow technical considerations, but rather occupies longer processes of transformation that transect the creation of technologies, skills, organizational forms (Bowker 1996) and shared senses of justification (Yates 2005). In their scope, infrastructures are seldom produced by a ‘single vision, practice or plan’ (Edwards 2012, p. 12); rather, their making is closer to a gradual process of institutional change where, as Thelen writes, structures and practices are ‘transformed through political re-alignments and specifically through the incorporation of groups whose role in the system was unanticipated at the time of their creation’ (Thelen 2004, p. 34). Indeed, when combined with insights from institutional studies of organizations and the specialized literature on infrastructures, such historical institutionalist accounts (e.g. Mahoney and Thelen 2010; Thelen 2004; Streeck and Thelen 2005) allow for a more detailed
understanding of how infrastructural work makes and re-invents markets, suggesting three processes of change that are here called *capture*, *revelation*, and *conversion*.

The notion of *capture* reflects the organizational origins and location of infrastructural work: as actors that are involved in connective activities that occur mostly in the background (Star and Ruhleder 1996), novel cadres of infrastructural workers often find their roots in unsuspecting critical moments within the history of an organizational field. During these critical moments (Mahoney 2000), internal conflicts, exogenous tensions, and/or isomorphic pressures (DiMaggio and Powell 1983) compel organizations to create new problem-oriented niches (Baum and Singh 1994) that require the enrolment of categories of agents hitherto unfamiliar to the organization (such as digital technologists in an entirely analog stock exchange). Given their external provenance, these agents are often distant from the core practices and values of the organization—they are peripheral, or invisible, just like the standards and technologies they produce (Star and Ruhleder 1996; Edwards 2012).

If successful in producing technologies that become taken-for-granted as part of the organization’s work, the incorporation of new cadres of infrastructural workers ‘into the coalitions on which institutions are founded can drive a change in the functions that these institutions serve or the roles they perform’ (2004, p. 36). Certainly, if adopted, market technologies and standards produced by infrastructural workers become self-reinforcing, experiencing increasing returns (Mahoney 2000, p. 508). Given their control over the knowledge and expertise required for deploying and managing such systems (Veblen 1921; Nobel 1979), infrastructural workers benefit, too, from this self-
reinforcing dynamic, acquiring intra-organizational symbolic capital (Bourdieu 1984) that is translated, for instance, into increased field visibility or promotions within their organization’s hierarchy (see Bourdieu 2005; Emirbayer and Johnson 2008). Captured market organizations, however, can be tense and unstable: if a divergence in values existed between the incumbent organizational core and the new cadres of infrastructural agents (if, for instance, incoming technologists held different views than extant administrators on how best to manage the exchange), frictions may emerge and lead to struggle about what is worthy and meaningful for the market organization (such notions may reflect, for example, diverging versions of what Fligstein [2001] calls conceptions of control, or of the type of justificatory repertoires identified by Boltanski and Thevenot [2006]). The morality of market infrastructures and their importance in organizational change are revealed here, in the concrete and meaningful forms of position-taking (Emirbayer and Johnson 2008, p. 14) that are enacted as part of the symbolic conflicts between a market organization’s new infrastructural underbelly and its established transactional core.

Revelation occurs precisely around these struggles to redefine a market organization: having acquired visibility and capital, infrastructural workers seek to distinguish themselves from others in the organizational field, a matter for which recourse to moral arguments becomes a notable bounding strategy (e.g. Emirbayer 1992, Abend 2014). It is then that markets are overtly exhibited as both moral and technical projects: having remained mostly in the background, infrastructural workers can now claim, on the basis of their expertise, that there are other ways of making markets (Weber 1978; Kjellberg, Azimont and Reid 2014). Infrastructural workers become, in this sense, moral entrepreneurs that
‘mobilize moral frames’ (Hitlin and Vaisey 2013, p. 63) to accomplish the organizational end of making markets according to their templates (Becker 1963).

As moral entrepreneurs, infrastructural workers face a clear challenge: in order to enroll supporters across the field and effect change, they must make their worth and contributions externally legible. Without such legibility, adopting an authoritative voice within the organizational field becomes unlikely. But how to produce legibility when most of their infrastructural work is externally ‘invisible’ (Star and Ruhleder 1996)? In dealing with this apparent paradox, infrastructural workers may engage in a strategy of making visible (or revealing) the infrastructures that they have made as they engage in moralized struggles for the organizational field's core. (Domínguez-Rubio and Fogué [2013] call attention to a similar, overtly political process whereby, in securing representation, the technological redesign of public spaces requires publicizing, or making visible and openly contested, the contents of infrastructures; see also Mackenzie 2005; Star 1999).

The strategies of revelation adopted by infrastructural workers are varied, but they all share a common feature of being actions that seek to render the intra-organizational qualities of infrastructural workers legible to the broader organizational field. These strategies may be discursive by, for instance, presenting specific infrastructures as ‘matters of concern’ (Latour 2004) in public debates. By exposing the role of infrastructures in the operation of the market, infrastructural workers can dispute the taken-for-grantedness of past infrastructural accomplishments and speak from a position of epistemic authority, tracing how future innovations may be implemented. But revelation
can also be substantively material by, for example, purposely re-fashioning infrastructures so as to grant them visibility to their users (this was, indeed, one of the strategies adopted by market engineers in a notable example—see below). Through this, market engineers make public their intra-organizational worth, expertise and charisma, embodied ‘in the machine, just as the warlord’s [is embodied] in an army and a prophet’s in a religious movement’ (MacKenzie and Elzen 1996, p. 156). Discursive and material revelations create a space for tension and competition: while making visible infrastructural workers, their charisma, and their expertise creates ‘a sense of security in the system’ (Hargrave and Van den Ven 2009, p. 130), opening the ‘black boxes’ of the marketplace also introduces uncertainty and contradiction (Hargrave and Van den Ven 2009), providing agents with awareness ‘that institutions are not natural and “taken for granted” but are social constructions’ (Lawrence, Suddaby and Leca 2009, p. 15).

It is upon revealing themselves and their work that infrastructural workers can convert other market actors to adopt systems that better reflect their moral and technical concerns. Having amassed intra-organizational symbolic capital through their efforts, and having revealed the scope of their products to the broader organizational field, infrastructural workers can exploit the familiarity that market actors have gained by using their systems in order to frame possible futures, without running ‘the risk of unsettling and losing members’ (Hargrave and Van den Ven 2009, p. 131). Indeed, familiarity is critical for enrolment: exploiting the social and symbolic capital developed in creating market infrastructures in the past, infrastructural workers can attract actors disadvantaged by the existing institutional order ‘to use their advantaged status
vis-à-vis other institutions to enact change’ (Mahoney and Thelen 2010, p. 9).

Moralized discussions play an important role at this stage: as moral entrepreneurs, infrastructural workers frame debates as being about broader social problems, such as the need to create ‘fairer’ or ‘more efficient’ markets (even if they are potentially to benefit from a change in the market’s organization).

3. Data and Methods

In the following pages, I explore the consequences of adopting an infrastructural conception of markets through two cases that concern the invention and adoption of the electronic order book, respectively. While the first case speaks to how market infrastructures are moral projects by studying the ethical and intellectual context of the patent for the first electronic order book, the second case investigates an instance of how this device became adopted within a market organization by exploring the dynamics of capture, revelation and conversion within the London Stock Exchange between circa 1965 and 1997.

Both cases combine a variety of sources on the historical development of electronic order books in Anglo-American finance. These include, for example, books and pamphlets produced by the inventor of the first electronic order book and some of his close collaborators; official publications including Parliamentary reports and the published minutes of the United Kingdom’s Treasury Committee; internal publications from the London Stock Exchange and Tradepoint (the first commercially successful electronic trading venue in the UK) obtained from public archives and provided by informants; and articles in trade magazines and newspapers including the Financial Times, London Times, New York Times, and The Guardian. While the first case is entirely based on documentary evidence,
the narrative of second case derives mostly from semi-structured interviews with people involved in the automation of stock exchanges and other trading sites between c. 1965 and 2010. The sources and their use are represented in Table 2.

Given that they represent a distinct attempt to sketch the role of infrastructural workers in making markets, further context should be given to the interviews that informed the second case. The interviews were produced through an iterative process that combined research on the histories of firms and institutions with traditional snowballing techniques: initially, I conducted research in specialist archives, trade publications and other periodicals on finance and technology to identify the names individuals involved in the automation of stock exchanges in Britain and America. I used data from this phase to organize a first round of semi-structured interviews leading to a second list of names not identified in the initial iteration. Archival research into this second set of names produced a new list of actors around which the second round of interviews was organized. This proceeded for five rounds, when I reached a point of saturation. The sample I produced through this research strategy is predominantly male, and spans the organizational hierarchies of major financial institutions: 9 interviewees were senior managers of stock exchanges or brokerage firms; 24 were technology developers, some of whom also occupied senior management positions in the past; 7 were traders with some involvement in technology; 4 were economists and/or regulators; and 2 were journalists or consultants. The interviews took place between October 2006 and June 2014 in New York and various locations in the United Kingdom.
Three interviews were conducted over the phone. Interviews lasted between one and three hours, and were recorded and transcribed by the author.

Analytically, both the documentary sources used in the first case and the interviews founding the second case were used to reconstruct the moral and organizational microhistories (Ginzburg 1993) of actors once responsible for making the electronic order book into a central infrastructure of modern finance. As microhistories, the accounts presented by actors (and my rendering of them) are slightly heroic. This reflects, perhaps, the complexity of their individual life-courses (in the case of interviewees, many spoke through metaphors of breaking organizational and social barriers in becoming recognized market engineers); but these heroic notes may reflect, too, the transformative role occupied by actors otherwise forgotten within the literature (on the role of ‘heroes’ in microhistory, see Revel 1995; the ‘invisibility’ of most interviewees may explain, for instance, both their desire to participate of the interviews as well as some informants’ eagerness to provide additional, difficult to access documentary sources about financial institutions). Although by no means representative, the stories of the interviewees provide a unique and valuable perspective into the organizational dynamics of institutions such as the London Stock Exchange and Tradepoint. The accounts, however, are robust: interviews were compared with documentary sources and between interviewees, seeking to obtain as clear and coherent a narrative as possible; indeed, when possible, interviewees were re-queried on the details of their accounts in order to elicit further points of comparison in the historical data.

4. Case 1: The Market of Brotherly Love
Like double-entry bookkeeping, order books are prominent technologies of the capitalist enterprise (Weber 1978; Sombart 1924; Carruthers and Espeland 1991). Faced with asymmetric and unpredictable variations in supply and demand, market intermediaries developed a simple class of devices that facilitated allocating goods across time. These devices consisted of lists indicating the schedules of delivery from sellers and the orders submitted by buyers that, through a given rule, established how items were to be distributed (see figure 1).

[INSERT FIGURE 1 HERE]

The history of this class of devices is rather imprecise—they are, after all, so widespread a technology and so simple a design. We know, however, that order books are an old solution to the problem of managing supply and demand. As William A. Shaw wrote in *The Economic Journal* in 1906, one of these devices was already central to the financial organization of Restoration England between 1660 and 1667, when the Treasury of Charles II installed a paper and ink order book to control the supply of government credit. The problem faced by the Treasury was the discontinuity of cash flows. Previous ways of tallying credit and debt were riddled with bureaucratic complexities, and whereas revenue trickled into the Treasury’s coffers gradually, expenditure was abrupt and clustered at the beginning of the fiscal year (Shaw 1906). By recording the demand and supply of money through the order book, credit could thus be administered through time.

In different guises, order books were reinvented across several sites of economic activity as mundane yet critical management devices. In financial markets they acquired salience amongst stock exchange intermediaries involved
in ‘making markets’ (Abolafia 1996), dealers that trade on their own accounts, set the prices of traded instruments, receive orders from brokers, and match trades accordingly (O’Hara 1995). By bearing the risk of short-term price fluctuations, market makers provide liquidity to brokers at the expense of a spread in prices: they buy at lower rates than they sell, profiting from the difference. This requires managing the flow of orders that enter the market. Like the demand for credit in 17th century England, orders to buy and sell stocks arrive asymmetrically, providing an incentive for using an inventory of sorts. This explains, perhaps, why the order book became central to the operation of the stock market, since it allowed market makers to control inventories and adjust the prices of their stocks according to changes in demand and supply.

Like many of the early recording technologies of finance, the original order books were made of paper and ink, with updated copies kept close to the market maker’s pitch on the trading floor. The importance of these devices to the practices of the stock exchange’s floor was reflected in language: by the early twentieth century, ‘keeping the book’ was synonymous to making a market in a particular security, be it among the New York Stock Exchange’s specialists or the London Stock Exchange’s jobbers. An important feature of these early order books dovetailed their physicality: because they were limited to the pitches of market makers, the information they contained could be easily controlled; the state of the order book was private to market makers who, in exchange for this privileged access to the ebb and flow of market transactions, guaranteed liquidity to brokers and their end users, investors.

Not all market participants sanctioned these forms of privilege, particularly in America where markets had been percolated by an earlier rise of
public discourses on financial democracy and investor protection (Ott 2011; Krippner 2011; Burke 1988). In these markets, hitherto dominated in volume and organizational clout by the New York Stock Exchange and its market markets—the specialists—such critiques grew in prominence and, by the early 1960s, had become part of the agenda of American financial regulators. For the Securities and Exchange Commission, markets required innovation. For the SEC, the pursuit of operational efficiencies would both increase investor protection and lower trading costs (including the notorious bid-ask spreads of NYSE specialists). In particular, the SEC considered the paper-based order books of stock specialists as surpassed by the novel suite of computer technologies increasingly used in business applications (Cortada 2006). Market makers, argued the Commission, needed to change their ways, adopting a system ‘which would select the best bids and offers, execute orders, and clear transactions [in the marketplace.] Wholesale dealers and other broker-dealer subscribers could enter quotations (and size of market) into a central computer for indexing under the appropriate security and could interrogate the computer to determine the highest bid and lowest offer, selected by the computer, together with the number of shares bid and offered at such prices’ (SEC 1963). This system ultimately did emerge, but only in the relatively untamed over-the-counter markets, becoming the technical foundation of the National Association of Securities Dealers Automated Quotation system in 1971 (or NASDAQ; see Ingebretsen 2002). The creation of NASDAQ and the ensuing demonstration of its applicability, however, did little to erode the position of established NYSE market makers who remained firmly in control of their order books (on the contrary, NASDAQ was seen by many at the big board as pernicious competition; Muniesa 2003). When NYSE
specialists automated, they did so only to lower their organization's operational costs (Keith and Grody 1988), keeping their privileged access to price formation and information flows from the market (Keith interview).

For other, more acerbic critics, market makers did not need re-tooling but extinction. Automation should replace rather than simply discipline the specialist. This radical opposition to stock exchange intermediaries was, certainly, the moral rationale for the invention of the electronic order book: issued by the United States Patent and Trademark Office to the Illinoisan industrialist, entrepreneur, and amateur economic philosopher Frederick Nymeyer in 1971, the patent presented a ‘new and improved computation system for commodity exchanges, stock exchanges, and similar auction markets [for] establishing exchange prices for any form of fungible goods [...] without requiring the exercise of human judgment as a substantial factor in price determination’ (USPTO 1971).

4.1. Frederick Nymeyer

The dense morality of the electronic order book is perhaps best reflected in the distinct zeal of its creator to reform stock markets (and, indeed, American society at large). Born in 1897, trained in economics in the 1920s, and an avid businessman throughout most of his adult life, Nymeyer’s works reflected the ideological mélange of post-war United States. A relatively understudied figure, Nymeyer is best known for his role as an apostle of Austrian economics in the United States. After reading Theory of Money and Credit and Omnipotent Government in 1946, Nymeyer wrote to Ludwig von Mises, a central political and intellectual reference of Austrian economic thought, asking for clarification of a particular passage (Hülsmann 2007; Greaves 2006). Mises replied, thanking
Nymeyer for his ‘thoroughness and critical acumen’, starting what would ‘turn into a long-term’ alliance (Hülsmann 2007, p. 853). Through multiple epistolary exchanges, Mises introduced Nymeyer to the broader works of Austrian theorists (including the seminar work of Eugen Böhm-Bawerk—whose *Capital and Interest* was referenced in the 1971 order book patent; USPTO 1971) and of which he became ‘a dedicated admirer’ (Hülsmann 2007, p. 854). After meeting in person in 1948, Nymeyer reciprocated Mises’ attention, providing ample support for him and his colleagues. For instance, noting that ‘Austrian works were not sufficiently well known’ in the United States (Hülsmann 2007, p. 855), Nymeyer strove to create a ‘Liberal Institute’ under the direction of Mises at the University of Chicago (the plan failed due to Chicago’s unease with the mode of funding and staffing preferred by the institute’s benefactors). Similarly, observing the lack of English translations of Austrian economics texts, Nymeyer founded the Libertarian Press in 1955, a “specialist” publisher, with a limited objective dedicated to making known in the English-speaking world the revolutionary ideas of the Austrian Neo-Classical economists’ (Nymeyer in Mises 1974; emphasis in the original). Nymeyer’s company soon grew into an important ‘publishing house [devoted] to disseminate Mises’s writings’ (Hülsmann 2007, p. 574), becoming the undisputed point of translation, publication, and dissemination (Sennholz 2007) of Austrian economics to American audiences. Tellingly, too, Nymeyer ‘probably had some influence in bringing Hayek to Chicago, and in the early 1950s played a significant role in raising funds for Mont Pèlerin Society meetings’ (Hülsmann 2007, p. 856).

These numerous actions were likely motivated by what seems to have been a strong elective affinity between Nymeyer’s religious convictions and
Mises’ economic worldviews. For Nymeyer, ‘the economics of Dr. von Mises’ constituted ‘by far the most satisfactory means to modernize the ethics of the Hebrew-Christian religion.’ ‘When that kind of synthesis is made,’ wrote Nymeyer to industrialist Howard Pew in 1959, ‘one turns out to be an extraordinary conservative adherent of the Christian religion. But also some of the absurdities are removed’ (Nymeyer, in Hülsmann 2007, p. 915-16). Just as Weber famously traced the cultural origins of capitalism to the ethics of ascetic Protestantism, it is possible to find, too, the invention of a critical infrastructure of modern financial capitalism in the work and spiritual devotion of a fervent Calvinist.

For Nymeyer, Calvinism and Austrian economics were part and parcel of a single project: to achieve moral perfection in a society marked by change and structured by markets. The most succinct reflection of this ethical and philosophical position was Progressive Calvinism, a periodical pamphlet published between 1955 and 1960 that served as the official voice of the Progressive Calvinism League, a group formed by Frederick Nymeyer, his son Martin B. Nymeyer, and John Van Mouwerik.

Progressive Calvinism (later changed to First Principles of Morality and Economics) was a peculiar intellectual project: as Nymeyer wrote, the pamphlet presented a ‘hybrid’ social philosophy, ‘a cross between Hebrew-Christian ethics and neoclassical economics’ (First Principles 1960; note that, for Nymeyer, neoclassical economics denoted Austrian economics). With this combination, Nymeyer sought to generate ‘awareness of the limitations of the human mind [to] promote true humility; [resisting] the arrogance of all attempts at universal planning, that is, all attempts at pretending we are as God, and all Comptian
Positivism’ (*Progressive Calvinism* 1950, p. 10). Nymeyer was a reformist, advocating a novel yet conservative way of thinking about the social world: he wrote not as a theologian but as a ‘practical social science [man]’ (*Progressive Calvinism* 1955, p. 3) who saw in business an activity that ‘solves correctly and naturally many important matters about which professional social scientists have impractical and even dangerous ideas’ (*Progressive Calvinism* 1955, p. 2-3).

**4.2 The morality of prices**

Within this moralizing intellectual project, and through a number of reflections on topics ranging from the consequences of automation on profits (*First Principles* 1960b) to the implications of Weber’s work for modern progressive Calvinists (*Progressive Calvinism* 1956 Sept), Nymeyer’s pamphlets sought to explore human action through a praxeological perspective (*Progressive Calvinism* 1956, November; Mises 1949), studying ‘the relations of men to men [...] and the relations of men to things’ (*First Principles* 1960, April, p. 102), a conceptual division that reflected some of the singularities of Nymeyer’s moral and religious philosophy. Specifically, for Nymeyer, the precepts of Calvinist and Christian thought accounted for two sets of relations in the world. First, the ‘relation of men to God’, he identified as purely religion; second, the ‘relation of men to men’, he understood as constituting ethics (*Progressive Calvinism* 1956, July, p. 196). However, as Nymeyer wrote, ‘a very important relationship is [...] practically lost sight of by our two-fold division. This important relationship is the relationship of men to things, the relationship of men to the natural world around us’ (*Progressive Calvinism* 1956, July, p. 196). Indeed, for Nymeyer, the significance of economics resided in its ability to ‘aid the interpreting of scripture’ by offering insights on, first, on the relations of men to men as
discerned through the study of ‘prices’; and second, the relations of men to things, captured under economic discussions of ‘value’.

Nymeyer explored this projection of economics onto Calvinist theology in a brief discussion published in First Principles in 1960. For Nymeyer, relations between men and things were given by how individualistic values are attributed to discrete economics goods. Following the subjectivist philosophy central to Austrian economic thought (Kirzner 1996; Hayek 1949), Nymeyer considered values as deriving from practical utility and the ‘objective’ psychology of scarcity, but also from ‘the significance which a good or a quantity of goods possesses for the well-being of a certain subject’ (Böhm-Bawerk 1891, p. 96). While the determination of value was central to men’s relation to things, it was prices that, in Nymeyer’s thinking, arbitrated the relations of men to men. As he wrote,

Primary economic relations between men pertain to questions connected with the exchange of goods or services. One man produces shoes; another produces food. In how "just" or in how "brotherly" a manner they treat each other depends on how they agree or come to accept the prices used in the exchange. If the price of the shoes is too high, the shoemaker has misdealt the farmer; if the price of food is too high, the farmer has misdealt the shoemaker. To appraise the justness (or brotherliness), of how men treat each other when exchanging, it will be necessary to describe accurately how prices are determined in a free market. In the usual discussions about brotherly love (in the field of economic problems) by moralists and theologians, a description is seldom presented of what takes place in the price determining process. Moralists and theologians rather freely pass judgment on a process concerning
which there is evidence that they do not understand it. Factual and scientific description ought to precede appraisal and condemnation (First Principles 1960, June, p. 102-103).

In his rendition of Calvinist theology, Nymeyer adopted a radically individualist conception of brotherly love: rather than being circumscribed to a particular group and defined on the basis of religious virtuosity, brotherly love was a universal dimension of transactions, evinced in the ethical status of the relations established between agents negotiating over a price. This universalism, which mirrored in important ways Weber’s (2010) discussion of puritan brotherliness, also served as a counterpoint to conceptions of justice as derived from caritative regulations and personal renunciation (see Symonds and Pudsey 2006). As Nymeyer wrote,

The “backbone” of brotherly love CANNOT be charity, instead it MUST be mutual exchange, or trade, or buying and selling [...] Charity can only supplement exchange (First Principles 1960, April, p. 101).

Nymeyer’s philosophy, however, diverged in important ways from Weberian forms of puritanism. Whereas Weber saw “‘personal’ or “human” relations between people’ as those where an ethical dimension was possible (Symonds and Pudsey 2006, p. 138), he also considered morality as removed from ‘the realm of economically rationalized relationships, where personal control is exercised in inverse ratio to the degree of rational differentiation of the economic structure’ (Weber 1978, p. 585). Nymeyer reversed Weber’s logic, placing market exchange as a generative site of ethics: formed by (transactional) associations between men, the legitimacy of markets and their allocation outcomes (that is, the relations of men to things, and of men to men) hinged
'upon the [free] individual wills of the [market] participants’ (Weber 1978, p. 585).

Nymeyer’s economistic theory of brotherly love was laid bare in his analysis of the morality of prices. Noting that ‘the free action of competition in the market place is often decried and criticized as unbrotherly, unchristian, as a violation of the ideal of brotherly love’ (First Principles 1960, September, p. 286), Nymeyer referred to Weber’s work in order to criticize the preponderance of these ‘medieval economic ethics [...] based on the principle of just price and the assurance to everyone of a chance to live. (Weber 2012, p. 357-358.)’ But, Nymeyer asked, ‘What is a “just price”?’ (Progressive Calvinism 1956, June, p. 286)

Nobody knows. The ideas of a “just price” and a “fair price” independent of free market activity are utterly meaningless [...] We would declare that God himself does not know and cannot know what a "just price" is, were it not that we feared offense would be taken at such a statement (p. 286)

In effect, ‘[b]rotherly love and price determination are related,’ contended Nymeyer, making it necessary to understand ‘accurately how prices are determined in a free market’ (First Principles 1960, April, p. 103). It is precisely here where Nymeyer’s electronic order book reveals its moral orientation: it was not a device for attaining operational efficiencies but, rather, an arrangement that created the conditions for producing ‘fair’ or ‘just prices’, a mechanism for creating brotherly love. Within Nymeyer's Austrian-inspired philosophy, a ‘fair price’ was the result of a struggle between the participants of a market aimed at determining a ‘single price for all. Probably most people would agree that that is
“justice” (First Principles 1960, November, p. 330). In a market where such price prevailed,

no buyer coerces a seller beyond the limits that the seller is willing to go; and vice versa, that no seller coerces any buyer beyond the limits that the buyer is willing to go. [...] Every buyer and seller, by this definition, himself wishes to be a buyer or seller at the price that prevails. Every actual buyer and seller prefers to pay the price he is paying or receiving, versus not trading at all. Every buyer and seller, according to his own estimation, gains by the transaction. He trades willingly. The market he creates or helps create is, in that sense, a free market (First Principles 1960, December, p. 359).

Nymeyer was keenly aware, however, that single ‘fair’ market-clearing prices were rare achievements. Rather, as suggested by Austrian economists like Böhm-Bawerk, Nymeyer saw transactions in markets as occurring along a range of multiple prices that reflect the overlapping preferences or limits at which agents are willing to engage in a trade (see Figure 2). For Nymeyer, all transactions occurring within this range are ‘just’ insofar as buyer and seller are not coerced to exchange. The ultimate price paid for a good, however, can vary substantially and particularly so in scarcely populated markets, ultimately making of market prices ‘arbitrary’ outcomes of the asymmetry of bargaining skills between buyers and sellers (Bohm-Bawerk 1891).

A remedy existed for eliminating these arbitrary prices that, according to Nymeyer, impeded attaining brotherly love in the marketplace and beyond: as Bohm-Bawerk argued, increased competition narrowed the range of values at which agents are willing to trade. Nymeyer observed,
When there are many buyers and many sellers, the range in which the buyers and sellers can be “tough” toward each other is narrow. [...] Skillful and ruthless traders have no real range in which to “extort” from another what their intelligence, wealth or strength might induce them to attempt to “extort.” The “market” restricts them [...] [Competition,] which is no respecter of persons, is the most influential factor in the world for promoting justice (First Principles 1960, December, p. 359; First Principles 1960, October, p. 317)

[INSERT FIGURE 2 HERE]

At the time when Nymeyer wrote these words, American stock markets were spaces of restricted competition—in the New York Stock Exchange, ‘probably the greatest market that has ever existed in this world’ (First Principles 1960, January, p. 8), opportunism was controlled and so were its competitive dimensions (Abolafia 1996). The mechanics of trading maintained by NYSE specialist market makers, who generated prices through the manual matching of orders in their pen-and-pencil order book as instructions to trade arrived from floor brokers, implied that competition could only be partially reflected in the marketplace: prices on the NYSE would always encode the market maker’s profit and his unique (and private) knowledge of information flows (O’Hara 1995). Nymeyer addressed this structural feature of the NYSE in the patent for the electronic order book, where he wrote that,

The maintenance of a fair and orderly market becomes difficult in direct relation to the increasing complexity of business structure upon which the markets are based [...] the increase in the number of individuals participating in the markets but not directly present increases the
possibility of manipulation of market prices by those persons, such as the stock specialists actually present at the exchange and actively engaged in making market price determinations (USPTO 1971).

Through the ‘possibility of manipulation’, NYSE specialists imposed barriers on brotherly love; complete automation provided a moral resolution. By transforming the order books of specialists into an open, yet anonymous, electronic trading mechanism, Nymeyer thus sought to create conditions through which trades resulted in fair prices, determined within the competitive struggles of a ‘free market’ (First Principles 1960, June, p. 103). Nymeyer was not eliminating the ‘the exercise of human judgment’ (USPTO 1971) in price determination; rather, he was combating what he considered as the arbitrary, unbrotherly prices of the NYSE.

To read Nymeyer’s patent simply as a ‘deliberate effort to cheapen the costs of production’ (Collins 1986, p. 25; Cortada 2006) or as a device designed with the primary justification of increasing efficiency (Fourcade and Healy 2007, p. 301-302) would thus miss a critical point. Insofar as Nymeyer considered stock markets as ‘sensitive barometer[s] of the expectations of business men’ (First Principles 1960, January, p. 8), the prices they reflected commanded an exacting ethical onus: ‘cause and effect are intermingled in the New York Stock Exchange’, wrote Nymeyer, but just as ‘opinions “outside of the market” […] influence the trend of the market […] in a reverse sense, the trend of the market’ influences the opinions of businessmen and investors alike (First Principles 1960, p. 8). In proposing what was certainly a radical transformation of the structure of American stock exchanges, Nymeyer also advocated reconfiguring the moral spaces of finance to guarantee the legitimacy of the market’s prices and of the
transactions that led to their determination—echoing, in important ways, the debates that saturated the reconstruction of trading floors in Chicago forty years earlier (Zaloom 2006).

But what Nymeyer advocated was not a punctual ‘technical fix’ (Jamison 1989)—an isolated intervention that sought to solve a bounded problem within a single organization. His was a moral infrastructure, a project that diffused the boundaries between the social and the technical throughout the American financial system, offering a ‘distribution of solutions’ to the marketplace (Bowker, Baker, Millerrand and Ribes 2010, p. 102). Nymeyer’s electronic order book was a ‘relational property, not a thing stripped of use’ (Star and Ruhleder 1996, p. 113) that by eliminating the specialist and permitting competition sought to account for, ‘in a Godlike manner, the marginal utility of each unit of goods to be traded, for every potential buyer and seller, [to then] match such data so perfectly that the ideal price, presumably the ‘just price,” is arrived at’ (First Principles 1960). The distributed character of Nymeyer’s patent is evinced in how legal scholars commented upon its historical importance: it was, perhaps, among the very first cases of a ‘business method’ coming under the protection of intellectual property law. Nymeyer did not specify the design of a novel device or the ‘manner of new manufacture’, as expected of patents at the time (Leith 2007, p. 11). Rather he presented a new way of ‘doing business’, a reconstruction of an idealized and morally virtuous market, disaggregating, classifying and re-bundling the different activities that were required to produce prices and exchange stocks (see figure 3 and Leith 2007, p. 11-16). To paraphrase Fourcade and Healy (2007), Nymeyer’s was a market moralized through the deployment of economic and engineering techniques; but it was, too, the outcome of a specific
ethical *disposif* aimed at bringing American stock markets in line with distinct moral ideals 'so the processes that go on inside them can be regarded as legitimate' (p. 304).

5. Case 2: Making markets on Floral Street

Although Nymeyer’s electronic order book provides a template for understanding market infrastructures as moral projects, it does not account for their adoption within organizations. Referenced by over 657 patents since 1971, Nymeyer’s design never materialized. Frederick Nymeyer might have been a heterogeneous engineer who, like Edison, linked technical, social, political, moral, and economic factors in his invention (Hughes 1993; Law 2012); but, unlike Edison, he did not succeed in seeing his electronic order book transform the organizational field it inhabited.

Electronic order books were developed, nonetheless, across numerous locations with varying degrees of success. Starting with relatively precarious experiments in the 1970s that included the trading systems of Institutional Networks Corporation (later called Instinet; Manns interview), the Cincinnati Stock Exchange, and the Toronto Stock Exchange (Muniesa 2003), by 2005 the electronic order book had become the technical norm for stock exchanges across the globe as the platform used to facilitate trade (Gorham and Singh 2009). This specific trajectory of adoption can be explained, in part, by how the internationalization of trading in the 1980s increased competition for business across the stock exchange industry. In competing for commissions associated to the volume of trades handled by their users, stock exchanges utilized the lower costs and increased operational efficiencies of order books and electronic trading as relative advantages within national, regional, and global markets (see
Domowitz and Steil 1999; Lee 1998; Glostein 1994). This explanation, however, conceals the organizational tensions and contradictions associated to the automation of stock trading: as firms traditionally owned by their user-members, the adoption of electronic order books challenged the interests of an important and powerful category of market actors: market makers who, like the NYSE specialists, stood at the center of exchange. As economists Domowitz and Steil (1999) highlight, automation often followed a specific type of transformation in stock exchange corporate governance referred to as demutualization—a legal process whereby the member-owned stock exchanges of the past were privatized as publicly traded companies transforming seats into shares.

Here, the London Stock Exchange provides an illustration of how infrastructural workers leveraged their roles and expertise in getting the organizational field to adopt electronic order books without the economic incentives of demutualization. Founded in 1802, the London Stock Exchange operated throughout most of its history as a member-owned, self-regulated organization: it only became a publicly traded company in 2000, three years after the introduction of its first electronic order book (the Stock Exchange Trading System, SETS) in 1997. The creation of SETS was, indeed, momentous: it signaled both a change in the technologies of the marketplace as well as a profound transformation of the structure of trading itself. From its foundation, the LSE had operated under an organizational arrangement known as single-capacity, whereby the membership of the Stock Exchange fell into one of two possible categories. While member stockbrokers provided advice to investors and submitted their order to the trading floor for execution, so-called jobbers
acted as competing market makers, quoting bids and asks to the brokers with which they transacted (unlike the NYSE’s specialists, London’s jobbers did not have a monopoly over the stocks they traded). This division of labor held informally for most of the nineteenth century and was codified within the LSE’s rules in 1909, when brokers were prohibited from buying or selling shares on their account, and jobbers forbidden from dealing directly with investors (Michie 1999).

In London, jobbers effectively made markets, not only by providing liquidity to the brokers on the trading floor but, as importantly, by occupying a powerful position within the political constellation of the market organization (see Michie 1999, Kynaston 2001, and Attard 2000 for telling histories of the London Stock Exchange and its jobbers). This changed, of course, with the arrival of electronic order books. As systems that receive orders to trade directly from end-users and dispense with the need of a jobber, electronic order books reverse the distribution of power, displacing the capacity to make markets on individual investors. A question thus emerges: why did LSE adopt a technology that challenged its most powerful members?

5.1 Capture

The history of the LSE’s electronic order book starts several decades before its physical inception with a critical, if unsuspecting, moment within British finance: the purchase of tabulating machines initially, and computers subsequently, to aid the processing of trades in the back-office of the Exchange. Inspired, perhaps, by a broader isomorphic trend of mechanization within British business, and certainly incentivized by the need to reduce operational costs in clearing and settlement services, LSE bought into the information age in 1949 when it leased
a Hollerith punched-card machine to facilitate accounting for the trades conducted on the floor between members. The affordances of mechanization soon captured the imaginary of the organization. ‘Calculations can to-day be done electronically’, wrote Mark Day in the *Stock Exchange Journal* in 1956 and as cogs and cams give place to transistors [sic.], magnetic cores and vacuum tubes, and electrical impulses become the order of the day, the question of the applicability of the Electronic Computer [sic.] to the Stock Exchange work is coming up for discussion and quite serious consideration.

Indeed, in 1966 LSE fully committed to digital computing, installing an ICT 1903 in the Settlement Office at 26 Austin Friars, and cementing the role of electronic technologies as solutions to the accounting challenges of the Exchange’s back-office.

An unsuspecting consequence of digitization was that, in incorporating computers to the organization, the Exchange also attracted their human appendages (Barley 1986; Yates 2005). Although the Exchange leased most of its computers from vendors, it created and internalized small maintenance crews to keep the novel electronic systems in order. As technical specialists trained in the operation of computers and telecommunication systems, these technologists were socially, culturally, and organizationally distant from the gentlemanly brokers and jobbers that controlled the Exchange and its marketplace (Michie 1999; Courtney and Thompson 1996). They were ‘invisible’ outsiders that, as one confided during interview, were ‘sort of plebs’ (Buck interview; Bennett interview) occupying roles far removed from the higher echelons of the organization’s hierarchy.
This sense of detachment was echoed by a distinct impression among Stock Exchange technologists that the organization they had joined was technically underdeveloped. This is perhaps best represented by the recollections of Peter Bennett, an Electronic and Electrical Engineer trained at City University, London, that was hired by the Stock Exchange in 1971 to become over the next twenty years one of its most prominent managers. For Bennett, the organization knew nothing about computers, and to cut a long story short, they spent a lot of money on this machine [the ICT], and conveyor belts and stuff like that. [It was as if it were designed] by someone who’d worked at Ford Dagenham because their idea of automation was to shift the paper from one end of the building to the other one on a conveyor belt. [All] this mainframe [...] did was [...] sort of very basic process control (Bennett interview).

The Stock Exchange was, however, a space of opportunities. An outcome of the organization’s expansion and its lack of a clear technological strategy was that, with relative autonomy, technologists could reframe the LSE’s problems and possibilities in terms of the Exchange’s recently acquired electronic resources (Barley 1988; Barley and Bechky 1994). For the newly arrived engineers, the LSE’s computers could be put to much better uses than shifting paper across the marketplace. In particular, they could be exploited to develop real-time technologies for the marketplace, rather than ‘merely’ batch-processing applications for its back-office\textsuperscript{10}. For these early technologists, the occasion to embark on such development came in 1969: As the place where jobber’s quotes and market prices were generated at the time, access to the
trading floor was a valuable commodity; as early as 1957, some member broking firms had deployed ad hoc video systems to relay quote and price information from the pitches on the floor to the offices of their firms. These makeshift systems competed with the Exchange’s very own information collection services and were a source of conflict and acrimony. But for the technologists, they were an opportunity for taking the computing technologies used in settlement closer to the core activities of the organization on the trading floor. As Bennett recalled,

I said, 'look, there's a lot more civilized way of [using] this pair of very expensive real-time computers. Why don't we just put a few screens on the market floor, hide them away, connect them to the [Argus computers], and then we can get the Argus 400 to actually broadcast, [in] digital form, TV signals which we can broadcast around the City [...] so we [installed] a City-wide closed-circuit television system [that captured] market prices [and broadcast them in] 22 channels of video so you could see the stock and the price [...] (Bennett interview).

The Market Price Display Service developed by Bennett and his colleagues in 1971 was quite probably, ‘one of the first stock exchange display systems anywhere in the world’ (Bennett interview) and one of the ‘first cable networks’ in Britain (McLelland, personal communication). It did not, however, alter the mechanics of price formation on the trading floor, merely providing an indication of the prices that were quoted by a handful of select jobbers. Simplicity notwithstanding, MPDS was quite a success. For the organization, it became an important source of revenues. And for its users, it offered a convenient and standardized visualization technology. Rather than calling on the trading floor, brokers could simply turn the dial on their customized MPDS television sets to
get a sense of the state of the market. And when conditions were calm, they could also tune into cricket matches during the trading day—a characteristic of the system that seems to have given it appeal amongst the City of London’s gentlemanly brokers (Bennett interview).

On the basis of its financial success (Bennett interview; Scannell interview), MPDS was expanded into a national service (Country MPDS) in 1974. The growth of information vendors such as Reuters and Telekurs, the increased demand for price and company information from brokers (Dobbie interview; Dugald interview), and the likelihood that competition could materialize in the form of an alternative trading system far from the control of the Stock Exchange\(^\text{11}\), underscored the technical challenges for the organization. By 1976 the limitations of the LSE’s systems were made apparent, when MDPS reached a technological bottleneck becoming incapable of handling additional quantities of data. For LSE technologists, the task was not merely to scale up MPDS but, rather, to develop a clearer strategy foregrounding technology within the Exchange. And in this they were not alone: having amassed credibility with the accomplishments of MPDS, they were supported by some members of the Exchange’s organizational core. What was needed, recalled stockbroker Patrick Mitford-Slade, then head of the LSE’s Information and Communications Committee, was a system that could handle ‘an unlimited amount of information’ (Mitford-Slade interview)\(^\text{12}\). And for this, the Exchange required an army.

The adoption of computer equipment for settlement and the modest, though significant, addition of technologists to the LSE’s hierarchy thus ‘layered’ the Exchange into a novel organizational path (Streek and Thelen 2005; Mahoney and Thelen 2010). The Stock Exchange did not change in structure,
persisting as an organization governed by its members. Similarly, the marketplace was not altered in its mechanics: jobbers remained at the center of exchange, though increasingly aided by a growing suite of taken-for-granted technologies that made trading costs lower and price dissemination faster and more efficient. But while not changing normative structures, technologists altered the Exchange by amending, revising, and adding to the expectations and practices of the organization and its users (Mahoney and Thelen 2010, p. 15-31): as early as 1971, the *Stock Exchange Journal* noted that ‘[in] little over a year the City’s brokers [became] a group of push button devotees’ (Hughes, 1971); in 1973, the Stock Exchange council had recognized that ‘world-wide provision and reception of market information through visual display screens will in future become a vital aspect of the business of the Stock Exchange and its member firms’ (Council of the Stock Exchange, quoted in Michie, 1999); and in 1979, a review of broking services commissioned by the Exchange noted that

> It used to be taken for granted that a computer system would be put in charge of its own special priesthood who would make sure that its perfect functioning was not contaminated by the presence of the ungodly. The real problem was to teach the priesthood about Stockbroking, and some organizations never succeeded. Now the control is moving back into the hands of people whose expertise lies in the Stockmarket and its workings [...] The atmosphere has changed, and office staff who used to be afraid of the ‘electronic brains’ now take it for granted that they will operate keyboards and terminals as part of their work. The ‘punch girl’ who hammered holes into cards all day long without knowing what they meant is a vanishing species (Josephs 1979).
As the Exchange and its members increased investments in developing systems for the market, they also placed greater resources on the hands of technologists. For example, when LSE internalized research and development in 1976 to reduce external subcontracting, it created a more visible niche for technological work by establishing the Directorate of Information Systems and Settlement and recruiting George Hayter, a well-regarded technology specialist previously involved in developing one of Europe’s first real-time flight reservation systems at the British Overseas Airway Corporation. Greater investments also translated into increased organizational capital among LSE technologists (Emirbayer and Johnson 2008; Brynjolfsson and Hitt 2000). Employees who had joined the organization’s technical ranks to maintain the early generation of information systems rose to become respected leaders of a host of expensive and critical projects (Bennett interview; Buck interview; Newman interview). Modulated by the expansion of its technical corps, the Exchange was slowly transformed in content and composition through the type of structurating work that reconfigures organizations through the production and adoption of technology (Orlikowski 1992; Barley 1986; Mahoney and Thelen 2010). As services expanded (MPDS was overhauled in the late 1970s, seeing the introduction of TOPIC, an extensive price visualization system, EPIC, a real-time electronic market database, and TALISMAN, a robust and resilient paperless settlement system), so did the size of the technical teams that produced them. From a dozen technologists and engineers hired in the 1960s, LSE grew to employ between 3,300 and 3,500 people in technical services by 1986, standing perhaps as one of the largest sites of information technology development in corporate Europe (Sheridan interview; Bennett interview). The core group of a
dozen or so technical specialists that joined the organization in the early 1970s grew ‘to a couple of hundred [engineers], three hundred probably’ working in a dedicated research and development group (Buck interview). George Hayter alone oversaw between 2,000 and 2,200 employees whose responsibility was to ‘run the market and [make innovations] operational’ (Bennett interview’ Hayter interview). Programmers, developers, computer engineers, analysts, managers, and clerks of all sorts overflowed the Stock Exchange’s main tower, requiring up to 14 buildings across the City of London housing everything from restaurants and offices to back-up systems (Scannell interview).

More significant, perhaps, was the organizational corollary of this socio-material expansion (Orlikowski 2007). By the late 1970s, the development of new systems had become ‘definitely bottom up’, with ideas coming from people who ‘knew what technology was available’, particularly, the ‘Peter Bennetts and George Hayters of the world’ (Mitford-Slade interview). Interviews with both former stock exchange members and technologists convey this sense of autonomy: in matters of technology, the Exchange trusted its engineers. Bennett concurred: according to his recollections, he could ‘do no wrong. I mean, they gave me more or less a carte blanche to automate everything inside’ (Bennett interview). Exchange technologists had captured their organization.

The deference placed on technologists’ expertise to solve the technical challenges of the Exchange could have become a resilient organizational constraint. The same expertise that made technologists valuable for the Exchange made them invisible for matters of market governance: engineers were neither brokers not jobbers, having no apparent stake on the culture and practices of the organization; they did technology, not markets. After all, as noted
stockbroker Paul Bazalgette warned those tempted to feed their business into a computer, ‘dealing done that way will never be fun. Dealing certainly ought to be, and I think that between humans it usually is’ (cited in Kynaston 2002, p. 422).

As they captured resources, though, stock exchange technologists became increasingly vocal advocates of market reform. For them, technologies could replace the longstanding practices of the organization, spearheading the Exchange into a global arena of competition. And here, technologists found an uncanny ally in the Premiership of Margaret Thatcher, a ‘very radical conservative government’ that ‘didn’t like clubs and [...] didn’t like monopolies’ (Riley interview).

For the UK’s Office of Fair Trading, the Exchange’s practices and regulations were obstacles for competition, as envisioned in the Restrictive Practices Act of 1976. Having analyzed its Rules and Regulations in 1978, the Office of Fair Trading found the Exchange in breach of legislation. The ‘future operation of a national undertaking’, wrote stockbroker Dundas Hamilton, ‘[...] was to be decided in a court of law’ (Hamilton, 1986, p. 11). The election of a Conservative government in 1979 did little to thwart the case against LSE; at most, it opened a window for negotiating a settlement. And so, in 1983, the Exchange agreed to eliminate ‘by stages and with no unreasonable delay, all the rules which at present prescribe minimum scales of Commissions, and to complete this dismantling by 31 December 1986’ (Sir Nicholas Goodison quoted in Michie, 1999).

The end of fixed commissions threatened to unravel other market structures. In particular, increased competition over trading and the relatively low levels of capital held by member firms, made untenable the division between
brokers and jobbers, bringing the bicentenary tradition of single-capacity to an end. The deadline agreed between the Exchange and the OFT thus became a moment of great organizational change: in addition to eliminating single capacity and fixed commissions, the LSE agreed to accept foreign firms as members and to allow increased capital stakes of banks among the membership, implementing all changes on a single date, 26 October 1986.

Known within the literature on British finance as London's big bang, this date rendered uncertain the future of the market. While members of the LSE had practical experience with, and understood the mechanics of, other global financial marketplaces (Ross-Russell interview; Mitford interview; Newman interview; Hayter interview), questions remained about which trading system best suited London's history. As the Council noted, ‘Market participants of the type found in other financial centers cannot be conjured into being at the stroke of one pen [...] Different types of Firm may evolve, but the market framework itself cannot immediately create them’ (Council of the Stock Exchange 1984). In transforming the structure of trading, LSE understood the necessity of modernizing its systems: and so, exploiting the uncertainty of change, big bang became a pivotal opportunity for Exchange technologists to re-engineer the marketplace and its organization.

Technologists seized this historical conjuncture (Mahoney 2000) as a chance to build what they saw as a 'better' market for London—one that was patently different in mechanism and structure from the markets that had been made by jobbers over the previous centuries. In particular, the plan developed by George Hayter's department envisioned complete sociotechnical integration, reassembling the heterogeneous network of market information and settlement
systems installed by the Exchange over the previous decade under a single technological umbrella, a general-purpose infrastructure to replace those in place. As George Hayter announced in 1983, this Integrated Data Network (IDN) was set to have ‘a widespread impact on the working of the Securities Industry over many years’. Based on packet switching and real-time computing, IDN tackled the ‘proliferation of networks’ within the Exchange that, for LSE technologists, had led to ‘high cost, inflexibility and inconvenience to service users’. Offering a unique communication platform, IDN facilitated the interoperability of the existing systems at the Exchange, providing ‘faster, easier and cheaper communications’ for the UK securities industry ‘by setting up a common data network operating to a set of recognized international standards’ (Hayter 1983). Importantly, IDN was designed for bilateral electronic exchange, permitting ‘high volume data collection, transaction processing and teleprocessing applications which require two-way communications’ (Bennett 1984). Existing LSE systems such as MPDS, TOPIC and EPIC, placed the duty of quote and price formation on jobbers, and so were optimized for the unidirectional ‘outflow of rapidly changing market information’ (Bennett 1984). By making possible bidirectional data flows, however, IDN would serve as the infrastructural foundation for radical change: the introduction of a system that permitted real-time communication between exchange counterparties making possible a ‘globally accessible order book’ for London’s prime marketplace (Bennett 1984).

In this, IDN revealed the distinct moral and organizational vision of Exchange technologists. In addition to challenging the position of jobbers at the center of the marketplace and of price formation, IDN entailed a novel
conception of what the stock exchange should be. Whereas the LSE’s membership understood their mission as providing ‘the market where stocks and shares are bought and sold’ (London Stock Exchange, nd.), technologists saw the organization’s competitive role as producing platforms and infrastructures for the electronic marketplaces for the future. Commenting on the difficulties faced by American stock exchanges at the time, Bennett suggested what was tantamount to a new conception of control (Fligstein 2001). For him, stock exchanges in the United States had not taken a lead in the development of networked markets, but have instead largely abrogated the responsibility for networking and have handed the business to third party operators. In contrast, the U.K. Stock Exchange has invested, and continues to invest, heavily in information and communications systems and it has built up a considerable systems development and operations skills in these areas (Bennett, 1984).

Bennett not only justified the growing body of technologists within the organization. For him as for many other market engineers, the future of the Exchange resided in technology. As Stanley Young, LSE’s former Director for New Strategy Development, tellingly noted, ‘We recognized that the old world had changed and that we were at the forefront of something that was incredible, because technology just freed us from this physical box that we were in called a floor’ (Young interview).

But IDN was never to be. Perhaps it was simply too ambitious a project: as Edwards notes, infrastructures seldom respond to a single vision or a master plan (Edwards 2012); rather, they are the products of tinkering and wrestling with an installed base (Star and Ruhleder 1996), of the mangle of meeting and
accommodating the resistance of what exists within the organization (Pickering 1993). By late 1984, the ambitions of an IDN proved unrealistic, so Exchange technologists shifted to the more mundane task of producing a system in time for big bang. NASDAQ, the automated quotation service of the National Association of Securities Dealers, provided an operational template. ‘NASDAQ was intriguing’, recalled Hayter, ‘because [their] market-makers looked a bit like [our] jobbers, except that they were dual capacity, they were able to trade on the one side with their clients and on the other side for themselves’. Thus, by early 1986, the solution arrived: through a bricolage (Levi Strauss 1978; MacKenzie 2003) of existing organizational resources, Exchange technologists ‘put two legacy systems together […], which was actually quite a safe route’ (Bennett interview). The result was Stock Exchange Automated Quotations (SEAQ), a system that through computer screens and telephones preserved the LSE’s quote driven markets (author ref). LSE technologists might have captured the organization, but in producing systems for big bang and expanding their influence over the market’s design, they nevertheless failed to challenge the position of jobbers within the marketplace.

5.2 Revelation

SEAQ was a great success. Despite copious investments refurbishing its trading floor for big bang, within days of SEAQ’s arrival, market makers had abandoned the floor for the screen. ‘Within three or four months’, recalled Mitford-Slater, ‘even [those who pressed most for keeping the floor] had gone because they’d realized that business wasn’t [there]’ (Mitford-Slade interview; author ref). In making the trading floor irrelevant, SEAQ manifested the import of technologists within the organization.
Indeed, the increased visibility and autonomy of Exchange technologists both at LSE as within the broader organizational field of global stock exchanges, regulators, and financial intermediaries was a notable pattern in the years surrounding big bang. At LSE, for example, Peter Bennett was promoted to Executive Director and joined, along with George Hayter and Peter Cox, the Exchange’s Management Board. Similarly, technologists were given leadership in establishing new ventures, the most prominent of which was perhaps an electronic system for the budding market in overseas securities traded in London. Capturing this market, which prior to big bang took place through piecemeal and unregulated over-the-counter transactions, required a strong demonstration of heterogeneous engineering (Hughes 1993; Law 2012). As Project Manager Peter Cox recalled, for the participating foreign firms, the market was ‘a bit of a Wild West’, so the challenge for the Exchange’s engineers was not to ‘put all the sexy technology in place, but just try to organize a market for these players’ (Cox interview). The creation of an orderly market was not only a technological feat: market engineers understood quite well that the legitimacy of transactions hinges on guaranteeing the agreements between traders, in organizing trust by standardizing and regulating their actions (Busch 2000; MacKenzie 2007, p. 12-15; Weber 2000 [1894]). ‘We allowed them to set the rules for how [their] quotations were to be interpreted’, said Hayter, ‘These were not universally accepted; they were not standardized, until we got these people together in a room’ (Hayter interview). The exercise of fomenting ‘confidence in the market place’ (Cox 1985) was plainly successful. The resulting trading system, SEAQ International (SEAQ-I), was a commercial success; upon its introduction in 1985, it expanded rapidly into a wide variety of shares and
commanded a large segment of the aggregate European stock market. By the late 1980s, SEAQ-I captured between 26% and 60% of the trading in the shares of the 250 largest European companies by capitalization. Trading in French shares on SEAQ-I in 1990 represented as much as one-fourth of the volumes traded on the Paris Bourse (Jacquillat and Gresse 1998). SEAQ-I ‘sucked liquidity from the continental market centers’, mentioned Bennett with pride (Bennett interview), making London once again a pivot in the global financial marketplace. But more importantly, SEAQ-I placed technologists at the helm of a new market; it demonstrated, in concrete organizational ways, that they too could make markets.

Outwith the Exchange, technologists were also increasingly noted. The chief developers at institutions such as Instinet (US) and the New York Stock Exchange, for example, where either aware from reputation or personally met LSE’s technologists (Manns interview, Keith interview). The visibility of LSE technologists was partly the product of overt strategies to create relations and establish their status and expertise within the burgeoning field of global market technologies. Some, such as Hayter, actively cultivated networks within the industry by organizing specialist conferences on innovations in banking and finance (Computer in the City, Hayter interview), and participating of specialist international meetings on technology; notably, these included the International Federation of Stock Exchanges’ committee on technology, created by Hayter and other European market technologists, and to which they ‘dragged [in] people like Bill Lupien and Bill Porter from Instinet and E*Trade, respectively [...] to sound wake up calls for the sleeping stock exchanges’ (Hayter interview). Peter Bennett similarly nurtured relations, contributing to international projects such as the...
United States’ Office of Technology Assessment’s *Electronic Bulls and Bears* report (U.S. Congress, Office of Technology Assessment 1990), and establishing working relations with Michael Porter (founder of Monitor Group), Peter Schwarz (founder of the Global Business Network), IBM’s Federal Systems Division, and Boeing’s Information Systems group, around discussions on the challenges faced by the Exchange (Bennett interview).

But the prominence of technologists was also a result of the increased visibility of their market infrastructures. Despite some initial glitches, SEAQ and SEAQ-I demonstrated their resilience, growing to be known across the global financial industry as flagship cases of market innovations. As Bennett recalled, ‘The people at the New York Stock Exchange at the sort of technical institutional level were jealous of our systems [...] they couldn’t believe we had this system, because they had Quotron [...] and this was ten times better than Quotron. They couldn’t believe we owned and controlled this [and that] we could actually use this as a centerpiece of our market automation program’ (Bennett interview).

Jealousy might well have been the best form of recognition: owing to the prominence of the systems they developed, Exchange technologists were soon invited to join the efforts of automating other marketplaces, including futures and options exchanges in Britain and across the world (Cox interview; McLelland interview).

Visibility came at a cost, though. On October 19, 1987, global markets collapsed precipitously, entering a long period of reduced activity—the UK’s main stock index, FTSE 100, only recovered its pre-crash levels 23 months after the crash, in September 1989. As trading volumes fell, so did the Exchange’s income, and in late 1989, on the back of ever-expanding expenditures in
technology, LSE incurred a substantial loss. Controlled by its members, LSE’s management reconsidered their corporate strategy. For the membership, the crash rendered investments in technology as disproportionate: for them, Bennett noted, ‘[this was] not the way to run an Exchange. [They thought we] need to concentrate on other things, like designing a bigger and better market’ (Bennett interview). The first casualty was research and development. In an attempt to control costs, the production and maintenance of market technologies were outsourced. George Hayter left in December 1990 – ‘[If] you’re going to outsource to Arthur Andersen, you don’t need a director who’s responsible for internal IT services’, he recalled – going off to ‘develop stock exchanges in Eastern Europe’ (Hayter interview).

Peter Bennett left LSE the same year and, for a time, ‘earned [his] bread’ by convincing ‘the top exchanges in Europe to agree that there was a need for a European price dissemination system’ (Bennett interview). Bennett’s project belonged to the same genealogy of technologies that inspired Integrated Data Network years earlier. And like much of the developments in financial markets at the time it was, too, a product of regulatory pressures. Seeking to integrate markets across the region, the European Commission had set 1992 as the deadline for implementing the free flow of financial services between the then twelve member states of the European Union. For entrepreneurs like Bennett, this presented an opportunity for creating communications infrastructures tailored for Europe’s emerging single market. As Michael Waller-Bridge recalled:

we [Bennett, Waller-Bridge and Stephen Wilson] generated […] the idea that there should be [a] cost effective infrastructure on a pan-European basis, not in a federalized sense but a set of cooperative arrangements
[between national stock exchanges]. Peter and I and others in the group were assigned to it. And this became a joint venture. It was a joint venture between the principal stock exchanges of the then 12 member states. Peter was in charge of the technology. I was in charge of the joint venture discussions and was put in charge of the joint venture company.

The project, known as the Pan European Market Information Network (PIPE), was an ambitious attempt to create ‘a central information capture and delivery point for regulated and strategic securities market information’ enabling the ‘the dissemination of this information in real time throughout Europe’. Importantly, as ‘a network capable of providing interactive access to market systems operated by Exchanges’, PIPE would have created ‘a central point for automated trade execution, trade confirmation and settlement message routing’, similar in design to the globally accessible order book envisioned for IDN (Federation of Stock Exchanges in the European Authority 1990). The project was patently ethical; like Nymeyer’s order book, PIPE made reference to equality in the context of a financial marketplace characterized by the contrast between its member organizations—a strategy that resonated, perhaps, with the cultural frames mobilized by elite institutional actors in the creation of the single European market (Fligstein and Mara-Drita 1996). ‘The inspiration’, said Waller-Bridge, ‘had really been the Consolidated Tape in the United States which was enacted by congressional fear in 1975 to insure that there was equivalent access to [market] data across America’ (Waller-Bridge interview; author ref).

But like IDN, PIPE also failed. Opposition from the London Stock Exchange cancelled the project, and ‘[even] the idea of the joint infrastructure on a [European] scale went out [the window]’ (Waller-Bridge interview).
[We] felt we really couldn’t operate in that environment. Peter and I and [Wilson] then left and started a consulting company. And from that consulting company, called Bennett, Waller-Bridge, Wilson or BWW [...], we had a plan to [show that a] European-wide infrastructure could work. It really was going to work, [and] it could lead to a [pan-European trading] system. [But] we were no longer within [a financial] institution. We were outside, so [in 1991] we decided to do this as a venture (Waller-Bridge interview).

The course taken by Bennett and his colleagues was bold. To build a European infrastructure, they needed institutional support. Their company, a small consultancy in London, was insufficient. They needed an exchange. And so they built one, in Thames Wharf.

[That's] where all the creative work was done [...] [That's where we defined] what were the market constructs, what the technology was, what the regulatory structure was, et cetera, et cetera. And that was really the genesis of the whole thing that became Tradepoint. [It] took us the best part of five years [to launch Tradepoint] [You’ve] got to remember that when we started we were literally three guys, a bunch of packing boxes and an assistant answering the phone, some IKEA tables and chairs, one phone line, trying to think ‘right, how are we going to do this’ with literally a clean sheet of paper (Wilson interview).

The trading system produced by Bennett, Waller-Bridge, and Wilson leveraged the technical and social resources they had nurtured while at the Exchange and in the development of PIPE (like Bennett, Waller-Bridge and Wilson were also former LSE technologists). They recruited, for example, two
notable technologists and former colleagues, Ian McLelland and John Scannell, to
develop Tradepoint’s platform. Their challenge was not creating a trading
system from scratch but, rather, ‘contriving ways and means’ of tinkering with
(Star and Ruhleder 1996) commercially available solutions to create an
electronic platform compatible with London’s institutional environment.

We bought […] the basic software package from the Vancouver Stock
Exchange, [a] basic market package. It wouldn’t be suitable for us, but it
got us to base camp, [and] we could then change it. [McLelland’s] team
assembled and [built] the software, and routine parts of it that they
weren’t doing themselves they would outsource to India. [It] was a huge
development. [What] Ian built was amazing at the time (Waller-Bridge
interview).

These technological capabilities were complemented with the relations
that engineers forged with market participants in the past and which provided
robust signals of external legitimacy. Notably, Tradepoint appointed Stanley
Ross, a prominent investment banker responsible for creating the Eurobond
market in 1963, as chairman of the firm. Similarly, the firm attracted Sir Michael
Jenkins, another former LSE manager who had been instrumental in setting up
London’s clearing and settlement services in the 1970s and who served, since
1981, as Chief Executive of the London International Financial Futures Exchange,
LIFFE (Bennett interview). The status and experience of these heavyweights
were necessary—after all, Tradepoint was set to become the first stock exchange
to challenge the LSE’s structural position in the recent history of British finance.

Tradepoint was thus built as an ‘oppositional’ (and, in many respects, less
privileged; Fligstein and McAdam 2011, p. 6) challenger to the incumbent Stock
Exchange. Specifically, Tradepoint was a different conception of how to organize exchange: in addition to placing technology at the center of its corporate strategy, it departing from the LSE’s quote-driven market by offering ‘[a public] electronic order driven marketplace with guaranteed performance of trades’ (Waller-Bridge interview). Echoing Nymeyer’s patent, Tradepoint’s selection of technology was predicated on a combination of economics and morality: by allowing for competition beyond the control of the LSE’s market makers, Tradepoint’s electronic order book sought to narrow spreads and drive down costs for end investors (Wilson interview). As Wilson recalled, ‘[Our] view was that we needed really to embrace institutional access to [the] London marketplace’ (Wilson interview). Contrasting the principles of his exchange with those of the LSE’s market making system, Waller-Bridge noted, too, that theirs was ‘consumer led at the institutional level’ (Waller-Bridge interview). Investors would ‘have equal access to the price formation mechanism, which would then bring along competition, lower charges, be better for the pension funds, better for the savings. We even thought of calling it “The People’s Exchange” [...] in the sense that it would be working very much at a neutral stance of the institutions’ (Waller-Bridge interview).

Tradepoint, however, implied a radical departure from the financial practices of London’s markets: ‘[There] was absolutely no heritage, no one in the UK market at the time had any real knowledge or experience of order book trading. It was a completely foreign construct whereby you physically put an order into the market rather than trading on the phone and reporting it using some kind of price discovery’ (Waller-Bridge interview). How best, then, to convince prospective market users of the advantages of their system?
In recruiting support, the makers of Tradepoint engaged in an overt strategy of revelation, of making public and visible the infrastructures they had built. In addition to hiring the services of Brunswick, a notorious public relations firm (Waller-Bridge interview), the engineers manifested the superiority of their system by staging demonstrations of its awesome materiality:

[This] was all done [with commercially available] computers, [and] I do remember that we had issues with investors saying: “This must be a huge computer, absolutely vast to deal with an electronic market! Had you got big enough computers?” And I’d say “Oh, we’ve got very good computers. Peter Bennett knows his stuff, Ian McLelland knows his stuff, and John Scannell knows his stuff. [...] We’ve got it all speced properly [and] it is going be backed up and tested”. Typically, in those days, computers were about still the size of [a very small] room, but [we’d recently] moved to [Floral Street in] Covent Garden and we had this large room [where the] computer was placed and it looked rather small, because actually, [without] all the peripherals, the actual computer was probably the size of [a] sofa. So I said “We can’t show someone that, because [...] they will think it’s too small. I mean, you can go through this rationally but they just won’t [trust] us.” And Peter said, “You’re right! Where are we going to do?” And I said, “Look John [Scannell], please, could you go and buy the biggest, fattest wire [possible], like [the ones] in a James Bond film? And you have a room, and it says ‘Computer Room’ on it, and you put the computer in there, and then you have this giant wire, [this] sort of pipe thing [coming out of the room].” [Then,] at least then we [could] say “The computers are in there, we don’t like to disturb the computers, but that is
the Computer Room, and this has to be kept on its own uninterrupted power supply." And people would come on the tour and they’d see this room which said “Do Not Enter: Computer Room”, John Scannell’s empire, and they’d see this huge pipe going in, and it somehow gave a sense that there was power and depth to it, because people found it very difficult to believe that you would actually support a market on the technology at the time, which you could do, and [we] did do (Waller-Bridge interview, emphasis added).

Waller-Bridge’s recollections clearly allude to what MacKenzie and Elzen (1996) write of as the embodiment of the charisma and expertise of engineers in their machines (MacKenzie and Elzen 1996): in creating an artificially elaborate computer room at Tradepoint, Waller-Bridge and Scannell inverted the infrastructure of their marketplace (Bowker and Star 1999), stressing the ‘sense of power and depth’ of the computer-based order book by amplifying through aesthetics its robust materiality. The strategy was vital: although Bennett’s involvement in Tradepoint was ‘something very important; [people] knew [the system] was going to be substantive’, his expertise were interrogated by the novelty of the platform. To convince, Tradepoint had to deter hesitation, and for this it utilized a ‘sort of pipe thing’ that, while playing with the user’s imaginary of technology, established a ‘sense of security in the system’ (Hargrave and Van den Ven 2009, p. 130).

5.3. Conversion

As much as they sought to invoke trust in their system, the strategies followed by Tradepoint’s technologists simultaneously questioned the taken-for-grantedness of London’s markets: they demonstrated practically that a different
marketplace was possible. This was certainly a controversial proposal, as Wilson recalled. 'At the time', said Wilson in interview, 'the idea [of competing] with the [London] Stock Exchange' was unthought-of. Because, why would you? The [regulations] somehow don't allow it because, of course, there can only be one stock exchange. You have the London Stock Exchange, the Paris Stock Exchange, the Frankfurt Stock Exchange, [and] the Milan Stock Exchange. They are a bit like the village pub or church. You have one. And there is no concept of competition' (Wilson interview).

Such controversy, however, underpinned a conversion of the organizational field towards the electronic order book. Although contentious, the trading structure of Tradepoint resonated with the moral and practical horizons of two important sets of agents within British finance. On the one hand, Tradepoint’s emphasis on reducing costs for end investors found support in Her Majesty’s Treasury, from whom they required authorization to operate as a recognized investment exchange. For the Treasury, the question at hand was one of the externalities of innovation: Over the previous decade, and despite tremendous changes in London’s markets, the costs of processing small trades for private investors ‘shot up’; as Hayter (1993) wrote, by allowing ‘market forces to operate freely, [big bang] clearly benefited institutions at the expense of small investors’ (p. 159). While certainly preoccupied with the stability of the British financial system, the Treasury was not particularly concerned with potential fragmenting effects of Tradepoint’s introduction. As one former Treasury official confided, the regulator’s view was that 'The City could protect itself'; what mattered for the Treasury was ‘improving protection for ordinary retail investors’ (Interview with Treasury official). And in this, Tradepoint
provoked the Treasury's sensibilities: 'The way I looked at [Tradepoint] is that, kind of like in the business of making goods or transporting goods, we had 300 years of industrial revolution, but actually the business of doing deals and the way we did deals never really changed'. Technological change transformed finance, thought the Treasury, yet 'the actual doing [of] the deals was very much the same' (Interview with Treasury official). Tradepoint was interesting in this regard: by representing an 'industrial revolution [...] in the dealing process', it embodied 'the benefits of competition [...] for investors [...] The whole point [of authorizing Tradepoint] really was the belief that competition was a good thing. We wanted more competition in financial services' (Interview with Treasury official). And so, in 1995 and with the ascent of the Treasury, Tradepoint opened as the first recognized investment exchange to challenge LSE (Waller-Bridge interview).

Tradepoint's technical specifications also appealed to growingly important segments of the marketplace. For the newer foreign members of the LSE that joined with big bang, the Exchange represented an unreactive, 'slow-moving' organization (Wilson interview). The marketplace needed change, they argued, and the electronic order book developed by Tradepoint served as a tangible, if contentious, template for the future. For incumbent market makers, however, order books were inconsistent with the established practices of London's markets: decrying the modernizing ambitions of the LSE's foreign corporate membership, Mark Potashnick, Head of Equities at the British merchant bank Kleinwort Benson, warned of the ‘cultur[al] change [for institutional investors of having to] be part of a price formation system as opposed to react to prices which are made to them’ (Treasury Committee 1996,
In defending its market makers, the Stock Exchange concurred, noting that ‘To have [...] ready made liquidity, you have to pay for it’ (LSE Councilman Ian Plenderleith, in Treasury Committee 1996, p. 19). But for Gordon Lawson, Managing Director of Equities at Salomon Brothers, LSE’s market making system was neither natural nor culturally unavoidable: ‘Having had the experience [of dealing] in other markets [Salomon’s can] draw [its] conclusions about the efficiencies and inefficiencies [of the LSE’s system]’ (Lawson, in Treasury Committee 1996, p. 44) Indeed, the privileges afforded to market makers ‘should be removed’ (Treasury Committee 1996: 44), argued Lawson, for they resulted in an unnecessarily slow and expensive marketplace. For the international financial community in London, order books were the future.

But Tradepoint was also relevant for a set of emerging practices within the marketplace. In addition to being, perhaps, a ‘more comfortable [mechanism for] transacting business in London’ for international firms (Potashnick in Treasury Committee 1996, p. 34), the lower transaction costs of Tradepoint’s electronic order book and the anonymity it conferred on its participants catered to the needs of a new class of market participants, such as derivatives traders and hedge funds, that were heavily involved in Europe’s expanding derivatives markets (Financial Times 1995a; Financial Times 1995b; LSE official interview). Hedging market risks by replicating as accurately as possible the underlying portfolios of their traded derivatives, these market participants valued the expediency, anonymity and low transaction costs of Tradepoint’s electronic order book, constituting one of many technological hinges (Abbott 2005; MacKenzie 2014) of today’s domain of algorithmic trading. As Waller-Bridge recalled,
there were members [of Tradepoint] that were represented by boxes with flashing lights. And there was definitely experimental algo-trading. Now as for the speeds of transactions per second and latency and things like that it would have been quite different to today. But it was definitely there.

Tradepoint’s success in recruiting support was consequential. As Tradepoint demonstrated the practicability of an electronic order book and enrolled market constituencies, pressure mounted on LSE’s management to change. And so, in 1996 and despite strong opposition from market makers (Financial Times 1996), LSE proceeded with the development of their own electronic order book, Stock Exchange Trading System, to attenuate public and regulatory criticism (SETS would only become operational in October 1997 due to the complaints raised by some market participants about the tight deadlines for implementing the system: ‘Just because order-driven trading is used in overseas markets doesn’t mean it is right for London’, said one fund manager to the Financial Times; Financial Times 1996). While it is likely that the order book would have arrived at LSE independently of Tradepoint’s efforts, the infrastructural investments of its market engineers certainly accelerated its delivery (Waller-Bridge interview; Smyth-Osborne interview; Barnes interview). London was converted.

6. Conclusions

So, who made markets in London? Certainly transactional agents played a fundamental role. In his detailed study of eighteenth century joint-stock markets in Britain, for instance, Carruthers (1999) demonstrates the depth of the political and social project deployed by early cadres of investors and intermediaries in
establishing what became the central institutions of British finance. Indeed, until demutualization in 2000, the London Stock Exchange and its marketplace were largely controlled by the LSE’s membership, who dictated on the grounds of their interests the course of the organization. Had jobbers and brokers not used the electronic order book, and had regulators aligned with the privileges of market makers rather than with the competitive moralities of Tradepoint’s creators, this infrastructure would have likely disappeared. This was, in fact, a distinct possibility faced by Tradepoint in its early years. Its systems were ‘too fast’ for manual traders who were used to dealing with markets made by jobbers over the phone (Smyth-Osborne interview; Tradepoint was eventually rescued by the Swiss Stock Exchange, who used its regulatory recognition as a channel for accessing the British stock market; Barnes interview). Infrastructures of exchange, like those elsewhere, are irrelevant unless meshed with the practices of the organizational fields they inhabit—without the acquiescence of transactional workers, markets would not have changed.

It would be nevertheless incomplete to write of London’s markets as made only by transactional agents, not the least because such account would conceal the long, conflictive, and deeply moralized organizational processes that transformed market infrastructures within the field of global finance. Predicated on the unanticipated consequences (Merton 1936; Mahoney 2000) of the mechanization of the back-office, the transformation of markets in London was framed by tensions and battles between incumbent and challenging conceptions of control over exchanges, technology, and finance itself: should exchanges be marketplaces that, like the 1960s Stock Exchange, provide investors with the ability to buy and sell stocks and bonds; or should they be businesses geared
towards the production and commercialization of electronic platforms for trade (Lee 1998)? Recalling an event he attended in Downing Street in late 1996, Waller-Bridge's interview underscored some of these definitional struggles and their associated forms of moralized and political position-taking: as he walked through the crowd of regulators, politicians, and financiers, Waller-Bridge crossed paths with a well-known market maker. Their conversation was brief and 'frightening': ‘You might make an electronic exchange’, said the market maker to Waller-Bridge 'but remember that it’s me that makes prices’ (Waller-Bridge interview). Indeed, the success of infrastructural workers was not based on their market power but rather on their practical experience, cultivated connections, and diffuse organizational clout. To introduce what was a patently radical and moralized innovation, infrastructural workers had to capture the Exchange to create a voice within their field and despite initial organizational invisibility, reveal the bounties of their efforts, and enroll novel market constituencies through moral and technical affinities in to then effect change. Their capacity to act was thus not punctual, but rather distributed through events and processes that took place over a long and convoluted temporal horizon.

This article opened with a seemingly simple question to which social scientists give perplexingly similar answers. In advocating an infrastructural conception of markets, this study has also stressed the importance of foregrounding infrastructural work as a form of ‘market making’, locating the moralities and sociomaterial practices of market engineers within broader processes that reconstitute their organizational fields. Much like Granovetter’s seminal argument for taking into account the embeddedness of transactions
within social relations (Granovetter 1986), our imaginary of markets can expand, too, by studying them in the plural (Zelizer 1988), as historically contingent, blatantly material infrastructural realizations. In effect, despite important research on the technicalities of finance (MacKenzie 2007), economists seem to be a step ahead in this direction, for as Roth wrote:

As marketplaces proliferate on the web, a great deal of market design is going to be done by computer programmers, among others, since they possess some of the essential expertise. Economists will have an opportunity to learn a lot from the markets that result, just as we will learn from our own work designing unusual markets (Roth 2002, p. 1343)

And in this, the infrastructural conception creates new and potentially interesting avenues of research. Polanyi (1957) was correct in highlighting market societies as political projects. He was right, too, in showing economies as achievements of social organization. Yet in re-imagining markets through their infrastructures, his substantivist approach seems limiting. Perhaps market societies exist, not as stark utopias, but crystallized in the cables, silicon, standards, and sweat of market engineers.

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**FIGURE 1** – Representation of a simple order book. As orders to buy and sell arrive, the existing values on the order book are matched if compatible, and the list of available bids and asks is updated accordingly.

<table>
<thead>
<tr>
<th>Bid size</th>
<th>Price</th>
<th>Ask size</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>$11.05</td>
<td>150</td>
</tr>
<tr>
<td>200</td>
<td>$11.01</td>
<td>100</td>
</tr>
</tbody>
</table>

- **Sell 200 at $11.05**
FIGURE 2 – Four ideal market scenarios, as represented in Nymeyer's First Principles (1960)

CHART I

"Just" and "Unjust" Market Prices For Horses Under Four Circumstances

(1) Isolated Exchange
(2) One-Sided Competition Among Buyers
(3) One-Sided Competition Among Sellers
(4) Two-Sided Competition

(Dollars as price for a horse)
8. NOTES

1 Turnover velocity refers to the percentage of shares (stocks) of a particular corporation that are traded over a given time interval (generally, one year). Thus, an 80% turnover velocity would imply that 800,000 shares of a company with 1 million shares outstanding were bought and sold throughout a specific year.

2 My use of organizational fields is loosely based on Fligstein and McAdam 2012, Erimbayer and Johnson 2008, and Vaughan 2008.

3 Generally, of course, users are integral to the process of technological innovation (Oodshorn and Pinch 2005) and infrastructures (Ribes, Jackson, Geiger, Burton, Finholt 2013). Here, however, I am not concerned with how users co-constituted the market’s infrastructures but rather stress the organizational asymmetries that characterized technological innovation at the London Stock Exchange during the period studied.

4 As Stigler and Sherwins (1985) write, ‘if there is a single price (allowing for transportation costs) over a given area, that must mean that either buyers or sellers (or both) can and do consider transactions at any point within the area to be an excellent (in the limit, a perfect) substitute for transactions at other points within the area. Hence the market area embraces the buyers who are willing to deal with any seller, or the sellers who are willing to deal with any buyer, or both’ (p. 555). This definition of markets as given by the potential to engage in substitutive transactions is central to anti-trust regulation, where the scope of competition conceptualized in terms of these ‘relevant markets’. See Onto (2014), Manne (1965).

5 In his study of payment systems, Maurer writes that ‘[f]rom Mauss to Viveiros de Castro, we are interested more in the exchange of objects or perspectives than we are the technologies or techniques that facilitate that exchange’ (Maurer, unpublished manuscript).
What matters to the tradition of markets as networks (Granovetter 1974, White 1981, Brut 1992, Uzzi 1997), for example, is studying how changes in the relational patterns established between transacting agents, whether individual traders (e.g. Baker 1984) or firms and corporations (Baker 1990, Davis and Greve 1997, Haunschild and Beckman 1998, Biggart and Castanias 2001), constitutes economic outcomes. The literature on institutions, organizations and cognition similarly situates market making in buyers and sellers, consumers and producers, as forming the market’s core constituencies (DiMaggio and Powell 1983, Dobbin 1994, Fligstein 2001, Carruthers 1994).

A futures is a contract between two parties to buy or sell a specific asset of a standardized quantity and quality for an agreed price and on an agreed date upon the delivery of payment.

See, for instance, the visions presented by Fisher Black, a founder of modern financial economics and a prominent advocate for financial automation; Black 1971; see also Mehrling 2005 and MacKenzie 2007.

References to Nymeyer within the literature are rare. Google Scholar reveals less than three-dozen cursory mentions of his name in the scientific literature, for instance. Nymeyer was nevertheless an important figure in the seminal American conservative business networks from c. 1940 to c. 1980. He was close, for example, to Robert W. Baird, John T. Brown, J. Howard Pew and was acquainted with James Kilpatrick and William F. Buckley, among other noted political conservatives (Hülsmann 2006, p. 855; Doherty 2009, p. 298).

Stock Exchange technologists located themselves in one of two groups, which had few crossovers: those working on settlement technologies, which tended to utilize IBM mainframes and work through the processes in batches, and those working on market information systems, which tended to rely on real-time, high-
reliability digital systems, such as those designed by Digital Electronic Computers (DEC).

11 This threat had materialized in 1971 when a consortium of merchant banks (who did not have direct access to the trading floor) created an alternative trading system called ARIEL in order to bypass the LSE’s brokers and market makers. The system was used for ‘bed and breakfast’ business (that is, marginal transactions) but was nevertheless successful in forcing the LSE’s brokers to reduce their commissions (Manns interview).

12 Mitford-Slade stressed, however, that the work of Stock Exchange technologists was not entirely understood by members of the organization, despite their success with MPDS. For example, Mitford-Slade recalled that, when LSE’s council created the Information and Communications Committee, ‘people got a bit confused with the name [...] They thought we were PR or something. But we weren’t PR. We were definitely technology’ (Mitford-Slade interview). The projects presented by market technologists were ‘quite an investment to launch into [requiring] quite a lot of persuasion [...] [The LSE’s engineers] had to sell [their ideas] to me and I had to sell them to a lot of people who didn’t understand technology whatsoever’ (Mitford-Slade interview).

13 I have chosen to reproduce an extended extract from the interview in order to convey the revelatory strategy used by Tradepoint’s market engineers.