Socio-Economic Review, 2023, Vol. 21, No. 2, 885–908
https://doi.org/10.1093/ser/mwac017
Advance Access Publication Date: 29 March 2022
Article

MPIfG Journal Article
Georg Rilinger: Conceptual Limits of Performativity: Assessing the Feasibility of Market Design Blueprints. In: Socio-Economic Review 21(2), 885-908 (2023). Oxford University Press
The original publication is available at the publisher's web site: https://doi.org/10.1093/ser/mwac017
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Article

Conceptual limits of performativity: assessing the feasibility of market design blueprints

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Abstract

Market designers work as social engineers. They create institutional structures to enforce the assumptions of theoretical market mechanisms. Despite much work on performative effects of economics, sociology has not analyzed the feasibility of designers' theoretical blueprints. This article suggests that this may be done by identifying assumptions that derail the mechanism if they are not enforced. Sociologists then need to trace obstacles to their realization in practices of implementation. Blueprints are infeasible if the assumptions cannot be enforced either by themselves or jointly. To illustrate the approach, the article identifies one such assumption and traces its impact on a historical experiment of market design: the creation of markets for transmission capacity in California's electricity markets. To realize the design's explicit assumptions, designers built institutions that violated an implicit uniformity assumption and created opportunities for manipulations. Since the design's assumptions could not be realized simultaneously, it was infeasible.

Key words: economic sociology, economic thought, financial markets, liberalization, performativity

JEL classification: Z13, D47, H41

1. Introduction

Market designers try to replace bureaucratic means for allocating goods with synthetic market mechanisms. These mechanisms are not the self-regulating marvels of neoliberal lore. Market designers recognize that real market environments rarely meet the idealizing assumptions of economic theory. Instead, they develop blueprints for custom tailored market mechanisms and help to implement them (Nik-Khah and Mirowski, 2019). The blueprints describe institutions that would realize the assumptions of the market mechanism as envisioned by a formal model. Market design is thus a form of social engineering. The designers shape the market context to get actors to behave as the theory requires. The equilibria promised by the invisible hand then turn into the constructions of the economist qua engineer.[1]

Initially, designers applied their engineering approach to relatively few allocation problems. However, in the last two decades, the 'engineers of the human soul' (Mirowski, 2016, p. 17) have expanded their work significantly. Virtual trading platforms now rely on principles of market design to match buyers and sellers. Beneath Amazon's buy-now button is an auction between potential sellers and Uber's software finds the perfect match between supply and demand under a complex set of constraints. Governmental agencies employ market designers to tweak the infrastructures of electronic clearing houses. For example, designers amended the rules for the US treasury auctions to smooth our price swings in March of 2020. Policy makers debate the use of synthetic markets for problems ranging from refugee allocation and emission reduction to the accessibility of healthcare (Kominers *et al.*, 2017; Frankel *et al.*, 2019).

Despite the boundless optimism some commentators express for this new technique (Posner and Weyl, 2018), the experience has been mixed: while some 'smart markets' continue to operate, others have failed catastrophically or produced ambiguous results (Cramton, 2017, p. 593). Here, failure may mean that the markets do not conform to the mechanisms outlined in the blueprint. But failure can also mean that markets do not produce the results promised by the blueprint. For example, despite being generally celebrated as a success, the Federal Communications Commissions's auctions to allocate spectrum licenses failed to meet at least one crucial goal: they did not distribute the licenses among a large number of companies (Labaton and Romero, 2001). Given the mixed experiences, it is crucial to ask: what is the difference between a theoretical market design blueprint that can be realized and one that cannot?

Though there is a rich literature on experiments with market design, economic sociology has not yet addressed this question. The existing research falls into two camps. The literature on performativity forms the first camp. It starts with the assumption that all economic theories are complicit in creating the world they purport to describe (Callon, 1998). Modern markets are suffused with economic knowledge that 'formats' the interactions through legal rules, information systems, even the spatial and temporal configuration of the market (Callon, 2007, p. 315). But it is historically contingent to what extent economic models shape economic practice. Social factors such as organizational structure, embeddedness and culture determine whether an economic context 'performs' the propositions of a theory (Callon, 2007; MacKenzie, 2007).

From the perspective of this literature, economic engineering cannot be understood as mechanical, one-step implementation of a theoretical blueprint (Breslau, 2011, p. 380). Instead, it is a complex, iterative process of slowly creating a social infrastructure that bears resemblance to the model. Market designers laboriously construct correspondences between economic theory and markets in the face of practical challenges (Garcia-Parpet, 2007; Guala, 2007).

1 For an overview from an economic perspective, cf. Roth (2008).

The second line of research takes a somewhat different perspective. This research is informed by a theoretical literature that describes markets as the product of political struggles between stakeholders (Fligstein, 1996; Bourdieu, 2005, pp. 193–216). Market design experiments are not neutral processes that follow a logic of progressive, technical mastery. Instead, they are political processes in which economists provide only one voice among many. Economists' blueprints should therefore be treated as rhetorical tools or epistemic frameworks (Breslau, 2013, p. 830). Different groups of stakeholders use the arguments provided by these frameworks to articulate their interests and shape market rules.

Although research in the political tradition has occasionally criticized the performativity literature as technocratic (Mirowski and Nik-Khah, 2007), the two perspectives are complementary. Performativity studies agree that practical processes of market creation are suffused with politics (MacKenzie, 2006, pp. 147–150; Blok, 2011). The two literatures therefore differ mostly in focus. While performativity studies look at the technical and material dimension of processes that give rise to new market infrastructures, the alternative perspective focuses on the political dimension. Bringing the two sides together, the work of market designers appears as a kind of 'applied Platonism' (Breslau, 2011, p. 382), in which theoretical models for market mechanisms serve as guiding ideal. The ideal configures and orients the political, social and technological processes in which the participants identify and resolve practical problems, negotiate interests and create the new market infrastructure (Reverdy and Breslau, 2019).

In recent years, the camps have therefore begun to converge. Responding to calls to include political, material, organizational and institutional dimensions of market construction, studies now examine how a variety of social factors contribute to stabilize 'agencements'—heterogeneous combinations of human and non-human elements that enable distinct forms of economic action (Muniesa, 2014; Pallesen and Jenle, 2018).

Despite providing invaluable insights into the practical processes of market construction, this literature has never evaluated the difference between a theoretical market design proposal that can be realized and one that cannot be realized. This is not only an important political question, but it is also crucial for the performativity literature. As long as the literature does not attend to this question of feasibility, the performativity argument remains underdetermined. Clearly, not every theoretical proposition could become true by virtue of designers' efforts. Before we can assert that political or practical obstacles derailed designers' efforts, we have to determine whether the project was feasible in the first place.

This article proposes a way to answer this question. In the past, economic sociology has evaluated economic theories by criticizing *unrealistic* assumptions (e.g. atomistic actors). This does not help much with the evaluation of markt design blueprints. For questions about the feasibility of such blueprints, it is beside the point whether or not their assumptions are descriptively accurate. Unlike explanatory theories, market design blueprints are self-reflexive about their use in practices of social engineering.The assumptions are not meant to describe what is true, but what can *become* true by virtue of institutional design. Of course, all theoretical frameworks are 'joint hypotheses' about what is and can become true (Polillo, 2020). But blueprints explicitly describe institutions that can realize the assumptions behind the model. With the power of platform design, it is possible to make even implausible assumptions like 'atomistic decision-making' come to be true. For example, a software interface might restrict the information that actors have about other participants. In this way, the designers could 'enforce' atomistic decisions. Accordingly, a blueprint's feasibility does not depend on the descriptive accuracy of its assumptions. Instead, it depends on whether the realization of the assumptions requires changes to the social context that are possible.

This article suggests that sociologists can evaluate the feasibility of designers' blueprints by exploring this question—i.e. by asking whether the propositions of the blueprint could likely be realized within the purview of design practices. Before outlining the proposed method, I attend to some meta-theoretical concerns. In the past, the literature has articulated severe reservations about attempts to specify scope conditions for performative effects. My paper advances the literature by proposing a practice-dependent notion of scope conditions. This definition is compatible with the theoretical program behind performativity studies. Based on this notion, I then argue that a blueprint is *infeasible*, if it either requires changes to the context of application that are usually not possible (simple infeasibility) or if it articulates requirements that can usually not be realized simultaneously (combinatorial infeasibility). To identify such sources of infeasibility, the sociologist has to search for blindspots in designers' blueprints—assumptions that must be enforced but are obscured by the structure of conceptual design work. While market designers largely consider the feasibility of their blueprints in terms of formal criteria, sociologists engage in qualitative comparisons between the logic of the model and the social context that designers need to manipulate. The sociological perspective therefore reveals practical obstacles to realization that designers are not necessarily aware of and that point to internal contradictions of the blueprint—to implement the model—contradicting changes would have to take place in reality.

In the empirical part of the article, I illustrate this approach with a historical example: the creation of transmission capacity markets for California's electricity system between 1992 and 2001. Such markets reflect the cost of transmitting electricity from producers to consumers. Closely linked to the markets for electricity contracts, they gave rise to opportunities for manipulative behavior that contributed to the Western Energy crisis of 2000/2001. This behavior can be understood as responding to a design flaw—the market architecture did not produce the behavior the designers had intended. The question is then, why the market was built in this way. Based on a variety of archival materials, I trace the corresponding design flaws to the underlying blueprint. That is, I show that the designers tried to implement a theoretical model that would always have produced such manipulative games. They did not result from political or technical decisions but from flaws in the intellectual vision. The blueprint's assumptions created conflicting requirements that could not be realized simultaneously. The conclusion relates my approach to existing research and argues that the issue of feasibility opens the path for critical studies of market design failure.

2. Performativity studies, market design and blindspots

This article suggests that it is possible for performativity studies to evaluate market design blueprints on their own terms. Such research would evaluate whether the blueprint *could* be realized in implementation processes. As Ezra Zuckerman and others have observed, the performativity literature has never asked this question. It does not specify which theories *can* become performatively true and which ones cannot. This is true even for the earliest studies, which explicitly asked how the propositions of theories become true by virtue of using them (MacKenzie *et al.*, 2007). What matters are the circumstances under which actors adopt the theory, not its contents. However, it is intuitively clear that not all theories can become true by virtue of believing in them. The performativity argument is therefore underdetermined (Felin and Foss, 2009; Zuckerman, 2010; Brisset, 2016).

The whole issue may at first appear like a simple gap in the literature. But it points to a philosophical disagreement. Zuckerman (2010) holds that the refusal to specify scope conditions reflects a deep inconsistency in the position of the performativity literature. In turn, the performativity literature rejects the specification of scope conditions as philosophically untenable and incompatible with its core aims (Law, 1992; MacKenzie, 2009). Rather than take a side, I argue that the entire debate can be sidestepped. Contra Zuckerman, I contend that the performativity literature has a good reason to reject the specification of scope conditions. Contra performativity, I argue that this argument only applies to a narrow definition of scope-conditions. There is an alternative definition that can be accepted from the meta-theoretical position of this literature, opening the path for an evaluation of conceptual limits to performative effects.

Zuckerman argues that the refusal to identify scope-conditions derives from the 'radical constructivism' of performativity studies. This forces them to assume that any theoretical proposition could become true by virtue of collective belief. This position is problematic because it entails a performative contradiction. For example, the Efficient Market Hypothesis requires that asset prices aggregate all available information consistently. This presumes a unified, objective reality about which information can aggregate. This, in turn, violates a basic tenet of social constructivism: that objective reality is a function of potentially inconsistent meaning making processes. If performativity studies now asserted that the hypothesis can become true, they would imply that social constructivism is false. This would be a performative contradiction because their statement relies on it (Zuckerman, 2010).

While logically sound, this critique does not capture the position of performativity studies. The literature has a meta-theoretical objection against the specification of scope-conditions. It is anchored in Actor Network Theory (ANT), which rejects the epistemological distinction between theory and practice, making both part of an embodied and material process that gives rise to agencements. From this perspective, the truth of a theory is an accomplishment of the practices that go into its validation, not an antecedent feature of the theory itself (Bloor, 1991; Law, 1992). If the truth of a theory is the outcome of practices to validate it, then any judgment about the truth of the theory is impossible without considering these practices.

Contra Zuckerman, we note that this argument does *not* commit ANT to the claim that any proposition about the world could become true. Rather, ANT remains *agnostic* with respect to this question because any answer would depend on the standards of the practices that accomplish its truth or falsehood. For example, performativity scholars would be agnostic about whether the expression $2+2=5$ is true. But they would accept that this expression cannot become true within most arithmetic exercises in primary schools.

This yields a straightforward definition of scope conditions that is compatible with this literature. Just like most high schools do not teach arithmetic in radically different ways, market design practices are somewhat stable across time and space. Market designers will not read a blueprint's instructions completely differently in different settings. Accordingly, we can distinguish between implementation problems that would likely occur in all market design practices and problems that are more idiosyncratic to a given setting. Adopting a 'realist mode of speech' (Barnes, 1981), we can identify the former problems with the blueprint and the latter with the practice. If designers would not usually be able to follow the instructions of a blueprint, there is clearly something wrong with the blueprint. It is infeasible. In contrast, if a *specific* design practice is characterized by unusual circumstances that block the implementation, we can locate the problem in the political or technical conditions of design work. The definition of feasibility is thus tethered to the way market designers ordinarily understand and use blueprints.

How, then, do we identify features of blueprints that designers would not usually be able to realize? To develop an analytical strategy, I begin with an overview of the conceptual work that goes into the creation of new blueprints.

Since market design is not a unified subfield of economics, I focus on the broadly 'experimentalist' tradition (McCabe *et al.*, 1991; Smith, 2006). This tradition is less associated with a specific subdiscipline in economics and more with a particular methodological orientation (Mirowski and Nik-Khah, 2017). The experimentalists develop concrete solutions to allocation problems. These are often 'smart markets', i.e. markets that rely on a mixture of human and computational information processing. Crucially, they conceptualize markets as algorithms for the solution of optimization problems under constraints. I will now outline this approach in greater detail.

The conceptual goal of market design is to create the formal description of a mechanism that induces individuals to mimic behavior in a perfectly competitive market (Roth, 2002, p. 1341). In a perfectly competitive market, strategic interactions between individuals aggregate into allocations with desirable welfare benefits, such as pareto optimality and allocative efficiency. These benefits obtain in equilibrium, where all profitable trades have been exhausted. Less an assumed reality than a guiding ideal, the model of the perfectly competitive market provides a goal (the welfare benefits), a mechanism to get there (dynamic interactions between individuals) and a set of assumptions that need to be met to realize the mechanism (rational action, perfect competition, etc.) (Breslau, 2011; Rodrik, 2015, p. 13).

When designers approach a new industry or allocation problem, they try to identify violations to this guiding ideal. Empirical research in different subfields of economics helps them to identify such market failures. In the next step, the designers search for sets of institutional arrangements that can configure a competitive trading process to resolve these failures. For example, if the problem is that sellers have an interest in hiding the true cost of their commodity ('private information'), then an auction format can be devised that incentivizes market players to reveal their true cost. Game theory, experiments, theoretical arguments and empirical knowledge guide designers in specifying these rule systems (Roth, 2002, 2008; Stoft, 2002, pp. 74, 82, 93).

Designers use the formal language of mathematics to develop and justify their mechanisms. They draw on tools for the analysis of constrained extrema that originate from Newtonian mechanics (Amadae, 2003, pp. 220–223) and linear programing (Bichler, 2017, p. 3). The discipline combines these tools with an axiomatic understanding of truth. That means that truth is located on the level of mathematical entailment relations, rather than, for example, experience (Weintraub, 2002). This understanding of truth entails a very general procedure to establish the validity of a new mechanism. First, designers define the obstacle the mechanism needs to resolve as an optimization problem under constraints. Then, they develop the mechanism as a set of rules that characterize a trading process. This yields a system of equations that captures agents' decision-making process. That is, the mechanism is defined as a mathematical model—a stylized representation of the world under the assumed framework of rules, in which behavior takes the form of a mathematical function.

The economists then analyze the resulting system of equations with the tools of multivariate calculus and optimization theory (Rodrik, 2015, p. 30). They establish the validity of the mechanism by showing that the trading process converges on an equilibrium that fulfills the conditions of the optimization problem.

The resulting blueprints are still theoretical: they develop a formal market mechanism that links a rule structure to behavior that leads to an efficient equilibrium. The blueprint specifies a set of assumptions that need to be realized when the mechanism is implemented and a set of institutions that can enforce these assumptions. Some of these assumptions may already be met—they specify descriptive claims about how markets already work and how agents behave in them. Others require institutional design. Either way, up to the point of implementation, economic design is a *circular* process that moves between empirics (the practical context of design), the theoretical ideal (i.e. perfectly competitive markets) and the new mechanism (the set of equations describing the trading process). The circular movement is organized by examining, introducing and removing assumptions of mathematical models. The work is complete when the designers can both prove that the mechanism solves the all problem and argue that the final set of assumption is complete and feasible. The mechanism is not just a theoretical solution to a market failure. It is also a *feasible* solution, because there are practical ways to realize all explicit assumptions during the construction of the market, under ordinary conditions of design work.

The pivotal role of assumptions provides a vantage point for the analysis here. The goal is to determine whether a given blueprint is infeasible. There are two ways this might be the case. First, the blueprint may rely on assumptions that require changes to the social process that are not usually possible. This is 'simple' infeasibility because a single assumption would usually prevent designers from implementing the mechanism. For example, a market design blueprint might require that products are standardized across the entire market, but the design process can usually access a small part of it. For all intents and purposes, the designers would never be able to realize the assumption. Second, the blueprint may be infeasible if it relies on assumptions whose requirements usually contradict each other. This 'combinational' infeasibility, too, emerges relative to the context of design work. It describes a situation where it is possible to realize model assumptions independently from each other, but not together. The requirements for the realization of one assumption would violate the requirements of the other. In the empirical case, I provide an illustration of this kind of problem.

Of course, designers are aware of feasibility problems and search for obstacles in the circular movement between assumptions, empirical setting and theoretical ideal. Explicit assumptions can be infeasible and market designers seek to identify reasons why that may be the case. Nonetheless, their approach is likely to suffer from *blindspots*. A blindspot is an implicit assumption that has not been considered but must be enforced for the mechanism to work as advertised. The concept refers us to gaps between practices of conceptual work and the practices of implementation they are supposed to inform. A blindspot is an assumption that is usually relevant for the implementation process and that *could* become subject of attention for designers, but that designers ignore because of the way their conceptual work is organized.

The highly deductive and formal approach is liable to blindspots because designers only have to specify those assumptions with necessity that are required for the mathematical demonstration of the link between action and aggregate outcome. Many more assumptions can be stated, and designers often do. But on the level of conceptual argument, it is the rules of mathematical inference that determine what assumptions *need* to be specified.[2] For example, in the standard account of perfectly competitive markets, an explicitly stated assumption is that demand varies with price. This assumption is necessary because it determines the slope of the demand curve. However, the equally important assumption that there are laws and free contracting is not necessarily stated, because it has no correspondence in the mathematical framework. The methods stem from physics, where they were not used to build institutions but to describe 'pure mechanisms'. Accordingly, there is a potential mismatch between the explicitly stated assumptions and what may be necessary for implementation. Focusing on the explicit assumptions necessary for the proof that the mechanism solves the allocation problem, economists may omit assumptions that must be met for the mechanism to operate as stated.

Unlike this formalist work, qualitative, inductive research does not begin with general propositions about idealized market mechanisms. Instead, it works from the empirical condition of design work toward an identification of social processes that stabilize economic interactions and organize the market. These processes might pose obstacles to the implementation of a formal market mechanism. If they do, but do not register as violations to explicit assumptions of the blueprint, they constitute blindspots. To identify such blindspots, the sociologist has to compare the formal structure of the model to the conditions of design work. A good way to start the analysis is to focus on implicit assumptions that are embedded in the structural form of blueprints—these assumptions are highly artificial and will therefore be violated in most contexts.

Mathematical models and their associated rules of reasoning rely on assumptions that are not usually stated because they do not introduce variation into that class of the model. These assumptions are embedded in the structural *form* of the model and are constitutive for using it. Such assumptions are not unique to economic models, but to all mathematical representations of social life. For example, the linear model characteristic for much work in quantitative sociology assumes that there are fixed entities with varying attributes. The assumptions that characterize this implicit ontology are purely a function of the mathematical form (i.e. the use of variables), not of any substance presented with it (Abbott, 1988, pp. 38–40).

Here, I will just give one example of a structural assumption that can turn into a problematic blindspot. Mathematical models require that individual behavior can be described by a rule. They describe behavior in functional form, e.g. as a complex decision function, a linear program or a simple supply curve. Definitionally, a mathematical function is a mapping of a set into another set. For the function $f(x)$: $x -> y$, the set of elements x is mapped into the set y according to a fixed rule. Unless the designer chooses a probabilistic class of models, the principle behind the mapping is fixed. To the extent that agents in a market are described by such a function, it is assumed that their decision making follows a single rule. This could also be called the 'uniformity assumption' because all individuals must follow the same calculation that the model stipulates. Uniformity means more than profit maximization—it means that all agents perform the same calculation based on their individual values and a fixed set of information. Not all models make this assumption. Some are robust to

2 Which assumptions need to be stated does not follow a strict logic but is established pragmatically. How many you end up having to include depends on rules of proof that are established by convention. This is the lesson of the amusing conversation between Achilles and the Tortoise in Carrol (1895).

uncertainty about the information available to actors. Here, model-conform behavior can be compatible with actors who execute different calculations with non-overlapping sets of information. Other models are robust to some level of miscalculations (Carroll, 2019).

If a model makes the uniformity assumption, it is embedded in the form of model and often remains implicit. It constitutes a *potential* blindspot because it guarantees the link between actors' interactions and the equilibrium, but it is generally violated in practice. It is violated because our frame of reference is not usually fixed. Any one context of action can be inflected by considerations that telescope out into other contexts and involvements. For example, when playing a boardgame, people can decide on the moves relative to the game or relative to the social relations between the players. And people can think about these relations in terms of a variety of time horizons and descriptions. As Alfred Schutz put it, the world within potential 'reach' is extremely flexible and temporally variable (Schutz and Luckmann, 1973, pp. 38–40). That means that individuals can confront formally identical decisions in radically different ways, depending on how they define the context. Even if the basic goal is to maximize utility relative to stable preferences, the considerations to fulfill this goal can vary drastically. Uniform decision making is thus quite unlikely and must be enforced in some way.

The assumption is just an example of a strong assumption that is implicit in the structure of many economic models. Other assumptions are that markets constitute closed social systems, and that all change takes place in terms of the variables reflected in the model. None of these assumptions have to be blindspots and none are *necessarily* problematic for the success of market design. It may well be possible to devise institutional structures that can enforce them. Whether or not that is the case depends on the other features of the blueprint and the regular conditions of implementation. After identifying potential blindspots, it is therefore necessary to take two additional steps. First, we must establish whether it is necessary to enforce the assumptions for the mechanism to operate as advertised. In that case, the assumption matters pragmatically. Second, if so, we have to ask if the assumption *could* usually be enforced or whether problems to do so are idiosyncratic. The blueprint is infeasible if the assumption usually creates requirements that contradict other requirements of the blueprint (combinational infeasibility) or if they can usually not be realized (simple infeasibility). I will now illustrate such an analysis with an empirical example where the uniformity assumption did pose a blindspot that rendered the design infeasible.

3. Data and case

In 1996, the California Assembly passed AB1890 to restructure the state's electricity industry. The opening of the wholesale markets in 1998 was preceded by 4 years of intensive design efforts. Throughout this process, market designers were heavily involved. They worked as experts for stakeholders, published independent research on the potential structure of these markets, and testified as experts in regulatory proceedings that determined basic structural features of the markets. The resulting infrastructure was an early highpoint of economic engineering.

During the first 2 years, the markets performed well. They generated low prices and provided reliable electricity to customers. But in the spring of 2000 persistent price spikes triggered a crisis that lasted over a year. By 2001, the three biggest utilities approached insolvency and rolling blackouts pushed the electricity system to the brink of collapse.

Finally, the state government had to step in and take over the provision of electricity. In short, the Western Energy Crisis of 2000/2001 is a case of failed market design.

Despite their failure, however, it is not easy to trace the markets' problems to the underlying design. This has two principal reasons. First, the Western Energy Crisis did not have a single cause. A complex configuration of factors such as the weather patterns, the development of demand and supply, politics, regulatory idiosyncrasies, market manipulation, market power and environmental standards all played a role.[3] Second, and more importantly, the California markets did not have a single, underlying design. As the existing sociological literature has established for other cases, economists are only ever one voice in the complex negotiations that surround market design processes. In California, the design process was fraught by ideological, political and economic divisions between stakeholders. Some of the market features that proved most consequential for the crisis—most notably legal prescriptions against long-term forward contracts and a retail price freeze—had no foundation in economics at all (Joskow, 2001). For these two reasons, it is difficult to isolate the question whether the theoretical design was feasible from an analysis of the political dynamics that shaped its implementation.

I approach this analytical problem by focusing on a single element of the California wholesale markets: the mechanism for allocating transmission capacity on the shared gird. After the political process had settled on a basic approach to the problem, this mechanism received a definitive theoretical foundation. Economists at the Electric Power Research Institute in Palo Alto developed it in the context of regulatory proceedings before the California Public Utility Commission (CPUC) and the associated working groups of the Wester Power Exchange process (WEPEX). The archival material and technical publications that document the creation of the California markets refer to the theoretical model by Chao, Peck as well as the theoretical antecedents that they relied on (see Table 1). While the blueprint responded to political requirements, it became the definitive foundation for the implementation process. We can therefore examine its feasibility.

The market for transmission capacity also provides a useful example for the type of analysis proposed here, because the implementation produced opportunities for market manipulation. These 'games' were neither decisive for the California energy crisis nor pervasive. The exercise of market power was far more problematic activity (Borenstein *et al.*, 2002). Yet, the games associated with the transmission capacity markets exacerbated market power problems. The nature of these crimes has been extensively documented by the existing literature (Lambert, 2006, pp. 170–181), but they have not been traced to the original design yet. By establishing this link, it is possible to demonstrate how market designers' blueprints figured into processes that led to the conditions for the California energy crisis. Specifically, I can now argue that it was not the complex political and material processes of market construction that explains the failure of these markets. Instead, the very conceptual vision that animated these processes was infeasible. This is a new interpretation of the root cause for these manipulative strategies.

At this point, we might briefly consider the problem of hindsight bias. The empirical argument will be a retrospective analysis of a failed market design effort. This poses a problem: retrospectively, *any* difference between model and reality could be described as an antecedent, implicit assumption of the model. So, how do we distinguish between implicit

3 For alternative explanations of the crisis, cf. Sweeney (2002), Taylor et al. (2015).

Table 1 Archival material

Technical publications for theoretical model of market for transmission capacity		
Publications by Economists/Engineers		
Schweppe et al. (1988); Caramanis et al. (1982); Hogan (1992); Hogan (1993); Oren et al. (1986); Wu et al. (1994)		Develop the idea of a contract network to represent power flows. Researchers associated with MIT, California, and Harvard
Bushnell and Oren (1997); Chao and Peck (1996, 1997); Chao and Huntington (1998); Oren et al. (1995); Oren (1997); Wu and Varaiya (1995)		Theoretical blueprint of the California market for transmission constraints
Walton and Tabors (1996); Gribik (1996); Harvey et al. (1996); Varaiya (1997)		Technical details about implementation/empirical studies
Material the chronicles implementation in California		
Federal energy regulatory commission	Docket number (accessible via Ebrary)	Notes
California Parties' application for establishment of ISO/PX	ER96-1663, EC96-19	Formal filings that outline and debate the design of the California markets
Development of orders concerning deregulation (592, 888, 2000)	RM96-6, RM95-8, RM99-2	Landmark decisions to open the transmission system in order to prepare the ground for deregulation (Order 888 in 1996, Order 2000 in 1999). Contains transcripts that debate market design issues in energy markets

continued

California public utility commission	Boxes in proceeding R-94-04-31	Notes
Proposed policies governing restructuring California's electric service industry and reforming regulation." and preferred policy decision D.95-12-063, as modified by decision 96-10-009	Boxes 10–20	Proposal for deregulation ('Blue Book'), stakeholders' arguments for decentralized market implementation with zonal model, Memorandum of Understanding, final policy decision on shape of California market
Transcripts of hearings pertaining to proposals for market deregulation	Boxes 69–71	Oral statements about the proposals and their implementation
Power exchange/California independent system operator	Archival material	
Electricity oversight board, subject files	California State Archive, R400.005, Box 5, folders 10-25, R400.010, Box 18, folder 1 - Box 19, folder 14	Material related to design of PX and CAISO, Information on Congestion Management, 1997–2001

assumptions of the blueprint and factors that became relevant during the implementation? Implicit assumptions are those that designers could have identified prior to implementation but did not. These are assumptions that would matter for *any* implementation of the mechanism. Precisely, this is the reason why this article focuses on formal properties of the design blueprint. The uniformity assumption concerns the nature of rational action in general and is almost always violated. It therefore needs to be enforced in any case. To the extent that the assumption remains implicit, is thus a potential blindspot of the blueprint and qualifies for a feasibility analysis.

The analysis uses two types of archival material. On the one hand, I rely on the publications of economists and engineers who designed the market for transmission capacity. I use these sources to reconstruct the challenge that a market for transmission capacity poses to the economist as well as the theoretical design that the economists developed in response. On the other hand, I rely on archival material from the office of the CPUC in San Francisco, online filings with the Federal Energy Regulatory Commission and documents from the two organizations that administered the markets in California, the California Independent System Operator (CAISO) and the Power Exchange (PX). I use these sources to trace how the WEPEX group implemented the theoretical design and how the blindspots led to opportunities for gaming. Table 1 summarizes these archival materials.

4. The blueprints for transmission pricing

In this section, I describe the blueprint for California's transmission capacity market. To understand what the designers were trying to do, it is important to appreciate the challenge they confronted. On a technical level, the electricity industry consists of generators that produce energy and feed it into the transmission system. The transmission system is a complex network that delivers energy via high-voltage lines to local distribution systems and end users. Importantly, the physical characteristics of electricity require that the network be managed in real time. Electric energy cannot be stored economically. Instead, it must be produced the moment it is consumed. In addition, the voltage and current across the grid must be kept in a very tight band of error to prevent cascading blackouts. Under any scheme of market design, a system operator is therefore necessary who balances the aggregate input of generators with the aggregate output to consumers *in real time*. Designers therefore conceptualize electricity markets as sequential *forward* markets that trade financial obligations to deliver energy at specific locations in the future. In the aggregate, these financial transactions create schedules for production and consumption of energy. The system operator then implements the resulting schedules. The central challenge of market design is how much coordination can be achieved by the forward markets before the system operator takes over (Cramton, 2017).

In California, the political process decided that decentralized markets should help with the allocation of transmission capacity. Energy markets are supposed to find what engineers call the 'economic dispatch'. This is the most cost-effective order for dispatching available generation to meet the aggregate demand. The cheapest generators serve as much demand as possible. When they reach their capacity limits, the second cheapest take over and so on until all demand is met. A perfectly competitive market with perfect information could find this dispatch order because the competition between suppliers would drive every producers' price down to marginal cost and consumers would try to find the cheapest supplier.

However, finding the economic dispatch is complicated by, among other factors, the presence of limited transmission capacity. Transmission lines have limits that restrict the amount of power they can carry. These limits might block the cheapest generator from serving an area. Such 'congestion' changes the economic dispatch because a more expensive generator at a different location must take over. Without reflecting transmission constraints, energy markets could not find the economic dispatch and therefore become inefficient—they would hide the cost of switching to more expensive generators. It is therefore desirable to include these constraints in the market. But the physical characteristics of energy render this difficult.

The availability of capacity does not merely depend on the static limits imposed by the individual transmission lines. Electric energy travels on all available paths. If the network has loops, simultaneous flows of energy interact with each other. Any adjustment of generation in response to capacity constraints can therefore create new limitations elsewhere. Because of these interactions, the discovery of the economic dispatch constitutes a non-linear optimization problem. The challenge for market designers was to describe a market mechanism that could incorporate these non-linear dependencies.

Based on the works by Schweppe *et al.* (1988), Hogan (1992, 1993, 1994) and others, Chao and Peck (1996, 1997) developed a decentralized solution to the problem. The goal was to create a market that finds an economic dispatch of available generation capacity relative to the available transmission capacity. The designers translated this task into the formal language of combinatorial optimization problems under constraints. The task was to find the combination of generators that would meet the system's aggregate demand at least cost, while ensuring that the sum of power flows did not exceed the capacity limits of the transmission lines. By choosing this mathematical formalization, the designers assume that the market will work as a linear or dynamic program. The solution is a trading process that operates literally as a *search algorithm*. This algorithm traverses a space of possible combinatorial solutions until it finds the optimal combination of generator outputs.

In the next step, the designers define institutional rules for the new market mechanism. These rules set up a system of interactions that can solve the optimization problem. For each directed link in the network, the designers create capacity rights that represent the maximum power flow on that line. This leads to a system of property rights, where each link has a fixed set of transmission capacity rights assigned to it.

The core of the proposal is the definition of a trading rule that makes *energy* transactions between the two locations contingent on the possession of transmission capacity rights. Each energy transaction requires rights that represent the increase in real power flow on all links that are affected by injection of power at the origin node. These bundles can be described as sets of coefficients that represent quantities of transmission capacity rights on links that a trader needs to transfer a unit of *power* from one node to the other. By linking the energy market to the transmission capacity market, the two constraints of the optimization problem are now represented in the energy market: no energy transaction is possible that does not conform to the existing power flows, because they require transmission rights that reflect the changes in these flows. And no transaction can exceed the existing transmission capacity, because the rights correspond to the real capacity of the lines.

All transmission rights can be calculated as an expression of the quantity of energy inserted at a given node and the current transmission capacity. Since this calculation requires knowledge of all power-flows, individuals cannot compute it. Instead, the authors imagine a centralized bulletin-board that always states how many rights are needed or would be received for a particular transaction. The market operator would constantly update this bulletin board by calculating the power flows at the current transaction structure and the marginal changes that new transactions would create.

The resulting market process solves the optimization problem. In the market for transmission capacity, traders or consumers of energy who will benefit most from capacity will be able to pay most for the transmission rights. In a perfectly competitive market with perfect information, the price of capacity rights will therefore tend to the largest possible profit that can be realized in the underlying energy transaction. This optimizes the usage of scarce capacity *relative to* the optimization of energy transactions. In the energy markets, consumers and traders seek to benefit from price differences between locations. As long as demand at a given node can be served cheaper with energy from a different location, trades will take place to exploit these price differences. If transmission capacity becomes scarce and the price for the rights goes up, the locations with the largest price differences will buy them. Each transaction leads to new calculations of transmission rights, so that the search behavior iteratively optimizes the available transmission capacity relative to the inputs. This produces an economic dispatch order.

For this system to work, several assumptions need to be met. First, market participants must have perfect information about the available trades in the system. Second, they must pursue profitable trades. Third, the market must be competitive, i.e. no supplier can set the price independently. Fourth, the trades must express 'rational expectations.' That is, the forward market cannot omit available information about the real-time operation of the system. The results of the forward market must anticipate the real-time operation of the system with only *random* error. This assumption ensures that sequential forward markets improve on each other. If these assumptions are met, the market works like a search algorithm that relies on humans and centralized computation alike. The computer provides information on the capacity requirements for energy transfers, and rational actors find profitable trades.

Formally, the economists show that there exists a vector of prices and quantities at each node, as well as a vector of transmission rights for transactions between each set of nodes that fulfill the optimization problem. Then, they run simulations that mimic the market process thus defined and show that it converges on the equilibrium from arbitrary starting positions and in short periods of time (Lyapunov Stability). This establishes that the market mechanism is a valid and computable solution.

Since the mechanism is specified as a linear program, it makes the uniformity assumption. This assumption refers to the way market actors use information. Regardless of whether participants want to trade in the energy or the transmission market, they must all engage in the same basic calculation to make profits: (a) Find profitable price differences between energy at two locations; (b) Find the cheapest capacity rights that allow you to execute the transaction; and (c) To execute this calculation, use a fixed set of information: supply function, demand function at each node and the variables that specify the market for transmission rights (prices of rights, required rights for each transaction). Only if market participants play their part in the search algorithm and iteratively apply this calculation does the market reflect the cost of scarce capacity. Due to the sensitivity of power flows, even minor deviations from the logic of the model can move the market far out of equilibrium. The uniformity assumption was implicit in the formal structure of the design but crucial for the mechanism to work.

5. Evaluating the blueprint

Identifying a potentially problematic, implicit assumption is only the first step of the analysis. Now, we must ask, first, whether the blindspot had consequences for the functioning of the mechanism—did it matter for the functioning of the market? If so, we need to evaluate if it could have been enforced. Here we need to determine whether problems to do so had to do with the idiosyncratic conditions in California or whether this would have been difficult anywhere.

When industry representatives and experts began to implement the blueprint during the WEPEX process, they did not consider how they could ensure that market participants would limit themselves to the precise calculation the blueprint required. Instead, they focused on the creation of structures that would realize the explicit assumptions. This task posed some difficulties, however. They found that even a rational actor might be overwhelmed by the complexity of the interactions between the markets for energy and transmission. Not only did the blueprint require traders to calculate the price differences between locations and factor in the prices for the required transmission rights. It also required them to figure out how to combine sequential transactions to find profitable trades. Since each energy transaction can impact the availability of transmission on all other links, this calculation becomes exponentially more difficult as the number of nodes increases. In a network with N nodes, any transaction between two nodes might require up to N^2 transmission rights (i.e. rights for all possible paths). For each subsequent transaction, the exponent increases by one. The grid under the control of the California ISO had about 3500 nodes and the larger Western Interconnect had over 20 000 nodes. Even with a centralized bulletin board that lists all rights required for any given transaction, the possible dynamic combinations for trades quickly go into billions. The sheer complexity of trades therefore posed a problem to the assumption of rational utility maximizers and the assumption of perfect information. It was not clear if real traders would be able to collect and process the information to find and exploit all profitable trades.

The solution to these problems came from economists with ties to MIT and California think-tanks. They argued that only a few transmission lines would likely be congested regularly. It did therefore not seem necessary to allow trading on the network as a whole—a much simpler structure would capture all important sources of congestion. The system operator would then take care of the remaining congestion in real time. Accordingly, they proposed to structure the market around a simplified representation of the grid. Based on the historical congestion patterns, the designers split California's grid into three zones and 25 scheduling points. With only 28 locations to consider, the complexity of finding profitable trades would decrease significantly. Similarly, it would become easier to keep track of price, supply and demand conditions in the system and publish them online in regular interval. The simplified structure thus helped to ensure that the explicit assumptions of the blueprint would be met.

But the system's convenience came at a price: the assumption of rational expectations required that the forward markets included all available information about the real-time operation of the system. The difference between the information represented in the forward market and the information about real-time operation had to be random. Of course, this is precisely what the designers were trying to ensure. They argued that the zones were defined in such a way that the predictable sources of congestion were taken care of. But this was a very strong claim. For the system to work, there could be no *predictable* congestion outside the scope of the zones. Unfortunately, the historical data the designers used to draw up the zones came from a time when no one made profits from congestion. Once the markets started, the congestion patterns began to change. There was now a potential difference between what could be known by traders in the forward markets, and what could be represented in these forward markets.

Precisely at this moment, the implementation created opportunities for traders to deviate from the calculations that the model required. And since no one enforced the uniformity assumption, the traders made use of this possibility. Instead of executing transactions based on price comparisons between locations and capacity rights, they figured out how to leverage their knowledge advantage against the system itself—and introduced a different way to make decisions into the system.

This gave rise to the infamous 'DEC game'.[4] In the forward market, traders in two separate companies would schedule a trade between two locations in the same zone. This trade would, either by itself or in combination with other trades, exceed the capacity limits of the line that connected the two locations. But since the transaction took place within the same zone, the market for transmission capacity would not reflect this congestion. From the perspective of the simplified network model, it looked like the trade took place at the same location. Accordingly, the trade was accepted, scheduled and submitted to the system operator. In real time, the system operator would now try to implement the schedules. Since it used the full network model, it recognized that the trade could not be executed. To deal with such real-time fluctuations, the system operator would buy 'decrements' from the trader, i.e. pay the generator to decrease its output and relieve the congestion. The price for the decrement was established via adjustment bids that specified how much the lost opportunity was worth to the trader. Conveniently, the DEC player had submitted very high adjustment bids and now reaped a massive windfall for not delivering energy—energy that they could not have delivered in the first place.

The game capitalized on the simplified information structure that the designers had embedded in the forward market. Based on the historical data, the intrazonal congestion patterns would indeed be hard to predict. But of course, traders could easily determine the capacity on transmission lines in zones and then create congestion through strategic trading. The profits from this game depended on the fact that the forward markets were supposed to be the best approximation to the economic dispatch of real-time operation. Accordingly, the operator treated all diversions from the forward market as unpredictable diversions from good faith agreements and compensated traders for it. As soon as traders figured out how they could get paid for their ability to predict or create congestion, they derailed the market mechanism, broke the precarious connection of mutual improvement between the two markets and made a massive profit.

This reveals a fatal flaw: since no one enforced the uniformity assumption—the assumption that all actors would execute the same calculation—the traders were free to switch to a different logic of action. This opportunity emerged because of the compromises required to realize the explicit assumptions. The simplified network structure created a profitable opportunity to deviate from the required calculations. Traders no longer compared price differences between locations and transmission capacity rights to find profitable trades. They now

4 For a detailed examination of the Enron strategies, cf. Lambert, 2006.

searched for transactions that violated technical constraints and that they would later be paid to revoke. This derailed the market as a search algorithm for the optimal dispatch. Accordingly, the implicit assumption was crucial. The designers would have needed to put structures into place to enforce uniform decision-making for the market to work as advertised.

But would enforcing the assumption usually have been possible? Independently of the other requirements, the assumption poses no special challenges. It merely requires significant control over the range of choices market participants can make. For example, by channeling actions through a software interface that records, standardizes and limits actors' choices, the designers can make sure that users' calculations become uniform. Uber makes it impossible to violate the logic of its algorithm, because the user can only order cabs or cancel the transaction. These two basic options leave no room to express considerations that are inconsistent with the task of optimizing the distribution of taxis to people relative to constraints on location, time, traffic, etc. The 'market' is almost entirely software that executes the search algorithm with minimal inputs.

In principle, it is thus possible to enforce uniform decision-making. But in the case of California's blueprint for transmission capacity, the assumption stood in tension with another requirement built into the blueprint: that the market mechanism would operate as a *decentralized* search algorithm. The designers had little choice in the matter: the political process had converged on the mandate that 'real' markets should be used to organize as much of the dispatch as possible. Stakeholders blocked alternative proposals for a centralized computation of locational prices. Accordingly, the designers proposed a blueprint for a decentralized trading regime. But it was infeasible—designers would not have been able to implement it anywhere because the requirements contradicted each other.

To see why this is so, it is necessary to consider what a centralized monitor would need to know in order to enforce the uniformity assumption. For each trade, the monitor would have to decide if the transaction reflects an attempt to create artificial transaction or a legitimate attempt to benefit from price differences. Since power flows interact with each other and can even cancel each other out, only the sum of all transactions reveals whether an individual transaction creates congestion. The monitor would therefore have to be able to compare an individual transaction with the complete dispatch schedule. But in a decentralized system, bilateral trades on a simplified network between individual market participants were supposed to produce this schedule—and this structure was affected by the game. The information a centralized monitor would need to evaluate the transaction was thus not available when a decentralized market process solved the optimization problem. Accordingly, the blueprint was combinationally infeasible: as a decentralized search algorithm, the implicit assumption could not be enforced. Meanwhile, the need to put a simplified network structure into place created incentives to violate the assumption. The requirements for the blueprint's explicit assumptions (simplified network structure) thus were inconsistent with the requirements for the implicit assumption (centralized oversight). Since the simplified network structure corresponded to the cognitive limitations of human actors and the need for centralized oversight from the interdependencies of power flows, these requirements were not tied to California's situation. Market design practices would therefore generally have a hard time to implement this blueprint. Indeed, similar attempts to implement iterations of this blueprint in other regions has always led to versions of the DEC game (Holmberg and Lazarczyk, 2015, p. 148). Accordingly, the blueprint was infeasible.

6. Discussion and Conclusion

I have argued that sociologists can evaluate the feasibility of market design blueprints within the performativity paradigm. We neither have to relinquish the idea that all meaning is determined in practice nor invoke a realm of ‘a priori’ truth to do so. The key is to realize that we are not evaluating blueprints ‘as such’ or independent from their context of application.

Adopting what Barry Barnes has called a ‘realist mode of speech’, we can index blueprints’ feasibility to the way they are usually understood and implemented. Market design practices are reasonably stable across settings. Blueprints will not be read or implemented completely differently. Accordingly, we can talk about blueprints *as if* they are independent entities when we are really referring to ordinary use. This opens the path toward an evaluation of scope conditions. If the blueprints’ requirements would generally be hard to meet for market designers, we can say that the blueprint is infeasible. This happens if the blueprints’ assumptions generate impossible or contradictory requirements. In contrast, if political or practical problems prevent designers from implementing assumptions that they could easily implement in other contexts, the problems are located in the design practice and not the blueprint. I have proposed that we can look for blindspots in designer’s blueprints to search for sources of infeasibility.

In the empirical analysis, I have illustrated this kind of analysis and argued that the blueprint for California’s transmission capacity markets was infeasible because it generated requirements that contradicted each other. This contradiction was not based on the political or technical constraints that designers faced in California. Given the complexity of electricity grids and the cognitive limitations of humans, *all* efforts to create a decentral trading regime would have needed to introduce a simplified representation of the grid. Such a simplified representation would always run up against the requirement for uniform behavior and generate the control requirements that a decentralized system cannot meet. This means that the failure of these markets can be attributed to the underlying design—rather than to particular features of the political or technical processes.

Apart from offering a novel explanation for manipulative behavior during the Western Energy Crisis, this article makes several contributions to the literature in the Social Studies of Finance. First of all, it returns to an issue that stood at the center of early performativity studies: how do economic theories contribute to the creation of a world that renders its propositions true? But with the search for *conceptual* limits to performative truth-making, I turn the classic approach on its head. Rather than examining how social processes set up conditions that enable the performative truth of a theory, I ask whether the theory describes a process that can possibly be created under the usual conditions of design work. This defines a conceptual limit on the performative effect of market design blueprints. The meta-theoretical argument that enables this argument also advances the literature by attending to the criticism that performativity studies do not specify ‘objective constraints’ on what theories can become true.

Second, the article proposes a research trajectory that can move the literature beyond an impasse. Right now, most studies focus on the political dynamics behind market design and try to establish a conversation between field-theory and the social studies of science (e.g. Beunza and Ferraro, 2019). But the core aim is still to understand economic theories are performed. As some critical observers have noted, this line of inquiry has gotten somewhat tired since economists have embraced their role as market designers. That economics is complicit in constructing the world is hardly surprising anymore. Part of the problem is that performativity studies are largely descriptive. Different case studies of how economics are performed therefore do not substantially advance beyond the general claim that the knowledge can *sometimes* become performatively true (Hirschman, 2015). The article indicates how we might shift gears and expand on this general insight. The scope conditions of performative effects refer us to problems that practices of market design have more generally and beyond the individual case. As such, they promise to reveal limits to this increasingly prevalent form of social engineering.

Third, my research points a path to a *critical* perspective on market design. As the terms of interaction between state and markets shift, synthetic markets increasingly appear as tools of governance. This poses a variety of political questions. First, under what conditions should we use synthetic markets to allocate public goods and when should we use other regulatory strategies? Second, how do we decide between alternative market mechanisms? These questions require a critical sociology of market design that evaluates whether it can live up to its promises. Only a sociological perspective that evaluates the feasibility of market design blueprints can hope to be part of this conversation. That is, because it attends to the question what kind of theoretical properties are easier or harder to realize and thus offers a framework from which a political position can be developed. This article has made a first step into this direction by pointing to two ways in which blueprints may become infeasible.

While the article does contribute a new way to study and understand market design, it is compatible with the existing research. A *feasible* blueprint does not have to lead to a working market. As many studies have shown, the translation of blueprints into new 'agencements' is more than a one-to-one translation. Since the blueprints are necessarily underdetermined (Guala, 2007), the product of the design process can vary substantially. These variations are the product of political, organizational and material processes that must be analyzed separately. Similarly, the choice of blueprints among competing visions is itself a political issue that needs to be evaluated as such (Reverdy and Breslau, 2019). As all arguments about scope conditions, my article simply points out that there may be practical boundaries to the kinds of theories that could be implemented, leaving open whether, and why a feasible theory comes to be realized later.

Market design is an extremely powerful and successful form of social engineering. Designers are increasingly building markets to provide and allocate some of the most essential goods and services in our societies. It is therefore increasingly important to determine under what conditions this is a good idea—what problems are amenable to this type of social engineering and which ones are not? Where are the limits to this type of social engineering? Though the performativity literature has studied market design for more than two decades, it has not tried to address this question head on. This article has argued that the meta-theoretical reservations about this line of inquiry may be dispelled. And it has shown how we might leverage a genuinely sociological perspective to identify infeasible blueprints.

Acknowledgements

I would like to thank Andrew Abbott, Kyla Bourne, Bruce Carruthers, Neil Fligstein, Garry Herrigel, Karin Knorr-Cetina, Austin Koslowski, Jane McCamant, Donald MacKenzie, Simon Shachter, Ben Rohr, Arjen van der Heide, Leon Wansleben, Ezra Zuckerman and the anonymous reviewers at SER for their constructive feedback. Special thanks go to reviewer two, whose valiant defense of the STS perspective has led to a back-and-forth that exceeds the length of the article by a substantial margin, and was extremely intellectually rewarding for me.

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