An 'Uber for Electricity': Institutional Theory For a Platform Model In an Historically Regulated Industry

Lynne Kiesling

Associate Professor of Instruction
Department of Economics
Northwestern University

May 2016

For discussion only; preliminary and incomplete. Please do not cite without permission.

Abstract: The regulated electric utility business model faces technology-driven change, for which both the regulatory model and the business model are ill-suited. Both the theory and practice of regulation are maladaptive to such dynamism; existing regulation may also slow or prevent innovation within the industry by erecting entry barriers, mandating administered paths of change, and allowing persistent transaction costs. This paper proposes a physical distribution and market platform model, and uses institutional, organizational, and Austrian economics to provide a theoretical economic framework for the distribution platform model.

* lkiesling@northwestern.edu or lynne@knowledgeproblem.com. I am grateful to Mark Silberg for research assistance. This analysis has benefited from conversations on this topic with Jean-Michel Glachant, Dominique Lazanski, Stephen Littlechild, and Samantha Zyontz, and from suggestions from participants in the Public Choice Society meetings in 2015. Some of the work in this research project occurred while I was a Visiting Senior Lecturer in the Department of Political Economy at King's College London, and I am grateful to them for their collegiality and hospitality.

I. Introduction

Four drivers, three of them innovation-induced, are opening electricity distribution regulatory and business models to scrutiny and evolution. The first driver, the pace of digital innovation and the breadth of its impact in everyday life, makes electricity all the more important while also providing easier and cheaper decentralized ways to monitor, observe, and automate electricity consumption and production. The resulting second driver has been the development of smart grid technologies, which provide a communication network on top of the distribution network and enable the creation of and observation of more information and knowledge at the distribution edge. A third driver is the change in the policy objectives over the past 40 years, adding environmental regulation to the century-old economic regulatory compact. The fourth driver of change in the electricity industry is the increasing share of distributed energy resources (DERs) in the distribution network, which have potential environmental and grid resilience benefits, but for which the distribution network architecture and the regulatory structure were not designed.

These drivers converge in pointing toward a desirable policy objective: an electricity distribution model for the future that will enable resilient, sustainable electricity and reduce barriers to innovation. This paper proposes such a model, an electricity distribution platform, and uses institutional, organizational, and Austrian economics to provide a theoretical economic framework for the distribution platform model.

In the past five years, general-purpose digital technologies have expanded greatly and been increasingly integrated into our daily lives. 2.0 billion users worldwide connect to the Internet daily, and across 13 major countries, the Internet accounts for 3.4 percent of GDP (McKinsey Global Institute 2011, p. 11). Slowly, these technologies are intersecting with the old industry that enables them: electricity. Smart grid technologies in electricity are applications of general-purpose digital communications technologies within and around the electric power network; a smart grid is a digital communications integration and overlay on the existing electro-mechanical physical wires network.

Smart grid technologies embedded in the distribution network enable automated outage notification, fault detection and repair, and routing of current flows around faults to maintain service. They also enable the interconnection of increasingly heterogeneous types of devices, owned and operated by increasingly heterogeneous agents. In the traditional, linear electricity value chain, large generators send energy toward end-use customers (via high-voltage transmission and low-voltage distribution networks intermediated by transformers). With smart grid technologies, multi-directional connection and current flow in a physically stable distribution network are now possible.

Smaller scale distributed generation and other distributed energy resources (DERs) are also increasingly economical, placing pressure on the historical regulated distribution utility model. These DERs are on-site energy sources from any number of resources, including solar photovoltaics (PV), small wind, biogas, and batteries. On-site is the crucial feature of these assets: when located on a home or business, DERs create new types of operators in power markets who both purchase electricity from the grid and generate power from their own sources. These operators, which can span industrial, commercial, and residential customers, are referred to as customer-generators or “prosumers”. In 29 states DER owners are paid the full regulated retail price for any excess energy that they generate and put out on the distribution grid; these “net metering” policies vary by state and sometimes by utility.

Using a bundled retail rate for net metering reflects both compromise and convenience. In traditionally regulated states the utility is still vertically integrated, limiting its ability or incentive to distinguish among the types of costs captured in the bundled retail rate. The retail rate and electric meters that run backwards was a relatively inexpensive way to enable net metering in an electro-mechanical technology environment. The more recent proliferation of sophisticated digital metering technology enables alternative pricing approaches for DER energy sales and payments for grid services, because it reduces the transaction costs of measuring excess generation and makes more of the grid services offered both transparent and transactive.

A 2013 Edison Electric Institute analysis sparked an ongoing debate over the financial implications of disruptive challenges for the traditional regulated distribution utility business model, focusing on the question of revenue generation for the distribution grid in an increasingly decentralized and distributed system and drawing parallels to the decline of the wires telephone industry (Edison Electric Institute 2013). Figure 1 illustrates the pressures that distributed technologies place on the traditional distribution utility business and regulatory model.

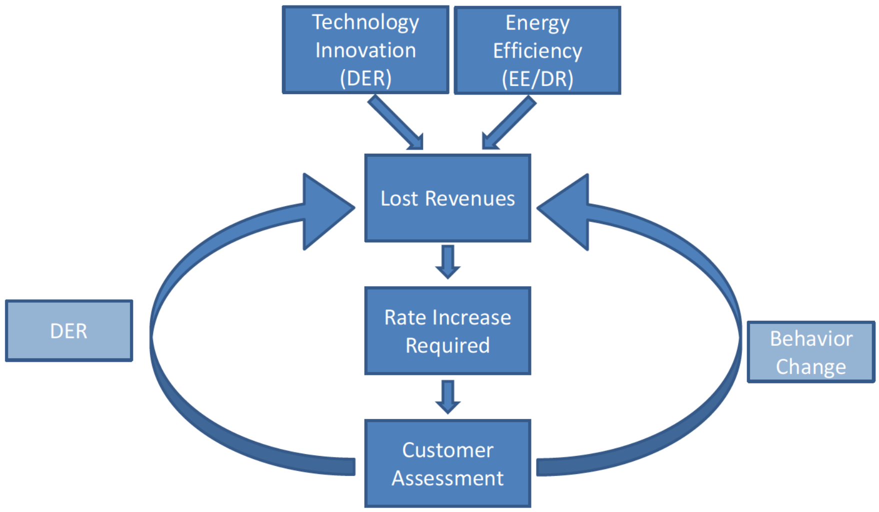

Figure 1. The "utility death spiral"

Source: EEI (2013), p. 12.

A May 2014 Barclay's report recommended down-weighting of electric utilities in investment portfolios due to the financial pressures likely to arise from "grid defection", although other analyses suggest that the economic value of the assets and functions in the distribution utility are not likely to erode as quickly as seen in the telecommunications industry (Barclay's 2014, Rocky Mountain Institute 2014).[1]

Digital distribution technologies enable innovation at the edge of the network, in similar ways to what has occurred with the Internet over the past two decades. The Internet's open architecture (open communication protocols and interoperability) makes creating new devices and applications layered on top of the Internet easy and inexpensive. Internet pioneer Vint Cerf credits this value creation to the Internet's role as a platform for "permissionless innovation" (Cerf 2012). Such welfare-enhancing creativity is possible in electricity as well, as seen in residential solar, microgrids, electric vehicles, and applications and devices for autonomous and mobile home energy management.

---

[1] In fact, the title for this paper was inspired by a Rocky Mountain Institute blog post, "An AirBnB or Uber for the Electricity Grid?", available at http://blog.rmi.org/blog_2014_09_02_an_airbnb_or_uber_for_the_electricity_grid; I wrote a response to that post at http://knowledgeproblem.com/2014/09/17/the-sharing-economy-and-the-electricity-industry/.

This period of technological dynamism is also an opportunity to reexamine the regulatory footprint and whether the historical vertical integration in this industry is still economically reasonable (Kiesling 2015). Digital innovation, smart grid, and the increasing energy efficiency and smaller scale of distributed energy resources are changing the economies of scale and scope that drove the traditional vertically-integrated regulated monopolist. Open, competitive retail markets with low entry barriers to producers and consumers (and customer-generators) at a range of scales create opportunities for DERs to generate electricity and provide other services outside of a regulated model, and for other customers to benefit economically and environmentally from such innovation. A business model for the distribution utility as a market and distribution platform that connects them, and that procures resources for grid services through market transactions, would enable such value creation.

II. Distribution platform model: theoretical framework

A. Historical background

Since the beginning of commercial electric power in the 1880s, vertically integrated firms have sold electricity as a bundled good with a fixed volumetric price to consumers to compensate both for the fixed costs of wires and equipment and the variable costs of generation. Separate real-time monitoring of electric current was technologically feasible by the 1950s, but bundling and vertical integration remained the status quo for the electric utility business and regulatory environment, until technological change in generation precipitated the regulatory and organizational changes that brought about competitive wholesale markets. Heretofore, monopoly utilities only traded with one another to meet emergency needs, which meant that few high-voltage interconnections existed among service territories. In the US, meaningful institutional change at the federal level occurred with the Energy Policy Act of 1992, creating the potential for wholesale electricity markets by reducing legal entry barriers to exchange, and allowing third-party generation and sales of electricity to distribution companies. This case illustrates how technological change can create potential value from organizational change; innovation changed the transactional boundary of the firm, reduced the benefits of vertical integration, and made generation unbundling possible. In a regulated industry, though, organizational structure is a function both of technology and of the regulatory institutions/framework. New technologies also made possible both centralized and decentralized generation, diversifying the means of energy generation and in turn providing further support for the regulatory unbundling of energy from wires. Yet the regulation of energy and wires as a bundled good persists in many regions to this day.

Since the 1990s and the changes wrought by technological change in generation and the liberalization of wholesale energy markets, an "elephant in the room" question has been the role, nature, and scope of the distribution utility, particularly in its transactions with residential customers. As digital and DER technologies around the distribution edge have become more feasible and heterogeneous in nature and scale, agents participating in the network are becoming more heterogeneous, rather than utilities and customer types by class (industrial, commercial, residential), with regulators setting the rules. Digital and DER technological change's dramatic reductions in transaction costs and decentralizing forces enable organizational unbundling of the vertically integrated distribution utility, self-generation at smaller scales for smaller customers, and organization of self-contained microgrid systems around the distribution edge. Furthermore, in retail markets when consumers can self-generate with electric vehicles or other forms of distributed energy, the existence of a retail market platform would enable such a consumer to be a consumer in some conditions and a producer in other conditions, so the definitions of types of agents in the network are no longer static.

B. Theoretical Lens 1: Platforms

As in other industries, digital technologies create the potential for the electricity distribution utility to operate as a platform. Baldwin and Woodard define a platform as "…a set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components." (2009, p. 19) The distribution utility as a platform is a market design implication of technological change and the increasing complexity of the economic and technological environment in which firms in the electricity industry operate, and it is a consequence with implications for regulatory institutions as well. The organizational and business model of the distribution utility is a consequence of how regulation has been implemented, with the distribution utility having a legal monopoly over the physical distribution of an unchanging, well-defined product in a specific market with clear boundaries. In other words, only the distribution utility has the legal right to transport and sell energy of a particular voltage and quality to residential customers. Regulatory restructuring that enables retail competition has led to organizational change in some jurisdictions. Although here I focus on a design for the distribution platform mode, the changes required to enable such a model are regulatory changes.

Following Gawer (2014), I synthesize three complementary definitions of a platform in the distribution platform model:

1. *Technological*: A technology platform is a common core of technologies within a modular architecture, with variable technology elements around the periphery that interoperate with the core technologies and architectures.
2. *Economic*: An economic platform is a means for facilitating and coordinating mutually-beneficial exchange or transactions in a two-sided or multi-sided market (Rochet & Tirole 2003).
3. *Organizational*: A platform can provide institutions that enable the coordination of the actions and plans of agents (be they individuals or firms) within a technology platform for mutual economic benefit, and it can have different organizational form in different industries and contexts.

Technological platforms

The technological definition of a platform emphasizes its technology elements and the architecture that shapes the system that these elements create. A platform is a collection of technology elements, typically with a stable, common technological core and a variable, heterogeneous periphery (Gawer 2014, p. 1242). Video game platforms are a canonical example – the core technology is a set of (usually proprietary) elements that work in conjunction with other, diverse elements to enable game playing. Those diverse elements include games written to play on the platform, and other devices like joysticks that complement the core system and the other periphery elements to create a game experience. A core of common components allows for economies of scope in production to develop around the platform, which is one of the main drivers of innovation around technological platforms. These economies of scope can be realized both within firms and across firms, and analyzing the implications of vertical integration and firm ownership around a platform is one good reason to extend the analysis of platforms in the organizational-institutional direction.

The common core and variable periphery technology elements interrelate in a modular fashion. Modularity means that when thinking about the system (or, as it is increasingly called, ecosystem), the design of the elements enables substitutability and ease of interconnection within the system. Modular systems have standardized physical sizes and interconnectivity rules, which makes each element less interdependent with the other elements in the system. In a technology platform, then, elements within the platform and at the periphery are independent in the sense that, for example, replacing an element in the core does not necessitate replacing other core elements or the elements at the periphery. Modularity entails breaking up an otherwise complex system (in the technical sense) into discrete components, and having the components interact is what yields the complex system and the desired outcomes. The function that most users would associate with modularity is “plug-and-play” functionality.

Such modular architecture makes platforms well-suited to facilitating innovation. Modularity makes designs more discrete, and implements common rules for interfaces that can act as focal points around which designers can create new designs. This approach simultaneously helps manage complexity and facilitate beneficial complexity, given heterogeneity and subjectivity of preferences and opportunity costs, as well as diffuse private knowledge.

This discussion demonstrates why interfaces are important technological aspects of platforms. With modular elements, a set of common core elements, and variable periphery elements, in order for the elements to work together to achieve the desired objectives they have to be able to communicate and share information across interfaces. Interfaces serve dual roles, as dividers between elements and between the core and the periphery, and also as connectors between elements and between the core and the periphery.

INTEROPERABILITY TKTK

Economic platforms

An economic analysis of platforms views them as transaction facilitators and intermediaries. By using technologies that reduce transaction costs, economic platforms create value by enabling parties to connect for mutual benefit, typically in the form of a transaction or exchange. Platform providers create markets, connecting producers and consumers (Rochet & Tirole 2003, Armstrong 2006, Rysman 2009). Such a framework views agents as having specific roles (buyer, seller, platform provider) and exchanging a specific good or service. In the video game platform example, the platform provider creates value by providing a technology (the game console and its operating system) that acts as a focal point (Schelling 1960) for a game seller and game buyer to transact; the exchange yields mutual benefit, and the existence of the platform provides incentives to the seller to develop games for the platform and the buyer to purchase the games. Thus an economic analysis of platforms analyzes the platform as a two-sided market or multi-sided market, where the platform provider coordinates agents through transactions and price signals.

Economic platform models generally rely on several assumptions. First, they assume an exogenous, fixed platform (Gawer 2014, p. 1241), a restrictive assumption that rules out analyzing dynamic evolution of the platform itself. Economic models also assume that the cross-platform relationship is buyer-seller, which rules out analyzing differentiation and heterogeneity in both the roles of agents around the platform and technological aspects of the platform. For example, a strictly economic model has a hard time analyzing a situation in which a platform complement firm then becomes a competitor (e.g., Facebook starting to offer search that competes with Google), or a competitor becomes a complement by choosing to adopt interoperable standards and architecture for its own products and services

However, these strict assumptions do allow some analysis of product differentiation and innovation at the edge of the platform (such as new, different games or complementary devices). But that analysis takes place within a transactional framework that abstracts from the process of innovation itself, and cannot provide an analysis of how a platform can facilitate innovation. That process must include experimentation, trial and error learning, and social learning through engaging in the market process (as discussed in the next section).

Platforms as institutional-organizational elements

Platforms arise and evolve in different organizational contexts, so an organizational lens is a worthwhile complement to the technological and economic platform analyses. Gawer's integrated theoretical framework for analyzing platforms starts from the observation that "… in order to create value, platforms rely crucially on economies of scope in supply and innovation (for the engineering design view), and economies of scope in demand (for the economics view)." (2014, p. 1244) Agents who constitute the platform ecosystem may take on multiple roles; they may be individuals, households, firms, or some other organizational form that is endogenous to the system.

Agents can be individuals or firms, and can play a variety of roles; those roles can change over time, as environment changes, as interactions in a complex system yield new patterns and outcomes. Both the technological analysis and the economic analysis abstract from how the roles of platform owners and platform complementors can evolve between complementarity and competition. They also abstract from the ability of an agent to have different roles in the ecosystem at different times, but this heterogeneity is a novel feature that digital technology enables, and that can have significant institutional and organizational implications.

The technology literature models agents as having fixed roles as collaborative innovators around the platform, while the economics literature models agents as having fixed roles as producers and consumers in multi-sided markets. Empirically, agents can and often do play different roles, and those roles can change as transaction costs and opportunity costs change (Gawer 2014, p. 1243). Modeling the platform as an institutional-organizational element draws on both the entrepreneurship literature and the organizational economics literature on vertical integration, both discussed above.

Raises the subject of governance, which in this context means not just the organizational and managerial questions, but also the regulatory institutions. ELABORATE

C. Theoretical Lens 2: Permissionless innovation, entrepreneurship, and experimentation in a decentralized platform

The underlying theory and practice of regulation within the electric utility industry so far does not consider experimentation processes that convert creativity, innovation, and technological change into new value propositions for consumers, perhaps revising market boundaries and creating economic growth in the process. Experimentation is among the most substantial drivers of value creation in an entrepreneurial theory of competition that emphasized competitive market processes—the ability of producers to bring new ideas to market, of producers to combine and bundle existing and new products and services in novel ways, and of consumers to discover these new value propositions and learn how much to value them. Yet despite the clear benefits, these concepts have not yet been integrated into the electricity sector. Rogers (1962) identifies experimentation as one of the primary factors influencing the diffusion of innovation. Greenstein (2008, 2012) argues that economic experiments played a significant role in creating value in the markets for Internet access; his analyses suggest that although economic experimentation is a driver of value creation, pre-1990s federal spectrum policy erected a regulatory barrier to such experimentation. The technological, entrepreneurial, and regulatory parallels between the Internet and the electricity industry are suggestive.

An environment that allows experimentation fosters social learning through trial and error. Such learning is the best (not perfect, but best) feasible social process for improving human well-being in the face of uncertainty and unavoidable cognitive limitations. Three primary reasons explain why permissionless experimentation creates such beneficial dynamism and value: it helps in mitigating the knowledge problem, it builds resiliency in the face of uncertainty about unknown and changing conditions, and it undercuts the ability of rent-seeking incumbent interests to maintain a status quo that can benefit them at a cost to others.

One of the most important reasons why an environment for experimentation is valuable is because it enables the experimentation and learning that can mitigate the knowledge problem. Neither regulators nor other market participants have access to the knowledge influencing *individual* decisions made about production or consumption. In dynamic markets with diffuse private knowledge, neither entrepreneurs nor policy makers can know *a priori* which goods and services will succeed with consumers and at what prices. Similarly, consumers' preferences are not fixed and known, either to others or even to themselves. Consumers learn their preferences through the process of evaluating available choices in a marketplace, and analyze the relative value of those tradeoffs over time. The set of available consumer choices itself changes due to entrepreneurial activity. Even the most benign, well-intentioned group of government administrators with the most powerful computer possible cannot access that knowledge, because it is dispersed in the minds of individuals, and they do not even create that knowledge until they are in a context where they have to consider making a choice. Experimentation makes learning possible and creates knowledge that would not otherwise exist, including the knowledge embedded in new products, services, and value propositions (Kiesling 2015b).

Humans are also limited in our ability to anticipate future events, contexts, and outcomes, all the more so because of the rich dynamism of change that emerges in a complex system like the modern global economy. Knowing what future we are creating from today's actions is almost impossible, particularly knowing specific outcomes that will happen. An environment that fosters trial-and-error learning is more likely than others to better enable more people to adapt to these unknown and changing conditions, and to find ways to improve well-being and living standards. No one can anticipate future uses of technology, and the only way to find them is to allow people to experiment, not to rely on selection and approval by a regulated monopoly or by a regulatory authority. Note the implications of this principle for environmental quality as well as economic well-being; as human action in this complex social system affects, for example, the complex global climate system, trial-and-error learning via permissionless experimentation is a process that enables discovery of new ways to achieve both economic well-being and environmental quality.

Finally, permissionless experimentation fosters creativity and advancement without obstacles from rent-seeking incumbents or prior claimants. Public choice theory suggests that incumbents have strong incentives to create entry barriers, and to lobby for policies that will allow entry barriers to persist, in order to make their market less rivalrous. Less rivalrous markets mean less consumer protection through competition, and less innovation that can have substantial economic and environmental benefit.

By contrast, economic regulation is a permission-based system. Permission means having to ask for explicit approval of regulators and government authorities in advance of bringing a new product, service, app, or other value proposition to market. In electricity, the form and extent of economic regulation may act as a permission barrier, preventing such unexpected benefits from arising. In some industries, including electricity, the permission that is often denied is permission to enter the industry — economic regulation in electricity is constructed upon a foundation of legal entry barriers to protect the incumbent's economies of scale. What happens, though, to those permission-based regulations when the physical and economic reality on which they are based change? Such a period of technological dynamism is occurring in electricity distribution and around the distribution edge, and putting pressure on existing regulated business models.

The economics literature on competition and entrepreneurship provides some insights into the dimensions of enabling that business model to evolve into a distribution market platform. Competition creates value through trial and error while exploring new technologies, innovations, business models, product differentiation, and commercial and profit opportunities. Both producers and consumers are entrepreneurs insofar as they discover new profit opportunities through their alertness. This experimentation-based theory of competition combines the Schumpeterian disruptive entrepreneur who generates creative destruction with the Kirznerian alert entrepreneur who interacts with those changes.

Schumpeter's (1934) pioneering work examines how disruptive innovation creates economic growth via individuals who create "new combinations" of materials and forces, leading to change away from economic equilibrium (1934, p. 65). Individuals come to discover these "combinations" by experimentation. Existing producers differ from these experimenters in their tendency to initiate dynamic, growth-generating change by participating in existing markets, producing existing goods and services, using existing techniques at lower prices. Schumpeter defines fives methods for creating dynamic change in markets: introducing a new good or service, or adding new features to an existing one, introducing new production technology or methods, opening new markets, and capturing new sources of raw materials or new methods of industrial organization (1934, p. 75). Competition in dynamic, free-enterprise societies is a process of change and creative destruction, with new combinations making previous ones obsolete (1942, 84). Dynamic competition often takes the form of product differentiation and bundling to compete for the market. Rivalry occurs among differentiated products; innovators and entrepreneurs change market definitions and boundaries by creating new products and services as well as new bundles of products and services. That dynamic discovery of new value propositions necessarily takes place in an experimentation process in which different producers interact, as do old and new combinations, to meet the market test of consumer value creation.

Schumpeter's disruptive innovator finds its complement in the activity of Kirzner's alert, aware, entrepreneur. The "entrepreneur-as-equilibrator" (2009, p. 147) uses differential alertness to profit, at least speculatively, from an existing opportunity to create net value. Differential alertness means awareness of and openness to a business opportunity that has not yet been widely noticed. This entrepreneur is not a Schumpeterian disruptive creator but engages in trial-and-error experimentation, playing a coordinating role by adapting to underlying changing conditions. Commercializing new products and service – as well as new bundles of products and services– is an example of "equilibrating entrepreneurship".

These ideas of entrepreneurship and experimentation are relevant to regulatory institutions and institutional change in electric power because decentralized coordination through market processes offers forward-looking coordination of future behavior that is not available to central authorities, including regulators. Smart grid and distributed energy innovations make these decentralized processes cheaper and easier. Markets offer agents of all types opportunities and incentives to make profitable discoveries through experimentation. Regulation as it is currently practiced does not. Regulatory institutions are based on equilibrium models grounded in static concepts of cost recovery that do not incorporate or allow for perceiving opportunities and making discoveries. Unleashing the benefits of experimentation and decentralized coordination in this regulated industry requires institutional change to accompany and facilitate technological change.

D. Implications for organizational structure: Vertical integration, unbundling, and vertical foreclosure

In a standard neoclassical competitive model, with full information, no incentive alignment problems, and zero transaction costs, the existence of firms is entirely an artefact of the cost functions in the industry, of such associated issues as economies of scale and scope, and of the size of the relevant (well-defined) market. This approach undergirds the natural monopoly theory and the definition of subadditivity of costs that is the hallmark of electricity regulation.

Work in new institutional economics and organization theory demonstrates that this standard approach overlooks the incentive and governance reasons for having some transactions occur within firms and some occur in markets. Principal-agent problems, the difficulty of writing complete contracts, and other transaction costs determine the transactional boundary of the firm, and when transaction costs change, the profit-maximizing firm's boundary should change to incorporate the new tradeoffs. The form and magnitude of the change in the firm's boundary is a function of the expected benefit and cost of rearranging how the transaction is realized, and also of the cost of bringing about the change. As Coase (1937) and others have shown, the desire and ability to decrease transaction costs shapes vertical integration and contracting in a variety of industries (see, for example, Joskow 1988; Klein, Crawford, and Alchian 1978; Baker, Gibbons, and Murphy 2002; Bajari and Tadelis 2001; Bresnahan and Levin 2012).

Vertical integration can have both beneficial and harmful welfare effects. Vertical integration's benefits can include exploiting economies of scale and scope, cost savings, and managerial and transaction cost benefits up to a point (e.g., Klein, Crawford, and Alchian 1978, Bresnahan and Levin 2012). Vertical integration can harm consumers if the firm's pricing includes cross subsidies that distort demand patterns, deadweight loss if the related market is a monopoly, and deadweight loss from regulatory evasion (Brennan 1987). It can also be a source of vertical foreclosure, in which the vertically integrated firm's participation in a downstream market with rival firms exerts an anti-competitive influence in that related market.

Integrated asset ownership and regulation have essentially been a form of insurance against wholesale price volatility while also providing a business model for earning a normal rate of return on the assets used to reduce physical (outage) risk. One difference between vertical integration and contracting is the identity of risk bearer in the case of system failure. In a vertical structure with one firm owning upstream and downstream assets, that identity is likely to be clearer, and the costs of internalizing any harms arising from failures may be lower as a result. With contracting, given the inevitability of incomplete contracting, no contract will be able to stipulate all of the contingencies that might arise between the parties, and unforeseen consequences might lead to costly renegotiation or harm internalization. Damages to or failures of the electrical system harm various suppliers and utilities, but also harm electric customers and the economy at large. One virtue of the historical regulatory regime for electricity is the extent to which it prioritizes reliability of supply over innovation.

The value of vertical integration as insurance, though, is the opportunity cost of alternative institutional arrangements to provide similar functions. Innovations like smart grid technologies change the opportunity cost of vertical integration by creating alternative ways for consumers to protect themselves against price volatility.

Transaction costs, the transactional boundary of the firm, and the feasibility of creating new markets forms the framework for understanding the potential for unbundling energy retail transactions from electricity distribution, a potential that smart grid technologies catalyze.

Innovation, including but not exclusively technological innovation, changes the efficient transactional boundary of the firm because it affects the transactions costs, economies of scale, and economies of scope that make vertical integration a profitable organizational structure. These technological changes have created the opportunity to change transaction costs in the industry, thereby creating opportunities to do two dynamic things: change the boundary of the firm in accordance with the change in transaction costs, and create new markets where they previously failed to exist because of transaction costs.

However, the organizational structure of firms in the industry is also a function of the regulatory environment. Technological change has created the potential for shifts of the transactional boundary of the firm and for market creation, but regulatory institutions reinforce the use of antiquated or sub-optimal, but known and familiar, technology. These institutions fail to integrate new technologies adequately into regulatory planning. The investment in existing electro-mechanical technology that is a sunk cost, yet creates an information monopoly for the regulated utility, reinforces an inertial lock-in and reduces the incentives to develop technology feedback effects.

III. A platform model for electricity

Using Gawer's framework, I model electricity distribution platforms as "… evolving organizations or meta-organizations that (1) federate and coordinate constitutive agents who can innovate and compete; (2) create value by generating and harnessing economies of scope in supply and/or demand; and (3) entail a modular technological architecture composed of a core and a periphery." (2014, p. 1240) Applying that model to electricity distribution suggests some clear roles and scope for a distribution platform – electricity distribution and retail market platform – while still leaving some questions open for analysis and debate. Tabors et. al. (2016) provide a detailed example of such a platform design in the specific context of the New York Reforming the Energy Vision (REV) regulatory proceeding; in this section I sketch briefly a more general framework in the context of the theoretical frameworks presented above.

A. Core functions of a distribution wires company

Given existing technology, fulfilling the core distribution role in the foreseeable future is likely to be a regulated function, retaining the legal entry barriers.[2] With this core role, the primary performance objective will be a measure of reliability and how well the distribution platform delivers reliable service. The role of the regulator will be to define, monitor, and evaluate performance metrics, and to evaluate the distribution platform's estimate of its infrastructure costs to maintain and invest in the assets to enable it to perform these functions satisfactorily. The distribution platform's role as retail market platform suggests a role for the regulator in information provision, market monitoring, and consumer protection through information requirements and fraud reporting procedures.

A core function of a distribution platform will continue to be providing the distribution wires network. Given existing technology, and given initial conditions of existing physical distribution wires network, a "central backbone" distribution network is likely to continue to have economic value into the foreseeable future. To the extent that economies of scale and scope still exist in electricity distribution, a grid that is a central backbone will have value.

The distribution platform firm has the operational and regulatory requirement to deliver electricity services to end users. Accompanying that role are a reliability requirement, with some administrative definition of what constitutes reliability, and the physical real-time network balancing function. The distribution platform is the orchestrator of grid needs, i.e. reliability, voltage regulation, and capacity. The distribution platform earns a normal rate of return and the revenue to maintain and modernize infrastructure through a wires charge to retail customers.

B. Proposed model

The defining feature of a platform firm is that it acts as an intermediary connecting two or more agents for mutual benefit, and the most common economic role of a platform firm is intermediation in transactions by providing a market platform that brings together potential

---

[2] That said, however, the existing regulatory prohibition against any private distribution wires connections across public rights-of-way is worth reconsidering, given that the prohibition is an entry/growth barrier for the construction of distributed systems such as microgrids and combined heat and power (CHP).

buyers and sellers and makes it easier for them to find each other. Consider the analogy to financial market exchanges, such as stock exchanges or futures exchanges, which provide trading platforms. By being attentive to the interests of both buyers and sellers, they define standard products and rules by which exchanges will occur, and provide timely information and a way for buyers to bid and sellers to offer, opening or closing new markets as the interests of buyers and sellers wax and wane. The distribution platform firm would also be a market platform.

As the end users become more heterogeneous and can possess more diverse technologies, the distribution company would create additional value by facilitating the interconnection of those agents and their technologies to the distribution network and the connection of agents, most likely in transactions. In that sense a distribution platform would layer market platforms on top of the physical distribution network. The existence of these retail market platforms would generate incentives and opportunities for entrepreneurs to develop devices that can operate on that platform (e.g., vehicles, home energy management) and applications that connect the owners of those devices to other agents via the platform. For this market facilitation the distribution platform would earn a service fee (details about per transaction or per kWh remain an open question).

ANCILLARY SERVICES

This definition of the primary roles of a distribution platform company may appear straightforward, but the scope of distribution platform that would enable it to fulfill these roles may involve the distribution platform itself being involved as a market participant in roles that could have anticompetitive effects. For example, given the load serving entity requirement, should the distribution platform engage in energy market transactions for backup energy generation to enable it to fulfill that role in the cases where decentralized contracts do not give it confidence, or other extenuating circumstances? To maintain system balance in the presence of sufficient diverse and intermittent energy sources like wind and solar, should the distribution platform own and control “behind the meter” residential solar? In both of these cases the presence of a large, regulated buyer or seller could lead to anticompetitive vertical foreclosure.

The distribution wires network has always had economic value, but the nature of that value is changing as technology changes, and the distribution utility's business model can, and should, change to continue creating value from this central backbone. In the early decades of the industry, the distribution network helped local electric companies increase their generation capacity utilization and reduce their average cost by supplying electricity for lighting to residences in the evening and for transportation and industrial motors during the day. The distribution network made large-scale remote generation possible, enabling electric companies to create and exploit economies of scale and scope to reduce average cost even further. For most of the 20th century, the benefits of centralized generation and the relatively low cost of maintaining the distribution grid meant that it continued to have value.

Smart grid and distributed energy technologies are changing that century-long calculus, along with the changing policy objectives that have expanded to encompass environmental quality along with the traditional social policy goals of universal electrification and low, stable prices for least-cost standard service. As distributed generation at smaller scale becomes more economical, the potential benefits from independence, reliability, and resiliency by disconnecting from the grid become more salient.

But even in a decentralized, meshed network rather than the traditional linear network, the distribution network as a central backbone still has the potential to provide value to being interconnected. The two main value categories are insurance and exchange. A distributed energy installation that disconnects completely from the distribution network is independent and likely to be reliable and/or resilient, but in the case of system maintenance or an unexpected system failure, that system's owner/user(s) bear all of the cost incurred in the outage. A reasonable range of risk aversion is consistent with wanting some insurance, some backup for the times when such an outage will occur. An insurance contract for such backup would be valuable, depending on the relative risk aversion of the distributed resource owner. Backup entails some form of external distribution of energy to that system, and thus entails use of the distribution network. The distribution platform company would have to factor that probability and capacity into its investment plans for maintenance and expansion. One form this transaction could take in a platform model would be for the distributed system owner to contract with a retailer for energy backup, a transaction that would require wires backup, so the insurance charge would be an energy price and a wires charge. There are lots of different ways to price this contract -- an annual fixed fee split between energy and wires (with the wires charge being part of an open-access tariff, along with the other standard distribution wires charges), and a pre-negotiated per-kWh energy price and wires price that would be incurred in the case of having to use the backup. Given how contentious the fights have been over the past two decades over standby charges and fixed fees charged to distributed system owners, the details of this insurance transaction are likely to be fraught and difficult to work out, but this form of insurance is one of the main benefits of a distribution network as a central backbone in a decentralized system.

The other, related, benefit is exchange. A distributed resource owner can benefit only from self-generation if not interconnected to other agents via a distribution network, and only the owner of that asset can benefit from it. Having some means of interconnection enables voluntary, mutually beneficial exchange. In the electricity context, this means of interconnection is multi-layered -- exchange requires a data connection for the exchange of information and a physical connection for current flow. If an agent is considering whether or not to purchase a distributed energy system, or what size of system to install, the possibility of exchange influences that decision greatly.

Deciding to buy a rooftop solar system or an electric vehicle provide examples. The potential to sell excess energy from a solar system, or to sell stored energy from a car battery, increases the probability that a consumer would be willing to buy the asset, knowing that s/he can monetize some of the value of the asset. Similarly, in making that decision the consumer may decide to purchase a larger-capacity solar system. Note how these opportunities, to purchase distributed energy assets and to exchange the energy derived from those assets, creates the opportunity for the homeowner to be both consumer and producer. The DER purchase calculus then becomes one of evaluating the discounted present value of the revenue stream that is likely from the asset, in addition to the consumption value that the owner will derive from consuming the energy and/or transportation services of the asset.

Importantly, this value proposition is precisely the same as that seen in other platform companies. Ride sharing platforms, for example (Uber, Lyft, Sidecar), give vehicle owners an opportunity to monetize an underutilized asset they own -- seat space in their cars -- while giving others an opportunity to get rides. Ride sharing platforms change the vehicle purchase calculus, at the margin affecting the decision of when to buy a new car, how nice a new car to buy, and how many hours to spend on the platform and available to give rides.

Note that the availability of these potential decentralized transactions may also serve the insurance role, because an interconnected DER owner could transact with another DER owner in the case of an individual system problem. In that case exchange enables DER owners to insure each other mutually, and the beneficial role of the distribution platform is facilitating the data and current connection, for which the distribution company earns a (per kWh) wires charge.

The potential benefits arising from exchange are the biggest reason for the distribution business model to be a platform, which lends itself naturally to providing the data and physical interconnection required for exchange. The mission of the firm evolves from providing reliable commodity electric service to all end users in geographical territory to facilitating their mutually-beneficial connections. Those connections are not necessarily only transactions, but most likely to be transactions. Thus a distribution platform company would provide market platforms for energy products, would provide standard terms and definitions (e.g., time-delimited, green-grey, ancillary services).

Everything else is done by agents operating around the edges of the platform. That includes wholesale markets that are upstream from the platform, but most importantly includes independent retailers who are energy service providers. The technologies enable them to offer energy services that are as customized or as generic as individual consumers prefer, as automated or manual as they prefer, bundled with other services or not as they prefer.

The burgeoning residential solar market is an example of the kind of market that can grow at the edge of such a platform (Kiesling & Silberg 2015). The residential solar market has grown substantially over the past decade, through a combination of technology, market, and policy drivers. Three-quarters of U.S. utility, commercial, and residential-scale PV systems went online between 2011 and the first half of 2013 (GTM Research 2013). Installed cost of distributed photovoltaics fell 44% between 2009 and 2014, with distributed solar installations comprising 31% of all electric power installations completed in 2013; in that same year, overall residential solar PV capacity increased 68% across the nation. California led this growth with a 161% increase in 2013 (Sherwood 2014). The residential solar market is showing how it can be competitive without vertical integration, and its growth would be facilitated by its technological and economic location at the edge of a distribution network with transparent, autonomous interconnection and competitive retail electricity markets.

Implications for utility business models and regulatory models – a platform-mediated network, and the compatible regulatory institutions that enable resiliency, value creation, flexibility, investment, innovation – retail competition, low entry barriers, technology-agnostic performance-based environmental policy

Unlike a traditional wires-only business model, a platform model emphasizes the role of the firm as an intermediary facilitating the interactions of agents in the network. A platform model does imply some technological differences in the distribution network compared to the traditional distribution grid architecture. The architecture of the distribution grid is designed for one-way current flow, from generator to end user. In a technological context with few large-scale generators and many users, one-way flow was a cost-effective architecture choice. But smart grid and distributed resource technologies have the potential to enable smaller-scale generation and distribution throughout the network, and to enable small-scale transactions between distributed agents, which would require a network capable of two-way current flow. Digital sensors and other distribution automation technologies allow for more transparent monitoring and balancing of two-way flows in a distribution network, but the distribution grid as currently built, configured, and operated cannot provide the central backbone for a platform utility; thus moving to a platform model

C. Challenges for proposed model (INCOMPLETE)

1. Risk and physical reliability
2. Financial risk
3. Cybersecurity and privacy
4. Political economy -- status quo bias, incumbent bias, transitional gains trap, even as a platform the firm has an incentive to expand its footprint

Challenge: should P2P wires be legal? Say, connecting neighbors? First priority should be public safety. As P2P wires become safer, and that will happen, that's when the value of the central backbone starts to erode. But that's likely to be a slow process. The regulatory emphasis here should be attentiveness to the pace and direction of technological change, and setting in place public safety policies that have to be renewed regularly so that they don't become maladaptive and stifle beneficial change as technologies and ecosystems evolve.

V. Conclusion

Digital innovations, largely exogenous to the electricity industry, have created the opportunity to apply digital innovation within the industry itself. These smart grid technologies encompass sensing, monitoring, and automation technologies embedded in the wires network as well as end-use devices that consumers can use to automate changes in their electricity consumption in response to price changes (transactive response) or other triggers. This distributed digital capability for decentralized, autonomous response also makes the electric power network more of a complex adaptive system – more adaptive in the sense that by programming their preferences and actions into digital devices, decentralized, autonomous response enables individual agents to create feedback effects that will largely be negative and equilibrating in nature.

Smart grid technologies and the increasingly decentralized capabilities of a physical and digital smart grid network also change the nature of the types of actions, interactions, relationships, and organizations that are possible in the electric system. Types of generation technologies become more heterogeneous, both in fuel type and in scale, and can be situated differently in the network. Types of consumption can become more heterogeneous too. Agents in the network are no longer only generators, consumers, or transporters (i.e. wires owners) – specifically, agents can now be both generators and consumers due to electric vehicles. Economic agents can take on multiple roles where before each agent had only one role. By changing what role agents could take, the scales at which they can operate, and the knowledge that is now accessible at the edge of the network, digital technologies change the role that the distribution utility can play in the system. It thus changes both the possible utility business models and regulatory institutions.

Three related literatures inform this analysis of a distribution platform model. The transactions cost theory of the firm and of vertical integration suggests that smart grid technologies will have substantial implications for the role, scope, and nature of the electricity distribution company of the future. We analyze these regulatory institutions and business models using a more dynamic theory of competition grounded in experimentation and emergent social learning, and building on the NIE and entrepreneurship literatures. We use that theory to examine platform-based proposals for regulatory and business models, and incorporate into the analysis the development of residential rooftop solar power markets in key US states. By emphasizing experimentation and the role that institutions play in the technological change process, this paper draws on new institutional economics to provide a new analysis of innovation processes in a capital-intensive historically regulated infrastructure industry.

Shift in the value of network connection from distribution utility providing value as a vertically-integrated electricity generator, distributor, and retailer, to the distribution utility providing value as an intermediating platform as a distributor and market platform provider.

Enabling a distribution platform business model will required the evolution of the regulatory compact from "electric service to all who request it in the utility's geographic service territory, earning the utility a normal rate of return from averaged rates" to "facilitating interconnection and transactions among all who request it in the utility's geographic service territory, earning the utility a normal rate of return".

One critique of retail regulation is its inability to adapt to unknown and changing conditions (Kiesling 2008). Because regulation stipulates product definitions, product quality, and market boundaries, it rigidifies processes that are usually dynamic and fluid in other markets. Regulation erects legal entry barriers into the distribution and (in many places) retail sale of electricity to residential customers, so it entrenches the historical vertically integrated organizational structure of the regulated firm, despite the very real possibility that innovation has changed the transactional boundary of the firm. In this sense the utility business structure is a regulatory construct. Traditional electricity regulation is static and formulaic, as befits a set of institutions designed to foster infrastructure investment in specific technologies with an objective of universal service at lowest financial cost. Procedural protections, such as the process of pursuing rate cases and rule changes allowing time for public comment (Administrative Procedure Act), increase the transparency of regulation in striving for this objective while also providing some bulwark against the public choice dynamic of concentrated interests being able to control processes and determine outcomes. These procedural protections mean that change happens slowly, which has its benefits because these investments are costly and long-lived, so prudence is a high-priority virtue. Prudence is also a virtue here because regulators are acting as agents, custodians, stewards of ratepayer resources. They are not making investment decisions using and risking their own capital alone.

Regulation's opportunity cost is the foregone alternative value propositions that entrepreneurs would create and consumers would try if the retail market were not constrained.

The technological dynamism of the 21st century is a broad expansion of general-purpose technologies with powerful decentralizing forces. These forces are changing what people see as valuable and how they achieve what they want to in their lives. One thing they are changing is the opportunity cost of electricity regulation. When few alternatives exist to the electro-mechanical distribution grid and standard commodity electricity service, that opportunity cost of regulation is relatively low. As digital and distributed energy technologies have evolved, more alternatives are available or could be available through entrepreneurial action. Consumers could prefer those alternatives, if they had opportunities to experiment with, say, in-home transactive devices that could automate appliance responses to electricity price changes, or a retailer bundling home energy management with home security, or residential rooftop solar. But the only way producers have incentives to create and consumers to try is through their mutually beneficial interactions in markets.

References

Armstrong, Mark. 2006. “Competition in Two-Sided Markets,” Rand Journal of Economics 37(3): 668-691.

Baker, George, Robert Gibbons, and Kevin Murphy. 2002. “Relational Contracts and the Theory of the Firm.” Quarterly Journal of Economics 117: 39-84.

Bajari, Patrick, and Steven Tadelis. 2001. “Incentives Versus Transaction Costs: A Theory of Procurement Contracts.” Rand Journal of Economics 32: 387-407.

Baldwin, Carliss Y., & C. Jason Woodard. 2009. “The architecture of platforms: a unified view.” In Annabelle Gawer, ed., Platforms, Markets and Innovation. London: Edward Elgar.

Bandura, Albert. 2002. “Growing primacy of human agency in adaptation and change in the electronic era,” *European Psychologist*, 7(1), 2-16.

Barclay’s Credit Research. 2014. The Solar Vortex: Credit Implications of Electric Grid Defection.

Bresnahan, Timothy, and Jonathan Levin. 2012. “Vertical Integration and Market Structure,” NBER Working Paper 17889,

Coase, Ronald. 1937. “The Nature of the Firm.” Economica 4: 386-405.

Edison Electric Institute. 2013. Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business.

Electric Power Research Institute. 2014. The Integrated Grid.

Gawer, Annabelle. 2014. “Bridging different perspectives on technological platforms: Toward an integrative framework,” Research Policy 43: 1239-1249.

Gawer, Annabelle, and Rebecca Henderson. 2007. “Platform Owner Entry and Innovation in Complementary Markets: Evidence from Intel,” Journal of Economics & Management Strategy 16(1): 1-34

Greenstein, Shane. 2008. Economic Experiments and Industry Know-How in Internet Access Markets. In Innovation, Policy, and the Economy, vol. 8, edited by Adam Jaffe, Josh Lerner, and Scott Stern, 59-109. Chicago: University of Chicago Press.

—. 2012. Economic Experiments and the Development of Wi-Fi. Advances in Strategic Management 29: 3–33.

GTM Research. "US Solar Power Growth." Cost of Solar. 2013. http://costofsolar.com/management/uploads/2013/10/US-solar-power-growth.jpg (accessed January 1, 2015).

Joskow, Paul. 1988. “Asset Specificity and the Structure of Vertical Relationships: Empirical Evidence”, Journal of Law, Economics and Organization, 4: 95-117

Kiesling, Lynne. 2008. *Deregulation, Innovation, and Market Liberalization: Electricity Restructuring in a Constantly Evolving Environment*. London: Routledge.

Kiesling, Lynne. 2014. “Incumbent Vertical Market Power, Experimentation, and Institutional Design in a Deregulating Electricity Industry.” Independent Review 19(2): 239-264.

Kiesling, Lynne. 2015. “Implications of Smart Grid Innovation for Organizational Models in Electricity Distribution.” Wiley Handbook of Smart Grid Development. Forthcoming.

Kiesling, Lynne. 2015b. “Knowledge Problem.” *Oxford Handbook of Austrian Economics*, P. Boettke and C. Coyne, eds. Oxford: Oxford University Press.

Kiesling, Lynne, and Mark Silberg. 2015. "Regulation, Innovation, and Experimentation: The Case of Residential Rooftop Solar,” Journal of the Wealth and Well-Being of Nations, forthcoming.

Kirzner, Israel. 2009. The Alert and Creative Entrepreneur: A Clarification. Small Business Economics 32, no. 2 (February): 145–52.

Klein, Benjamin, Robert Crawford, and Armen Alchian. 1978. “Vertical Integration, Appropriable Rents, and the Competitive Contracting Process.” Journal of Law and Economics 21: 297-326.

McKinsey Global Institute. 2011. Internet Matters: The Net’s Sweeping Impact on Jobs, Growth, and Prosperity.

Panzar, John, and Robert Willig. 1981. "Economies of Scope." American Economic Review 71(2): 268-272.

Rochet, Jean-Charles, and Jean Tirole. 2003. “Platform Competition in Two-Sided Markets,” Journal of the European Economic Association 1(4): 990-1029.

Rocky Mountain Institute. 2014. The Economics of Grid Defection: When and Where Distributed Solar Generation Competes with Traditional Utility Service.

Rogers, Everett. 1962. Diffusion of Innovations. New York: Free Press.

Rysman, Marc. 2009. “The Economics of Two-Sided Markets,” Journal of Economic Perspectives 23(3): 125-143

Schelling, Thomas. 1960. The Strategy of Conflict. Cambridge, Mass.: Harvard University Press.

Schumpeter, Joseph. 1934. The Theory of Economic Development. Cambridge, Mass.: Harvard University Press.

—. 1942. Capitalism, Socialism, and Democracy. New York: Harper Collins.

Sherwood, Larry. 2014. U.S. Solar Market Trends 2013. Interstate Renewable Energy Council.

Tabors, Richard, Geoffrey Parker, Paul Centolella, and Michael Caramanis. 2016. White Paper on Developing Competitive Electricity Markets and Pricing Structures. Boston, MA. Tabors Caramanis Rudkevich, Inc. Prepared under contract for the New York State Energy Research and Development Authority.