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Technology and the Architecture of Emergent Orders

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"Many kinds of economic planning are indeed practicable only if the planning authority can effectively shut out all extraneous influences; the result of such planning is therefore inevitably the piling-up of restrictions on the movements of men and goods."
-F.A. Hayek, *Road to Serfdom* (1994[1944]), p. 240

Introduction

Spontaneous or emergent orders in human affairs are based on voluntary interaction between individuals. This voluntary interaction fuels the market dynamism that fosters new technologies, products, and ideas. Ideally, the interactions should be afforded the widest scope possible in order to produce unpredictable and unforeseeable results. The architecture of the built environment, however, shapes and directs these interactions. While an emergent order cannot be planned, the physical infrastructure can affect the direction of its evolution. In the limiting case, some scholars argue that artifacts and technology are political, given their influence on our lives and society (Winner 1986).

Even if we do not wish to politicize technology, we can certainly recognize how many inventions have shaped society and potentially altered the balance between the private and government spheres. The public goods argument for government assumes that voluntary cooperation is insufficient to overcome free riding and provide an adequate supply of public goods. The private supply of public goods will depend on technology for organizing groups, what Cowen and Sutter (1999) call cooperative efficacy. Technological improvements which increase cooperative efficacy will result in citizens choosing voluntary supply over government provision for more public goods.

For example, technologies such as social networking sites, charitable websites, e-payment websites, and even mobile banking have fundamentally transformed charitable donations, especially in the wake of natural disasters. By lowering the cost of information sharing and transferring money around the world, these technologies have bolstered the ability of private sector agencies and actors to respond to natural disasters – perhaps even weakening the argument for government responses.

The automobile illustrates the interaction between technology and infrastructure and the consequent effects on society. Relative to rail, cars afford greater freedom but also drive Tiebout competition between local governments. Routes and schedules for a train and subway system could be set to prevent residents from moving out of a central city. The emergence of the automobile was driven by entrepreneurial innovations (improved gas-powered engines, mass production), but the pre-existing architecture still shapes the balance between government and market today. The high transactions costs involved with physical toll collection have largely prevented competitive market supply of the road network. With the road and highway system under government ownership, electronic toll collection, a potentially radical technology, is being developed primarily to charge tolls on the government run system, not to lead to a greater private supply of the infrastructure.

At a macro level, the contours of physical systems and infrastructure can affect the level and even the type of interactions that occur between individuals. While the architecture does not control the particular arrangements which emerge, walls can certainly prevent or hamper interaction and growth in particular areas. An everyday example is how the layout of a workplace influences interactions and conversations between coworkers, and consequently productivity and economic discovery. The dynamism of cities extolled by Jane Jacobs also illustrates the close connection between physical infrastructure and spontaneous order.

Due to the inherent nature of spontaneous orders, the path that will emerge due to the architecture of a barrier will be unpredictable and may be worse than the path without the barrier. For example, prohibition of alcohol in the U.S. led to black market provision by gangsters and bootleggers. Prohibition resulted in a far more dangerous product due to the lack of consistency and traditional reputational mechanisms, and increased violence as a substitute for traditional avenues of contract dispute resolution (Miron 1999). Widespread recognition of the significant problems led to prohibition's repeal only a decade later. This contrasts with the prohibition of marijuana, which is widely perceived among economists to have the same consequences as alcohol prohibition (Miron and Zwiebel 1995). In another example, the path dependency of decisions made about allocating the electromagnetic spectrum in the 1920s for radio and 1940s for television continue to affect the use of the spectrum today.

New technologies can fundamentally restructure the existing architecture and barriers, for instance, by opening the door to entry by new competitors. This would be an extreme form of Schumpeter's creative destruction, where the structure within which the nexus of voluntary interactions takes place is destroyed, making way for a hopefully improved nexus. New technology, however, must be developed by firms or bureaucracies with their own stake in the existing order, and these organizations will resist fundamental restructuring of the existing order. Thus organizations may attempt to maintain the status quo architecture and prevent new technology from transforming the spontaneous order and upsetting the current balance of economic and political power. The formation of industry interest groups may help explain why drug prohibition continues (Gray 2001). Sometimes these attempts are successful and sometimes they fail.

This paper examines several cases of new technologies with the potential to fundamentally restructure the existing order. We examine the features of the technology, existing infrastructure, and the barriers erected to restrict the new technology to better understand when new technologies succeed in impacting and altering the architectural structure. Section 2 theoretically explores how existing architectural designs and current architectures can affect emergent orders. Section 3, the heart of the paper, uses case studies to explore the ability of technology to reshape existing architecture and the extent to which incumbent organizations can prevent or redirect technology to sustain the current architecture. Section 4 draws conclusions from the case studies, arguing that to a large degree the ability of a new technology to reshape the underlying architecture depends on the political clout of the architectures of the current order. Section 5 concludes.

Existing Architecture and Emergent Orders

Infrastructure of Spontaneous Orders. Postrel (1999) claims that policies directed to enforce stability and control pose the most important challenge to markets today. The argument for government control has transformed from socialist central planning to more subtle redirections of market forces, "[t]he role of the state, in this view, therefore, is not so much to reallocate wealth as it is to curb, direct, or end unpredictable market evolution."

We live in a bottom-up world of human ingenuity and spontaneous order (Alchian 1950, Dawkins 2009[1976], Hayek 1980[1948], 1991[1988], Lansing 1991, Ridley 1996, Sowell 1980, Smith 2009). The particular manifestations of the spontaneous order, while entirely unpredictable, can be shaped, channeled, and sometimes limited by a physical infrastructure. How this infrastructure limits the growth of spontaneous orders, and in particular, the potential for new technologies, is the aim of this paper. The stifling of emergent technology or redirection into less radical forms can significantly undermine economic growth. It can also perpetuate the reliance on top-down orders while new technology could potentially permit a more decentralized order.

Infrastructure designers might curtail or restrain emergent technologies for several reasons. Since the bottom-up orders threaten the very contours of the current foundations, they also threaten the current balance of political and economic power. Elites can capture political institutions in order to ensure the architecture of economic institutions favor the elites (Acemoglu and Robinson 2008). Political architectures themselves may be vested in maintaining the current architectural design in order to maintain their position of privilege or political control as well.

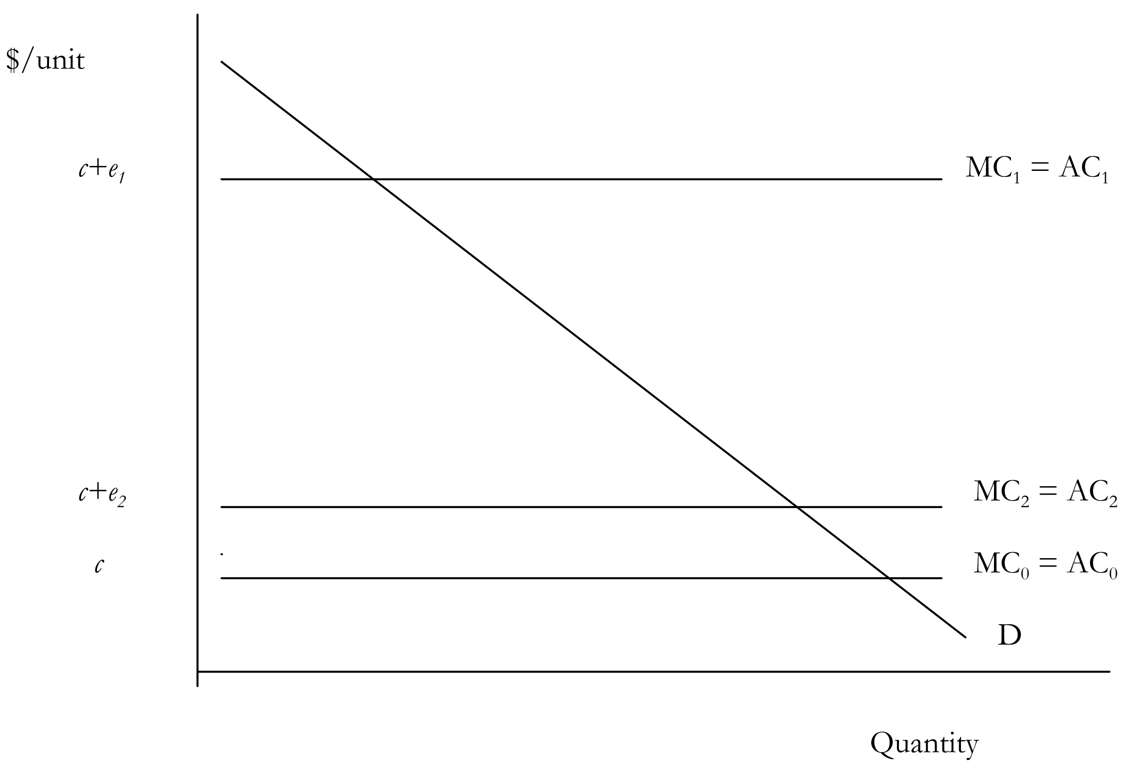
The Nature of Potentially Transformative Technologies. Technology determines the shape of cost curves and how goods and services can be most efficiently provided. Not only can new technology reduce costs, it can also change the efficient manner of supplying a good. We will refer to such new technologies as transformative, or potentially transformative, to allow for the possibility that the technology may not actually transform the existing order. Organizations within the existing order will want to preserve their role and resist change. Existing organizations try to block restructuring directly, but even anticipation of such resistance can eliminate the incentive to develop new technologies in their full transformative potential.

We offer a concrete example to illustrate the dilemma of potentially transformative technologies. Goldin (1977) argued that many goods and services can be provided through either selective access or open access, that is, with the potential to exclude nonpaying customers or not. Goldin then argued that excludability, one of the defining characteristics of public goods, is not an inherent feature of a good itself, but rather a product of the choice of institutions for provision. Goldin's institutional perspective implies that the efficient institution for providing a good depends on the cost of exclusion and that the optimal institutions for delivery could change if technology changes (Sutter 1996). We use the cost of exclusion to illustrate a transformative technology.

Figure 1 displays cost curves reflecting the role of the cost of exclusion in the choice between open access and selective access. The product can be produced in a form which does not allow exclusion at a constant per unit cost of c reflected by MC_0 *and* AC_0. This we might think of as say an automobile without locks. With no means of excluding nonpayers, the good cannot be marketed by for-profit firms. Some type of exclusion technology must be added to market the product. Initially exclusion might be very costly relative to the cost of production, with a constant per unit cost of e_1, resulting in a total cost of $c + e_1$, and cost curves MC_1 and AC_1. This good could be competitively supplied by the market at a price of $c + e_1$. The high cost of excluding nonpayers, however, implies that consumers may prefer provision of this good through open access with the per unit production cost of just *c*. This might be accomplished by establishing a tax-funded government enterprise.

Consider how this market might change if new technology reduces the cost of exclusion to a constant per unit e_2, with cost curves MC_2 and AC_2. Competitive supply at a price of $c + e_2$ might now be preferred to open access provision at *c*, since open access government provision would entail other costs, including the excess burden of taxes to pay for government provision. The reduction in the cost of exclusion from e_1 to e_2 would be an example of a

Figure 1: The Cost of Exclusion Between Open Access and Selective Access



transformative technology, since new technology changes the efficient delivery of this good.

We have used the case of selective access to illustrate a potentially transformative technology, but technology could affect the boundaries of the private and public sectors or the organization of an industry in other ways. Natural monopoly industries involve a declining long run average cost curve and thus some type of fixed or first unit cost of production. Significant economies of scale typically lead to public utilities regulation, while a transformative technology here could reduce the first unit cost and make unregulated competition a possibility. Centralized production or distribution can also lead to potential monopoly power. Thus the potential for transformative technologies of various sorts may emerge in many different areas of an economy.

The Transformative Technology Investment Dilemma. The feasibility of new technology to allow provision through selective access or distributed production does not imply that the technology will ever be developed or institutional change will occur. The potential market for transformative technologies could be very thin. A single purchaser for a new technology creates the potential for opportunistic behavior on the part of the purchaser, as research will essentially be a firm-specific investment. Opportunism does not capture the full dimension of potential difficulty in marketing a transformative technology. The bureaucracy or firm currently supplying the good and benefiting from the architecture of the current infrastructure will want to protect the status quo. Bureaucrats use asymmetric information to maximize their budgets (Niskanen 1971), so entrepreneurs cannot rationally anticipate bureaucrats will purchase a technology that will put their bureaus out of business. The incumbent organization could also legally restrict deployment of a new product. For years, the Bell system successfully maintained a monopoly on phone equipment in addition to control of the phone lines. An inability to market their new product if the development succeeds makes entrepreneurs less likely to undertake research and development. The prospect of lengthy delay and consequent uncertainty also reduces the economic value of investment in potentially transformative technologies.

The development of Doppler weather radar in the United States provides an example of a type of development dilemma for innovative technology. By the early 1980s research to adapt the military's Doppler radar technology for weather observation and forecasting was complete and Enterprise Electronics had a Doppler radar already in use by several television stations across the U. S. (Smith 2010, Henson 2010). The National Weather Service and the National Oceanic and Atmospheric Administration decided not to purchase Doppler weather radars from Enterprise and instead initiated a bidding process for custom radars eventually won by Unisys, although with product not substantially different than the Enterprise radars (Smith 2010). The innovator did not secure the primary market for the product and deployment of Doppler weather radars by the National Weather Service was delayed by about a decade. Military procurement provides numerous additional examples of the risk involved with product development for a single purchaser.

The prospect of delay could also lead innovators to sell or license promising technologies to the incumbent organization, which could then develop the technology in a way that merely complements as opposed to transforms the market. The incumbent organization could also be a significant source of research funding in the field (e.g., the U.S. Department of Transportation for highways) and choose not to fund research proposals threatening to push development in transformative directions.

New Technologies and the Existing Order

New technologies have the ability to fundamentally restructure, influence, or even obviate existing orders. In this section, we look at several emergent technologies to examine their effect on the existing order.

Cell Phones and the Telephone Monopoly. Wireless telephones and other personal communications devices represent a case where technology has transformed the architecture of an industry. The network of landlines established in the early 20th Century formed the physical foundation of AT&T's domination of telephone service for decades. AT&T was one of the largest and most powerful companies in the U.S. in the mid-Twentieth century, and thus enjoyed a favorable position to prevent the emergence of a transformative technology. But deregulation and competition came to the long distance segment of the industry following the settlement of the Justice Department's anti-trust suit with AT&T in 1981. This long distance competition only built on the local telephone infrastructure controlled by the regulated regional Bell operating companies, though, and did not transform the industry.

Cellular or wireless telephone technology represented a radically different architecture of the market, and one far more amenable to competition. An infrastructure based on cell towers allows for competing carriers to be regulated by market, rather than political, forces. The transformation of local telephone service has truly been a case of creative destruction in a short period of time. Baumol and Sidak (1994) included wireless as but one of seven routes to competition in local telephone service, a competition still overseen by regulators, due to the necessity of using the landline network. The pace of change rendered Baumol and Sidak's forward-thinking examination hopelessly outdated in less than a decade. The number of wireless subscribers in the U. S. increased from 34 million at the end of 1995 to over 300 million today, a total nearly equal to the U. S. population.[1] More significantly, although initially seen as a complement to landlines, wireless service often substitutes for traditional phone service; by the end of 2010 an estimated 26% of U. S. households were wireless-only. The wireless infrastructure has allowed a tremendous array of new products and services in addition to competitive phone service, as illustrated by the more than two trillion text messages sent in 2010 in the U. S. Another remarkable element of the transformation is the substantial investment in cell towers, which increased from fewer than 25,000 in the U. S. in 1995 to over 250,000 fifteen years later. The investment in cell towers contrasts with the limited expansion of capacity in electric power or highway infrastructure.[2]

Generation and Distribution of Electricity. The electric power grid represents perhaps the best example of a physical infrastructure shaping the architecture of an industry. Power grids allowed exploitation of economies of scale in electricity generation, combined with an inability (at the time) to transmit electricity long distances. The infrastructure, once-established, creates a second source of declining average cost: connecting another customer to the grid is much cheaper than constructing a duplicate grid. Declining long run average cost creates the tendency toward natural monopoly and the political demand for public utilities regulation. The decision to supply electricity through a centralized grid creates a need for government ownership or regulation. Population growth, increases in the demand for electricity, and the ability to transmit power longer distances have exhausted the economies of scale in generation. Yet the power grid persists, and will continue to for the foreseeable future, with the concomitant political regulation.

The power grid is not amenable to a spontaneous market process. The supply of power to the grid must meet or exceed the load on a minute-by-minute basis, with usage not limited to the contracted supply. The potential for fluctuation in usage creates the need for spinning reserve, and given the collective nature of the grid, any customer's failure to ensure sufficient generation to cover their usage creates the potential for a blackout. In addition, the configuration of transmission and distribution lines can create bottlenecks on the grid and the need to operate certain power plants. The grid is an architecture designed for open access by users with management by electrical engineers (or central planners) based on technical as opposed to market forces. The creation of true markets has proven difficult with an infrastructure designed for central planning by engineers and regulators.

The existing infrastructure has created organizations with a vested interest in maintaining the status quo. And this may have affected the design and adoption to date of alternative sources of energy. Alternative energy sources, particularly wind, solar, and geo-thermal power, can be generated in a distributed fashion, in contrast with large generating plants. Distributed generation can allow users to reduce their reliance on, and even possibly disconnect from, the electric grid, reducing the need for centralized supply and distribution guided by regulators. Yet wind power has been developed primarily through large turbines located in wind farms and connected to the grid – that is, in a way which does not transform the industry. The beneficiaries of the existing architecture, the electric grid operators and regulators, have resisted alternative energy that would allow households to disconnect from the power grid.[3]

Electronic Tolling and Highways. Streets, highways, and bridges are rival goods with a high cost of excluding non-payers. While toll roads have offered a mechanism for voluntary supply of highways for centuries (Klein 1990, Benson 1994), the cost of collecting tolls and the potential for toll evasion could easily result in consumers preferring government provision with free access and possible congestion to private toll roads. Electronic toll collection (ETC) can reduce the cost of exclusion sufficiently to make supply of roads by private companies economically feasible, and represents a potentially transformative technology.

Yet ETC is unlikely to be deployed in a transformative manner. The concept and technology for ETC are hardly new; Nobel Prize winning economist William Vickery first suggested using electronic transponders to collect tolls in 1959, and the technology was developed in rudimentary form in the 1970s. In 1981 an ETC system was implemented on the Golden Gate Bridge in California, and ETC has since been widely adopted for existing toll bridges and roads throughout the U. S. and the world. In addition, ETC has allowed for the construction of a number of recent privately financed highway construction projects like California's SR-91 project in Riverside County (Sullivan 2006).

ETC certainly has transformed the collection of tolls for existing toll roads and toll bridges. Although these highways and bridges are generally operated by nonprofit authorities, several factors seem to explain the diffusion of ETC. First, ETC can reduce the cost involved with collecting tolls, as road systems can significantly reduce the need for human toll workers. Second, ETC also enhances data collection from and about users, allowing road operators to improve service and increase revenues. Third, ETC offers substantial benefits to users in terms of reduced travel time, reduced congestion at toll plazas, and improved safety.

Most discussions of the further development of ETC involve it as a means of introducing congestion tolls for the current system of government roads. Development of the technology in this fashion would fail to transform the road system to allow operation by for-profit companies. Electronic tolling seems to be a technology which is being shaped by the beneficiaries of the existing infrastructure to augment rather than transform highway transportation.

Electronic Voting and Democracy. Historically, democracy has relied on representatives who periodically faced voters to craft and vote on legislation for their constituents. Experiments with direct democracy have been attempted to varying degrees around the world and at varying times, with the Swiss cantons as the most studied contemporary example (Frey 1994). Historically, even pirate crews used direct democracy to elect captains (Leeson 2009, Ch. 2). While the ballot initiative is a prominent current form of direct democracy, it only augments representative democracy due to the cost of collecting petition signatures. Electronic voting, though, has the capacity to transform the practice of democracy.

Political scientists and public choice economists have found that direct democracy often improves outcomes (Matsusaka 2005a). Swiss cantons using direct democracy to a greater extent have slower government growth (Feld and Matsusaka 2003, Pommerehne 1978, Pommerehne and Schneider 1982) and more politically informed (Feld and Kirchgassner 2000) and happier (Frey and Stutzer 2000) residents than cantons using representative democracy more extensively. Santerre (1986, 1989) finds lower spending in Connecticut suburbs with direct democracy.[4]

Direct democracy is by no means a panacea. James Madison argued in Federalist No. 10 that democracy leads to a 'tyranny of the majority' problem in which the majority will run roughshod over the rights of minority groups and individuals. Evidence on a majority's exploitation of minorities under direct democracy is mixed. Gamble (1997) finds supportive evidence from state and local civil rights ballot propositions in the U. S. (see also Haider-Markel, Querze, and Lindaman 2007), while Frey and Goette find that direct democracy in Switzerland effectively protects civil liberties. Donovan and Bowler (1998) argue that the tyranny of the majority problem is "not simply a function of direct democracy, but of the scale over which democracy is practiced."[5] They conclude that "…either representative or direct democracy can operate to translate tolerance (or hostility) of minorities into policy" (see also Hajnal, Gerber, and Louch 2002).

Technological advances create the potential to implement direct democracy through e-voting in a cost effective, secure, and confidential fashion. Using experiments in e-voting are under way around the world, Buchsbaum (2004) lays out several lessons that have already been learned. The practice of e-voting has been examined both in Estonia (Maaten 2004) and Spain (Riera and Cervello 2004), and has been found to increase voting (Zizziz and Lekkas 2011) and youth participation in democracy (Maidou and

Polatoglou 2004).

Electronically voting could result in substantial cost savings relative to in-person or absentee mail voting. The Election Administration Commission (EAC) estimates that the average state spends $33 million on education on voting procedures and $173 million maintaining computerized voter registrations and publicly displaying instructions on how to vote. These totals do not include the time cost of in person voting, the cost of ballots and voting stations, or the increased risk of driving fatalities and accidents on election days (Redelmeier 2008). Thus, e-voting appears more cost-effective and certainly no less secure than alternative voting mechanisms currently being used and under consideration.

Holding the elections of representative democracy or today's ballot initiatives electronically would not capture the full transformative potential of the technology. The frequency of elections could be increased, reducing the bundling of issues involved in a vote for representatives every two years (or less frequently). Citizens could approve legislation drafted by representatives, instead of relying on legislators to vote in their stead. Indeed, e-voting would treat some of the most detrimental maladies of democracy identified by public choice economists. Rent-seeking by special interest groups would be significantly diminished, if not eliminated in a direct democracy (Buchanan and Tullock 1999[1962]). The growth of government, largely attributable to special interest groups in representative democracy (Mueller and Murrell 1986, Peltzman 1980), could be restrained as well. Nonetheless e-voting seems unlikely to reshape representative democracy in the near future, due to a conflict of interest. Incumbent politicians and bureaucrats, the persons in charge of the current architecture, stand to lose power and resources with greater reliance on direct democracy.

Preserving the Existent Order with Political Clout

Our case studies demonstrate that in some instances transformative technologies have been deployed, while in other cases the technology has failed to drastically restructure the spontaneous order. What patterns or lessons emerge from these cases? The new technology has often been developed by companies independent of the organizations vested in the status quo architecture. For instance, several private companies developed and marketed technology (and data collection and management services) for toll roads and bridges, as opposed to government agencies with control over the roads and bridges. The organizations in charge of the infrastructure have not led the development of the transformative technologies, as might be expected given their interest in preserving the status quo.

And yet the disinterest of the designers has not prevented development of these technologies, even in the case of ETC where the technology seems unlikely to be used in its truly transformative potential. Another key factor is the existence of independent customers to use the technology – operators of existing toll roads and bridges, commercial television stations, or consumers of mobile phones. These independent customers have provided enough of a market to sustain innovation, even if this market is modest relative to the potential if the technology truly transformed the emergent order. Also, in the case of cellular phones (and cable television, not examined here), the technology was initially seen as supplementing, not replacing, the existing architecture, and so a failure to appreciate the transformative nature of the technology probably facilitated innovation.

The use of an auction for bandwidth in the electromagnetic spectrum by the Federal Communications Commission beginning in the 1990s also helped cell phones. The auction process made available the bandwidth needed to build an alternative to the landline system. The auctions probably also provided leverage against later efforts to halt the development of wireless technologies, as the payments in the initial auctions, and prospect of revenues from future auctions, committed the FCC to the development of wireless technology. And the emergence of millions of loyal users of wireless devices created a political constituency to support their continued development.

Conclusion

Potentially transformative technologies create numerous tensions. Inventors and firms trying to commercially develop potentially transformative technologies must estimate the market for their product, recognizing that the beneficiaries of the existing infrastructure will want to preserve the status quo. Thus one set of tensions will involve the funding of research and development of transformative technologies. Will potentially transformative technologies even be developed in fields where there exists substantial resistance to architectural restructuring? Transformative technologies can potentially be introduced from outside of an order (or industry), and thus will often involve interactions across markets or orders. These are often the technologies that are successful in overcoming incumbent beneficiaries of the existing infrastructure.

The elites who benefit from the status quo can use their positions of authority to attempt to block or shape transformative technologies to preserve the current infrastructure. These efforts can prevent not only the transformative technology, but the subsequent evolution of this technology and spillover effects into other arenas. Understanding how these political influences can and do affect emergent orders is essential. The architecture of infrastructure necessarily shapes the discovery process. But the administration of such physical systems should have limited ability to prevent the development of technology to reshape the contours of the built environment.

We have examined several cases of infrastructure and potentially transformative technologies in this paper, but these cases are hardly exhaustive. Other cases could be explored in future research. Peer-to-peer file sharing and strong encryption technologies would provide interesting extensions of the cases examined here. In each case the technologies have faced strong opposition and even attacks from entrenched elites, like the music industry. Nonetheless, technology continues to develop despite the obvious risks involved. History also provides examples of technologies that overcame vested interests, and presumably more obscure examples of innovations that never were.

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Notes

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[1] The statistics in this paragraph are from http://www.ctia.org/advocacy/research/index.cfm/aid/10323.

[2] Perhaps an even more interesting phenomena, outside the scope of this paper, is how cell phone technology in developing nations, along with mobile banking, have leap-frogged traditional landlines and brick and mortar banking, which are often government-controlled.

[3] This conclusion is subject to a number of qualifications, namely that the economic viability of either distributed or centralized wind power in the absence of generous government tax credits is not certain, nor is the potential for distributed wind power to be efficient relative to wind farms.

[4] For more evidence on direct versus representative democracy also see Besley and Case (2003), Matsusaka (2004, 2005b, 2007), Gerber (1999), and Olken (2010). There are contrarian views.

Farnham (1990) finds no difference between direct democracy and representative democracy using a national sample of 735 U.S. communities using different measures. Megdal (1983) fails to find any evidence that referendums have an influence on public expenditures looking at New Jersey school districts. This may be because the choice of local government form may be endogenous (Fahy 1998; Saas 1991). Bozzo and Irvine (2010) summarizes many of the critiques of referendums. A major critique is that referendums allow for the possibility that poorly written laws, with severe unintended consequences may be passed. Bozzo and Irvine (2010) also argues that referendums eliminate deliberation over the specific wording of a bill, decreasing the chance for compromise and potentially harming minority groups. Another issue is that most ballot-initiatives increase spending, yet few that mandate tax increases pass. For other contrarian views see Schacter (1995), Staszewski (2003), and Clark (1998).

[5] Haider-Markel, Querze, and Lindaman (2007) do not find evidence to support this argument.

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