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# Infrastructure

THE SOCIAL VALUE OF SHARED RESOURCES

Brett M. Frischmann

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# 1

## DEFINING INFRASTRUCTURE AND COMMONS MANAGEMENT

INFRASTRUCTURE AND COMMONS are not typically thought to be related to one another. Both concepts have rich histories and varied meaning, and both involve complex phenomena that are the subject of study in various disciplines, including engineering, economics, political science, and law. There is no separate field of infrastructure study or commons study, and there are no settled universal theories or even definitions of infrastructure or commons. This chapter develops the foundation for bringing the concepts together. After a brief introduction to the modern conception of infrastructure and its traditional roots in large-scale, human-made physical resource systems, the chapter discusses a few observations about traditional infrastructure resources, including the important observation that traditional infrastructures are generally “managed as commons.” This sets the stage for a more detailed discussion of “commons management” as a resource management strategy and for the economic analysis that takes place in subsequent chapters.

### A. Infrastructure Resources

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“Infrastructure” generally conjures up the notion of a large-scale physical resource made by humans for public consumption. Standard definitions of infrastructure refer to the

#### 4 Foundations

“underlying framework of a system” or the “underlying foundation” of a system.<sup>1</sup> Familiar examples of “traditional infrastructure” include (1) *transportation systems*, such as highway systems, railway systems, airline systems, and ports; (2) *communication systems*, such as telephone networks and postal services; (3) *governance systems*, such as court systems; and (4) *basic public services and facilities*, such as schools, sewers, and water systems. The list could be expanded considerably, but the point is simply to bring to mind the range of traditional infrastructure resources on which we rely daily.

This book views infrastructure capaciously, emphasizing the functional role of infrastructure. As chapter 4 explains, infrastructure resources are *shared means to many ends*. I deliberately extend the scope of analysis beyond traditional infrastructure categories. Thus, while chapters 9 and 10 examine transportation and communications infrastructures, chapters 11 and 12 examine environmental and intellectual infrastructures. Much like traditional infrastructure resources, these “nontraditional” infrastructure resources enable, frame, and support a wide range of activities in our lives.

Three generalizations about traditional infrastructure help set the stage. First, the government has played and continues to play a significant and widely accepted role in ensuring the provision of many traditional infrastructures. The role of government varies according to the context, community, and infrastructure resource in question. In many contexts, private parties and markets play an increasingly important role in providing many types of traditional infrastructure due to, among other things, a wave of privatization as well as cooperative ventures between industry and government.<sup>2</sup> Nonetheless, the government’s role as provider, subsidizer, coordinator, and/or regulator of traditional infrastructure provision remains intact in most communities in the United States and throughout the world. The reason, which relates to the next two generalizations and to the analysis to come in later chapters, is that “free” markets often fail to meet society’s demand for infrastructure.

Second, traditional infrastructures generally are managed in an openly accessible manner whereby all members of a community who wish to use the resources may do so

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<sup>1</sup> BLACK’S LAW DICTIONARY, “Infrastructure” 784 (1999); WEBSTER’S THIRD NEW INTERNATIONAL DICTIONARY OF THE ENGLISH LANGUAGE UNABRIDGED, “Infrastructure” 1161 (1993); MORRIS & MORRIS 309 (1988) (providing a historical account of how the term’s meaning has evolved). The US National Research Council (NRC) identified a host of “public works infrastructure” along with a more comprehensive notion of infrastructure that included “the operating procedures, management practices, and development policies that interact together with societal demand and the physical world to facilitate” the provision of a range of services, including “the transport of people and goods, provision of water for drinking and a variety of other uses, safe disposal of society’s waste products, provision of energy where it is needed, and transmission of information within and between communities.” NATIONAL RESEARCH COUNCIL 4 n.1 (1987). The NRC recognized three conceptual needs that are central to the project undertaken in this book: first, the need to look beyond physical facilities; second, the need to evaluate infrastructure from a systems perspective; and third, the need to acknowledge and more fully consider the complex dynamics of societal demand.

<sup>2</sup> LEVY 16–17 (1996).

on equal and nondiscriminatory terms.<sup>3</sup> For many infrastructure resources, the relevant “community” is the public at large. “Roads and highways, canals, railroads, the mail, telegraph, and telephone, some owned by public entities, most owned by private corporations, have always been . . . required to interconnect and serve the public on a nondiscriminatory basis.”<sup>4</sup> This does not mean that access is free. We pay tolls to access highways, we buy stamps to send letters, and we pay telephone companies to route our calls across their lines. Users must pay for access to some (though not all) of these resources. Nor does it mean that access to the resource is absolutely unregulated. Transportation of hazardous substances by highway or mail, for example, is heavily regulated. In short, the resource is accessible to all within a community regardless of the identity of the end-user or end-use—that is, without regard to who you are or what you are planning to do. Except for special cases, such as the narrowly defined priority given to a police officer driving with her siren and lights on, access to and use of most infrastructure resources are not prioritized based on such criteria. As discussed below, managing traditional infrastructure in this fashion often makes economic sense.

Third, traditional infrastructures generate significant spillovers (positive externalities)<sup>5</sup> that result in large social gains. As W. Edward Steinmueller observed:

Both traditional and modern uses of the term infrastructure are related to “synergies,” what economists call positive externalities, that are incompletely appropriated by the suppliers of goods and services within an economic system. The traditional idea of infrastructure was derived from the observation that the private gains from the construction and extension of transportation and communication networks, while very large, were also accompanied by additional large social gains.<sup>6</sup>

The economics of traditional infrastructure is quite complex, as reflected perhaps in the fact that economists sometimes refer to infrastructure “opaquely” as “social overhead capital.”<sup>7</sup> There are ongoing, hotly contested debates in economics about the costs and benefits of infrastructure—for example, about the degree to which particular infrastructure investments contribute to social welfare or economic growth, and about how to prioritize infrastructure investments in developing countries. Regardless, most economists recognize that infrastructure resources are important to society precisely because infrastructure resources give rise to large social gains. As chapter 3 explains, the nature of some of the gains as spillovers may explain why we take infrastructure for granted: The

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<sup>3</sup> LESSIG 19–25 (2001b); ROSE 752 (1986); BENKLER 22–23, 47–48 (2001a). See generally Rose 723–49 (1986) (discussing the history of public access rights to various infrastructure resources).

<sup>4</sup> Cooper 14–15 (2005).

<sup>5</sup> On externalities, see chapter 3.

<sup>6</sup> Steinmueller 117 (1996).

<sup>7</sup> Button 148 (1996).

externalities are sufficiently difficult to observe or measure quantitatively, much less capture in economic transactions, and the benefits may be diffuse and sufficiently small in magnitude to escape the attention of individual beneficiaries.

One of the central objectives of this book is to explore the relationships among these three generalizations. Might the accepted role for government associated with infrastructure market failure be related to society's need for nondiscriminatory community access or to the generation of substantial spillovers or to both? The societal need for nondiscriminatory community access to infrastructure and the generation of substantial spillovers each appears to independently constitute grounds for identifying a potential market failure and for supporting some role for government. But the confluence of the two factors suggests that something more complex may be involved. Might society's need for nondiscriminatory community access to infrastructure be related to the generation of substantial spillovers?<sup>8</sup>

Carol Rose was the first to draw an explicit connection between commons and positive externalities.<sup>9</sup> She explained that a “comedy of the commons” arises where open access to a resource leads to scale returns—greater social value with greater use of the resource. With respect to road systems, for example, she considered commerce to be an

interactive practice whose exponential returns to increasing participation run on without limit. . . . Through ever-expanding commerce, the nation becomes ever-wealthier, and hence trade and commerce routes must be held open to the public, even if contrary to private interest. Instead of worrying that too many people will engage in commerce, we worry that too few will undertake the effort.<sup>10</sup>

<sup>8</sup> Similarly, NOAM (1994), in Part III.3, observes:

“Infrastructure” is a term of considerable vagueness. It can best be described as those services that are a basic input to most other economic activities, and which provide substantial positive externalities to the economy as a whole. Transportation, energy, communications, education, and protection are prime examples. Network industries, in particular, are considered infrastructure services. The positive externalities to members of the network increase positively with added membership, for example by the greater reach of the telephone.

Infrastructure services can greatly contribute to the economic growth of individuals, regions and the nation. In consequence, in most countries they are provided by government. When historically they were provided in the past by private firms, English common law courts often imposed some quasi-public obligations, one of which one was common carriage. It mandated the provision of service to willing customers, bringing common carriage close to a service obligation to all once it was offered to some.

<sup>9</sup> Rose 723, 775–81 (1986). Demsetz came close. He suggested that “[c]ommunal property results in great externalities. The full costs of the activities of an owner of a communal property right are not borne directly by him, nor can they be called to his attention easily by the willingness of others to pay him an appropriate sum.” Demsetz 355 (1967). Demsetz focused exclusively on negative externalities (external costs) and failed to appreciate that communal property can result in great positive externalities (external benefits) and that such a result can be socially desirable.

<sup>10</sup> Rose 769–70 (1986); see also Cain (1998) (“[A]s long as Lake Michigan remained a ‘fixed fact,’ every railroad or town that was built and every farm that was settled north and west of the city would only increase the trade



Critically, (1) managing road systems in an open, nondiscriminatory manner is the key to sustaining and increasing *participation* in commerce, and (2) commerce is itself a *productive activity* that generates significant positive externalities. Commerce generates private value that is easily observed and captured by participants in economic transactions, as buyers and sellers exchange goods and services, but it also generates social value that is not easily observed and captured by participants—value associated with socialization, cultural exchange, and other such processes. Commerce is an excellent example of a *productive use* of roads that generates positive externalities and social surplus. There are many others, such as visiting other communities to see friends, relatives, or engage in recreation, or visiting state parks.<sup>11</sup> These activities generate private value that is easily observed and captured by participants as well as social value that is not easily observed and captured by participants. Rose’s critical insight is that certain resources ought to be managed as commons because doing so increases participation in socially valuable activities that yield scale returns. This book intensively explores the relationship between nondiscriminatory access to infrastructure and the generation of substantial spillovers. Before delving deeper, I explain “commons management.”

## B. Commons Management

The term “commons” generally conjures up the notion of a shared community resource, such as a public park or a common pasture. The term gained some notoriety with the publication of Garrett Hardin’s essay “The Tragedy of the Commons” in *Science* (1968). The term has more recently been used in a variety of different settings, ranging from environmental resources to spectrum policy. This book adopts a functional approach to understanding commons. As with infrastructure, the idea is to identify and examine the functional role of commons in complex systems. From this perspective, commons can be understood as a type of resource management strategy.

For purposes of this book, commons management refers to the situation in which a resource is accessible to all members of a community on nondiscriminatory terms, meaning terms that do not depend on the users’ identity or intended use.<sup>12</sup> I use “commons management” to capture a *nondiscriminatory sharing* strategy, which can be implemented through

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and prosperity of Chicago” (quoting I A. T. ANDREAS, HISTORY OF CHICAGO FROM THE EARLIEST TIME TO THE PRESENT 40 (1884)).

<sup>11</sup> See chapter 9. Cf. Branscomb & Keller (1996) (“Over the past half century, the U.S. highway system has advanced regional and national economic development by enhancing access to markets for goods, services, and people. It has also provided direct quality-of-life benefits, by providing easier access to both work and leisure.”).

<sup>12</sup> LESSIG 19–20 (2001b); OSTROM 1–7 (1990); Burger et al. 1–6 (2001); Bollier 2–3 (2001). I recognize that many commons arrangements discriminate against nonmembers, and even among members in some contexts where the contributions of members may vary or congestion issues arise. See chapter 7.



a variety of public and private institutions, including open access, common property, and other resource management or governance regimes. Grouping “open access” and “commons” under the “commons management” umbrella will be troublesome to some property scholars: Open access typically implies no ownership or property rights. No entity possesses the right to exclude others from the resource; all who want access can get access, typically for free.<sup>13</sup> Commons typically involves some form of communal ownership (community property rights, public property rights, joint ownership rights), such that members of the relevant community obtain access “under rules that may range from ‘anything goes’ to quite crisply articulated formal rules that are effectively enforced” and nonmembers can be excluded.<sup>14</sup> There are at least three dimensions of distinction between open access and commons as traditionally understood: first, ownership (none vs. communal/group); second, the definition of community (public at large vs. a more narrowly defined and circumscribed group with some boundary between members and nonmembers); and third, the degree of exclusion (none vs. exclusion of nonmembers). These distinctions are important, especially for understanding different institutions and how social arrangements operate at different scales. But our focus will be on infrastructure resources, for which the relevant community generally is the public at large. These “public commons” generally do not restrict membership and are available to users on nondiscriminatory terms; yet they are not always free, as is the case for pure open-access resources.

Accordingly, we put aside the distinctions between institutional regimes and focus on an important feature that they share: nondiscrimination, which means the underlying resource is accessible to members of a community on terms that do not depend on the users’ identity or intended use.<sup>15</sup> We abstract from the institutional *form* (property rights, regulations, norms) to focus on a particular institutional *function* (nondiscriminatory sharing). Tying form and function together obscures the fact that a commons management strategy is implemented by a variety of institutional forms, which are often mixed (property and regulation, private and communal property).<sup>16</sup>

<sup>13</sup> Hess & Ostrom 121–22 (2003).

<sup>14</sup> Benkler 6–7 (2003a).

<sup>15</sup> See also Benkler (2011) (emphasizing the symmetric freedom to operate and the absence of asymmetrical power to exclude or decide how users operate).

<sup>16</sup> See chapters 5–13. There are many ways in which a resource can come to be managed in a nondiscriminatory manner. A resource may be open for common use naturally because its characteristics prevent it from being owned or controlled by anyone. Rose 89, 93 (2003) (discussing the traditional Roman categories of nonexclusive property, one of which, *res communes*, was incapable of exclusive appropriation due to its inherent character). For example, for most of the earth’s history, the oceans and the atmosphere were natural commons. Exercising dominion over such resources was beyond the ability of human beings or simply unnecessary because there was no indication of scarcity. That has changed. A resource may be open for common use as the result of social construction. Laws or rules may prohibit ownership or ensure open access, or an open-access regime may arise through norms and customs among owners and users. For example, the Internet infrastructure has been governed by norms creating a nondiscrimination regime where end-users can access and use the infrastructure to route data packets without fear of discrimination or exclusion by infrastructure owners.

The general values of the commons management strategy are that it maintains openness, does not discriminate among users or uses of the resource, and eliminates the need to obtain approval or a license to use the resource.<sup>17</sup> Managing infrastructure resources as commons eliminates the need to rely on either market actors or the government to “pick winners” among users or uses. This catalyzes innovation through the creation of and experimentation with new uses. More generally, it facilitates the generation of positive externalities by permitting downstream production of public and social goods that might be stifled under a more restrictive access regime. Finally, it sustains the social option value of the infrastructure by precluding premature optimization of the resource for commercial gain. Chapter 5 examines these values.

Sustaining commons poses serious challenges, however. Environmental and information resources highlight the best-known and most-studied commons dilemmas. Environmental resources suffer from the “tragedy of the commons,”<sup>18</sup> a consumption or capacity problem, familiar to many infrastructure resources. Open access to some environmental resources may lead to congestion, depletion, and possibly ruin as users only take into account the private benefits and costs from their use and fail to account for negative externalities (costs to third parties) attributable to their consumption. If each user consumes rationally from a self-interested perspective but inefficiently from a social perspective, the resource may be overused to the point of ruin. Information resources suffer from a “free-rider dilemma,” a production problem, also familiar to many infrastructure resources. Open access to some information resources may diminish incentives to invest in the creation and development of the resources because free-riding users consume the resources without paying an adequate contribution to investors, who in turn are unable to recoup their investments. These challenges are not insurmountable and should not stand in the way of managing infrastructure as commons.<sup>19</sup> Social institutions reflect a strong commitment to sustaining common access to certain infrastructure resources. This book shows the wisdom of that commitment.

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See chapter 13. The open source and creative commons movements are two prominent examples. LESSIG 164–65, 255–56 (2001b); Reichman & Uhlir 430–32 (2003); see also David & Foray 87, 91 (1996) (The “activity of diffusing economically relevant knowledge is not itself a natural one.” “Rather, it is socially constructed through the creation of appropriate institutions and conventions, such as open science and intellectual property . . .”).

<sup>17</sup> LESSIG (2004b); LANDES & POSNER 15–16 (2004) (acknowledging such benefits with respect to the public domain).

<sup>18</sup> Hardin 1244–45 (1968).

<sup>19</sup> It is interesting how two frequently told stories of uncontrolled consumption—the tragedy of the commons and the free-rider story—came to dominate the policy discourse in the environmental and intellectual property areas and how both stories seem to lead to the conclusion that granting private property rights, typically with the power to grant access on discriminatory terms, is the best way to manage these resources. OSTROM 3 (1990) (connecting the tragedy of the commons with the prisoners’ dilemma); Ghosh 1332 (2004); Lemley (2005). Both stories can be translated in game-theoretic terms into a prisoners’ dilemma, another good story, although one that does not necessarily point to private property as a solution to the cooperation dilemma. See, e.g., Eastman (1997).