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# Infrastructure

THE SOCIAL VALUE OF SHARED RESOURCES

Brett M. Frischmann

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*To my wife, Kelly, and my three boys, Matthew, Jake, and Ben*

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# Contents

Introduction ix

## PART ONE | FOUNDATIONS

1. *Defining Infrastructure and Commons Management* 3
2. *Overview of Infrastructure Economics* 10
3. *Microeconomic Building Blocks* 24

## PART TWO | A DEMAND-SIDE THEORY OF INFRASTRUCTURE AND COMMONS MANAGEMENT

4. *Infrastructural Resources* 61
5. *Managing Infrastructure as Commons* 91

## PART THREE | COMPLICATIONS

6. *Commons Management and Infrastructure Pricing* 117
7. *Managing Congestion* 136
8. *Supply-Side Incentives* 159

## PART FOUR | TRADITIONAL INFRASTRUCTURE

9. *Transportation Infrastructure: Roads* 189
10. *Communications Infrastructure: Telecommunications* 211

## PART FIVE | NONTRADITIONAL INFRASTRUCTURE

11. *Environmental Infrastructure* 227
12. *Intellectual Infrastructure* 253

viii | Contents

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PART SIX | MODERN DEBATES

13. *The Internet and the Network Neutrality Debate* 317

14. *Application to Other Modern Debates* 358

CONCLUSION 365

ACKNOWLEDGMENTS 371

BIBLIOGRAPHY 375

INDEX 403

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## Introduction

This book devotes much-needed attention to understanding how society benefits from infrastructure resources and how management decisions affect a wide variety of interests. This book links *infrastructure*, a particular set of resources defined in terms of the manner in which they create value, with *commons*, a resource management principle by which a resource is shared within a community.

Too often, we take for granted the shared infrastructures that shape our lives, our relationships with each other, the opportunities we enjoy, and the environment we share. Think for a moment about the basic supporting infrastructures that you rely on daily. Some obvious examples are roads, the Internet, water systems, and the electric power grid, to name just a few. In fact, there are many less obvious examples, such as our shared language, legal institutions, ideas, and even the atmosphere. We depend heavily on shared infrastructures, yet it is difficult to appreciate just how much. It is difficult to fully appreciate how these resources contribute to our lives, because infrastructures are complex and the benefits provided are typically indirect. We don't pay much attention to infrastructure resources, because they are conveniently obscure, part of the background. We assume their continuous availability and pay attention to them only when catastrophe strikes, for example when a bridge fails or rolling blackouts deprive us of the electricity we need. And even then, the public attention given is reactive, isolated, and short-lived.

When a bridge collapses, for example, the immediate public outcry may be sufficient to support efforts to rebuild the particular bridge, but that is about as far as it goes. As the headline value of the disaster fades, the world moves on. According to the American Society of Civil Engineers (ASCE), "more than 26%, or one in four, of the nation's bridges

TABLE I.1 ASCE Report Card for America's Infrastructure (2009)

Infrastructure Type	2009 Grade
Aviation	D
Bridges	C
Dams	D
Drinking Water	D-
Energy	D+
Hazardous Waste	D
Inland Waterways	D-
Levees	D-
Public Parks and Recreation	C-
Rail	C-
Roads	D-
Schools	D
Solid Waste	C+
Transit	D
Wastewater	D-
<b>America's Infrastructure GPA</b>	<b>D</b>
<b>Estimated Five-Year Investment Need</b>	<b>\$2.2 trillion</b>

are either structurally deficient or functionally obsolete.”<sup>1</sup> In 2008, over 70,000 bridges in the United States were categorized as structurally deficient, and in addition, over 89,000 bridges were categorized as functionally obsolete.<sup>2</sup> And the problem is by no means limited to bridges. To take a rather simple illustration, the ASCE Report Card for America's Infrastructure (see table I.1) is abysmal, concluding with a “grade point average” of D and an estimated five-year investment need of \$2.2 trillion.

While there are reasons one might quibble with the ASCE grading system or even particular grades, the basic point is that we have a major infrastructure problem in the United States. Our complacent, reactive, piecemeal approach to infrastructure is incredibly shortsighted and must change. A more proactive, systematic, long-term approach to infrastructure is desperately needed, as experts have long recognized.<sup>3</sup> For such change

<sup>1</sup> ASCE (2009).

<sup>2</sup> DEPARTMENT OF TRANSPORTATION 38 (2008) (Table 2-1-9 contains the relevant statistics on bridges).

<sup>3</sup> This need has long been recognized among expert communities. That is, engineers, economists, and other experts who focus on infrastructure have long argued for a proactive, systematic, long-term approach to infrastructure. What has not been recognized or at least explored methodically are the demand-side issues examined in this book.

to even begin to occur, however, citizens must learn to appreciate the social value of shared infrastructure.<sup>4</sup> We simply cannot assume continuous availability. As the ASCE Report Card indicates, both governments and markets struggle to adequately supply the public with the infrastructures that it needs. The reasons are many, and this book will not discuss them all. Infrastructure resources often require substantial investment to supply, maintain, and manage. The investment must come from somewhere, and the public must pay one way or another (taxes, user fees, etc.). As economists like to put it, there is no such thing as a free lunch. Raising sufficient capital to invest can be difficult. There are a host of “supply-side” obstacles to efficient infrastructure provisioning. Economic analysis of infrastructure tends to focus on these issues. But one critical reason, which is generally overlooked and which this book will confront at length, is that infrastructure users, as voters and consumers, may not adequately signal social demand for infrastructures. There are a host of “demand-side” issues to confront. At bottom, demand-side problems arise because we do not fully appreciate the social value that infrastructures provide.

Infrastructure resources entail long-term commitments with deep consequences for the public. Infrastructures are a prerequisite for economic and social development. Infrastructures shape complex systems of human activity, including economic, cultural, and political systems. That is, infrastructures affect the behavior of individuals, firms, households, and other organizations by providing and shaping the available opportunities of these actors to participate in these systems and to interact with each other. Transportation and communications infrastructures, for example, enable economic and cultural engagement between communities, expanding the scope of markets and communities by enabling people, goods, and ideas to travel more easily. Legal infrastructure, including laws and court systems, for example, enable an incredible variety of economic and social interactions within and across communities. Property and contract laws are a basic foundation for markets of all sorts. The First Amendment shapes the speech environment—the political, economic, cultural, and other conversations people have.

Infrastructure resources are at the center of many contentious public policy debates, ranging from what to do about our crumbling roads and bridges, to whether and how to protect our natural environment, to patent law reform, to electromagnetic spectrum allocation, to providing universal health care, to energy policy, to network neutrality regulation and the future of the Internet. The list could go on and on. Although the policy arenas may seem unrelated, all of them are, to some extent, the same. Each of these policy debates (and many others) involves a battle to control infrastructure resources, set

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<sup>4</sup> Just as environmental movement helped society to see what it took for granted, this book aims to bring infrastructure to the foreground, so we can better see infrastructure where it exists and to sense its potential where it could come to exist.

the terms and conditions under which the public gets access, and determine how the infrastructure and various infrastructure-dependent systems will evolve over time.<sup>5</sup>

The battle is joined in each of these areas, with some groups arguing strongly for recourse to private property solutions<sup>6</sup> and other groups arguing strongly that such an approach would be fatal.<sup>7</sup> These groups draw on a broader intellectual debate about the merits of private control over (or, conversely, open access to) various types of resources. The intellectual debate takes place in a number of fields, including law, economics, and political science. On the private control side, there is robust economic theory in support of private ordering via markets with minimal government involvement. By contrast, on the open-access side, there is a frequent call for protecting the “commons,” but the theoretical support for this prescriptive call is underdeveloped from an economics perspective. In fact, many who oppose privatization, deregulation, and commercialization view the entire discipline of economics with sincere suspicion and doubt.

This book advances strong economic arguments for managing and sustaining infrastructure resources as commons. For better or worse, economics has become the methodology of choice for many scholars and policy makers in these areas. The book offers a rigorous economic challenge to the prevailing wisdom about managing infrastructure. Within economics, infrastructure resources typically have been evaluated using public goods and club goods frameworks; under either framework the analysis typically has focused on the problem of ensuring adequate supply. This book explores a set of questions that, once asked, seem obvious: What drives the demand side of the equation, and how should demand-side drivers affect public policy? Demand for infrastructure resources involves a range of important considerations that bear on the optimal design of a regime for infrastructure management.

A demand-side approach facilitates a better understanding of how infrastructure resources generate value for society and how decisions regarding the allocation of access to such resources affect social welfare. The key insights from this analysis are that infrastructure resources are basic inputs into a wide variety of productive activities and infrastructure users who choose to engage in such activities often produce public and social goods that generate spillovers that benefit society as a whole. Managing such resources as commons may be socially desirable from an economic perspective because doing so facilitates these downstream productive activities. For example, managing the Internet infrastructure in this manner facilitates active citizen involvement in the production and

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<sup>5</sup> The debates involve other issues as well. My point is that infrastructure issues are often at the core.

<sup>6</sup> E.g., “privatize public roads and bridges so that firms motivated by profit incentives will reduce costs and manage the resources efficiently” or “pay providers of ecosystem services for the benefits their land conveys to all of us” or “let the network owners control what traffic flows across their cables.”

<sup>7</sup> E.g., “privatization benefits only a few, such as current politicians, the owners, and current users with the means to pay increased tolls” or “commodification will not solve environmental problems” or “network neutrality is essential to the future of the Internet.”



sharing of public and social goods. Over the past decade, this has led to increased opportunities for a wide range of citizens to engage in entrepreneurship, political discourse, social network formation, and community building, among many other socially valuable activities.

To put the basic lesson more plainly: We should share infrastructure resources in an open, nondiscriminatory manner when it is feasible to do so. This is attractive public policy—not only for distributional or fairness reasons, but also for efficiency reasons. Society is better off sharing infrastructure openly. This book explains why. And it also explains that although many people question the feasibility of sharing, worrying that sharing will destroy incentives to invest or will lead to overuse, such concerns are greatly overstated and often can be addressed in a manner that preserves nondiscriminatory sharing.

The infrastructure commons ideas developed in this book have broad implications for scholarship and public policy across many fields, ranging from traditional infrastructure like roads to environmental economics to intellectual property to Internet policy. The book identifies resource valuation and attendant management problems that recur across many different fields and many different resource types, and it develops a functional economic approach to understanding and analyzing these problems. Accordingly, the theory is developed at a higher level of abstraction than would be appropriate if it focused exclusively on a single field or resource. This means that the theory needs refinement as it is applied in context. The book offers no universal prescriptions, because trade-offs will be different in different areas. Still, it is helpful and illuminating to take a step back and look across traditional disciplinary lines before examining the trade-offs. The first three parts of this book develop a general theoretical framework for examining the social value of shared infrastructure. The framework is not tailored to a particular type of infrastructure. Instead, it is based on a functional economic analysis of the characteristics of infrastructure resources. The final three parts of the book apply the framework to many different types of infrastructure, exploring nuanced trade-offs that arise in particular contexts as well as common issues that cut across different contexts. Despite their obvious differences, road systems, telephone networks, ecosystems, and ideas have much more in common than is conventionally appreciated.

### Detailed Summary of Chapters

Part I lays the foundation for the economic arguments developed throughout the rest of the book. Chapters 1, 2, and 3 are building blocks. The concepts “infrastructure” and “commons” are used differently and often loosely across a wide range of disciplines, including engineering, economics, political science, and law. Moreover, the two concepts are rarely used together. Accordingly, chapter 1 sets forth a general description of the concepts, drawing on some of the key functional features of *infrastructure as resources*



and *commons as a mode of resource management*. This discussion highlights some of the gaps in our understanding of how infrastructure generates social value and the role that commons management plays in facilitating value generation by infrastructure users. Chapter 2 gives an overview of infrastructure economics. Surprisingly, there is no particular subfield within economics devoted to infrastructure. The overview explains the basic supply-side orientation of public welfare economics and regulatory economics and highlights this book's point of departure—its focus on the demand side. Chapter 3 provides a detailed discussion of microeconomic concepts that serve as building blocks for the demand-side theory developed in Part II. The concepts are very important to understanding the value of infrastructure and evaluating and improving resource management. (Readers well versed in microeconomics may wish to skip this chapter. However, the chapter highlights some overlooked demand-side issues that arise in the analysis of public goods, social goods, and externalities.)

Part II develops a demand-side theory of infrastructure and commons management. It is the heart of the book. It delineates a set of infrastructure resources based on functional economic criteria and examines whether managing these resources as commons is an attractive resource management strategy.

Chapter 4 focuses on infrastructure resources. It aims to identify and evaluate infrastructure resources functionally from a systems perspective. First, it identifies and examines three economic criteria common to traditional infrastructure, such as transportation systems and telecommunications networks, and nontraditional infrastructure, such as the atmosphere and basic research. Specifically, infrastructural resources satisfy the following criteria:

- (1) The resource may be consumed nonrivalrously for some appreciable range of demand.
- (2) Social demand for the resource is driven primarily by downstream productive activity that requires the resource as an input.
- (3) The resource may be used as an input into a wide range of goods and services, which may include private goods, public goods, and social goods.

These criteria delineate a set of resources that are functionally *infrastructural*. Bear in mind that the economic concepts woven together in these criteria are carefully explained in chapter 3. Second, chapter 4 develops a typology of different infrastructure (commercial, public, social, and mixed infrastructure) based on the distribution of productive activities the infrastructure facilitates. Third, it discusses how both the resource set delineated by the three criteria and the subsets delineated by the typology are dependent on demand, and how resources may evolve into or out of the set or subsets. The chapter explains how different types of demand-side market failures arise when spillovers from public or social goods are prevalent.

Chapter 5 connects the demand-side analysis of how infrastructure resources generate value for society with the management of such resources as commons. The case for commons management must be evaluated carefully and contextually. Chapter 5 first considers commons management as a private strategy. There are a variety of reasons why private firms choose to manage their infrastructure as commons. I discuss five primary reasons: (a) consumers generally dislike and react negatively to discrimination; (b) commons management may economize on information and transaction costs and avoid unnecessary complexity; (c) commons management may facilitate joint production or cooperation with competitors; (d) commons management may support and encourage value-creating activities by users; and (e) commons management may maximize the option value of infrastructure when there is high uncertainty regarding sources of future market value.

Chapter 5 next considers commons management as a public strategy. There are a variety of situations in which commons management is not an attractive private strategy but nonetheless is an attractive public strategy; markets sometimes fail to adopt commons management even when doing so would improve social welfare. The chapter explains the conventional forms of and justifications for such regulation. Next, it utilizes the typology developed in chapter 4 and articulates additional, powerful reasons to manage public, social, and mixed infrastructure in a nondiscriminatory manner. Specifically, commons management can be an efficient means of indirectly supporting public participation in a variety of socially valuable activities, namely activities that involve the production, use, and distribution of public and social goods. As such, commons management can be understood as serving two public functions: First, it diffuses pressure within both market and political systems to “pick winners and losers” and leaves it to users to decide what to do with the opportunities (capabilities) provided by infrastructure. Second, it functions like an option—a social option. When there is high uncertainty about which users or uses will generate social value in the future, as is typically the case for public, social, or mixed infrastructure, managing the infrastructure as a commons sustains the generic nature of the infrastructure, precludes optimization for a narrower range of activities, and avoids social opportunity costs associated with path dependency. Together, these public functions suggest a third public function: Commons management structures the relationships between infrastructure and infrastructure-dependent systems in a manner that creates a spillover-rich environment, where spillovers flow from the many productive activities of users. These activities yield new and unanticipated innovations, knowledge, social capital, and other public and social goods that lead to economic growth and development as well as social welfare improvements not fully reflected in traditional economic measures.

Though theory reveals a weight on the scale in favor of commons management that seems to be ignored in most contexts, the theory does not necessarily tip the balance; there are other relevant considerations, some more important than others, depending on

the context. Part III focuses on three sets of complications that must be considered when evaluating the case for managing infrastructure as commons. The first set involve the impacts that commons management might have on pricing practices, and concerns that nondiscrimination rules must be accompanied by price regulation or government subsidies. The second set concerns congestion management and complications that arise when infrastructure is partially (non)rival and thus congestible, and the relationships between commons management and congestion management. Finally, the third set concerns the impact of nondiscrimination rules on supply-side incentives. As the chapters reveal, arguments based on these complications should be evaluated carefully. In many cases, the complications are manageable and do not undermine the case for commons management.

Part IV discusses examples of traditional infrastructure—specifically, transportation infrastructure (roads) in chapter 9 and telecommunications infrastructure (telephone networks) in chapter 10. These chapters illustrate how the demand-side theory applies to these traditional infrastructure resources and how commons management has been implemented. Both road and telecommunications infrastructures provide generic public capabilities, mobility and communication, that allow users to engage in an incredibly wide variety of productive activities. These activities generate private, public, and social goods and consequently substantial spillovers to the benefit of society. In the United States, the vast majority of road infrastructure is publicly owned, and the vast majority of telephone infrastructure is privately owned. The supply-side stories for these infrastructures are thus quite different. Yet both are sustained as commons, accessible to the public on nondiscriminatory terms. These chapters discuss a range of complications. Road infrastructure is complicated by congestion, negative externalities associated with environmental pollution, and public financing of maintenance and improvements. Telephone infrastructure is complicated by regulatory costs and the difficulties of transitioning from regulated monopoly to competition. While these chapters do not exhaustively cover these rich and complex fields, they begin to provide a more nuanced picture of how these fundamental infrastructure resources generate value for society, the critical role of commons management, and the various institutional means for sustaining commons when faced with an array of conflicting issues.

Part V shifts attention from traditional infrastructure to nontraditional infrastructure—specifically, environmental and intellectual infrastructure. It may seem odd to be grouping roads and telephone networks with lakes and ideas under the infrastructure umbrella. One reason for doing so is to highlight the demand-side similarities and the important, if varied, role of commons management. When feasible, society benefits tremendously by leveraging nonrivalry to support nondiscriminatory access to such resources because doing so enables the public to participate productively in a wide range of socially valuable activities. As with traditional infrastructure, many environmental and intellectual infrastructure resources are public, social, and mixed infrastructures that contribute immensely to our economic and social development. The case for commons

management depends, however, on managing a host of competing considerations. Intellectual infrastructures face supply-side issues similar to those issues faced by traditional infrastructure. Attracting private investment can be difficult because of the cost structure of supply, high costs of exclusion, and misappropriation risks. Environmental infrastructures do not face the same supply-side issues, but environmental infrastructure face complex congestion and degradation problems. In short, pure open access to intellectual or environmental infrastructure typically is not feasible absent additional institutional support, whether in the form of public subsidies for basic research or in the form of command and control regulation of industrial polluters. Viewing foundational environmental and intellectual resources through the infrastructure lens yields interesting insights regarding commons management institutions. In particular, both environmental and intellectual property legal systems construct semi-commons arrangements that create and regulate interdependent private rights and public commons. Each does so in very different ways, however.

Part VI applies the infrastructure theory to modern challenges. Chapter 13 applies infrastructure theory to the particularly contentious “network neutrality” debate. At the heart of this debate is whether the Internet infrastructure will continue to be managed as a commons. Ultimately, the outcome of this debate may very well determine whether the Internet continues to operate as a mixed infrastructure that supports widespread user production of commercial, public, and social goods, or whether it evolves into a commercial infrastructure optimized for the production and delivery of commercial outputs. The chapter criticizes the current framing of the debate as well as the recent rule enacted by the Federal Communications Commission. It then proposes and defends a nondiscrimination rule that reflects the core commons management principle discussed throughout this book. Chapter 14 briefly discusses some additional modern challenges.