

Infrastructure and Knowledge Commons

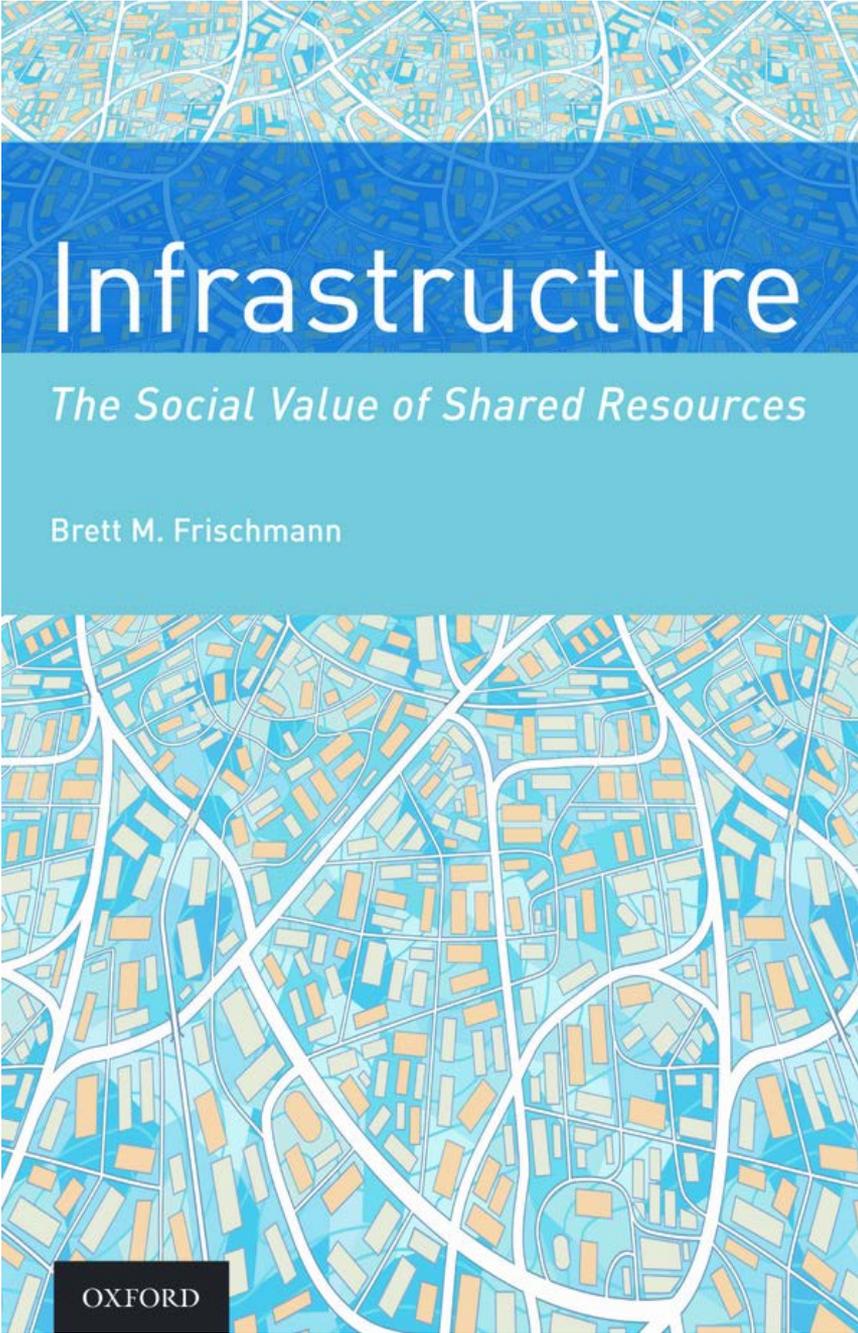
An Introduction to the Theoretical Concepts and Potential Applications

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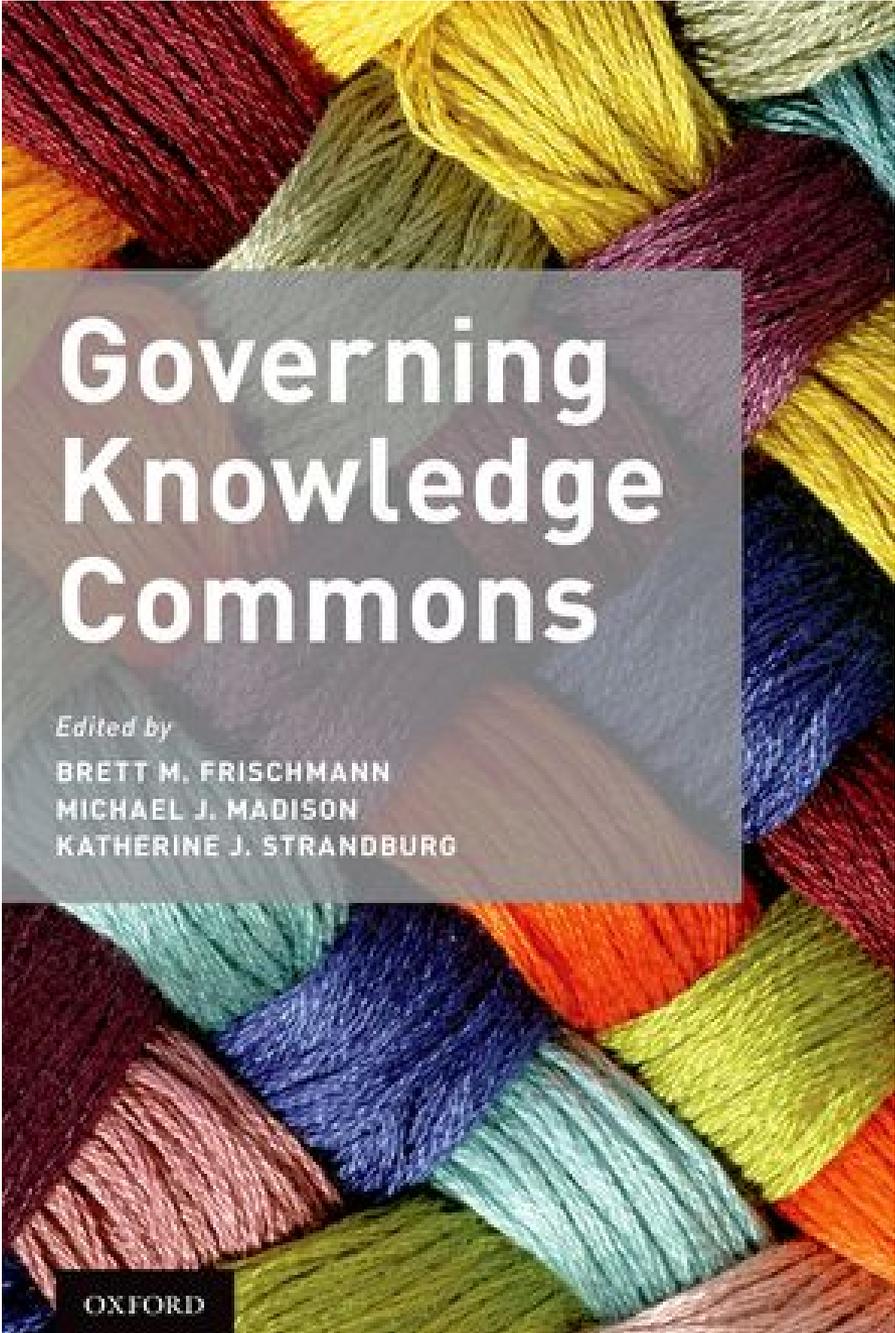


Infrastructure

The Social Value of Shared Resources

Brett M. Frischmann

OXFORD



Governing Knowledge Commons

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OXFORD

Project

- Approaching the economics of foundational resources from the demand side
 - Where does the value come from?
- Interdisciplinary
 - law and economics
 - many disciplines within law
 - many disciplines within economics

Introduction

Part I: Foundations

Chapter One: Defining Infrastructure and Commons Management

Chapter Two: Overview of Infrastructure Economics

Chapter Three: Microeconomic Building Blocks

Part II: A Demand-Side Theory of Infrastructure and Commons Management

Chapter Four: Infrastructural Resources

Chapter Five: Managing Infrastructure as Commons

Part III: Complications

Chapter Six: Commons Management and Infrastructure Pricing

Chapter Seven: Managing Congestion

Chapter Eight: Supply-Side Incentives

Part IV: Traditional Infrastructure

Chapter Nine: Transportation Infrastructure : Roads

Chapter Ten: Communications Infrastructure : Telecommunications

Part V: Nontraditional Infrastructure

Chapter Eleven: Environmental Infrastructure

Chapter Twelve: Intellectual Infrastructure

Part VI: Modern Debates

Chapter Thirteen: The Internet and the Network Neutrality Debate

Chapter Fourteen: Application to Other Modern Debates

Conclusion

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Some other recent applications include: Data, university science and technology research systems, the BBC

Background

1. Government intervention
2. Commons management is the norm
3. Positive externalities / large social surplus

Background

1. Government intervention

- Government's role varies considerably based on resource, community, context
- Infrastructure markets fail, in many different ways!

2. Commons management is the norm

3. Positive externalities / large social surplus

Background

1. Government intervention
- 2. Commons management is the norm**
3. Positive externalities / large social surplus

Commons Management

Commons \leftrightarrow *Open Access*

1. Ownership
2. Community Definition
3. Degree of Exclusion

Class exercise: fill in ...

	Commons	Open Access
Ownership		
Community Definition		
Degree of Exclusion		

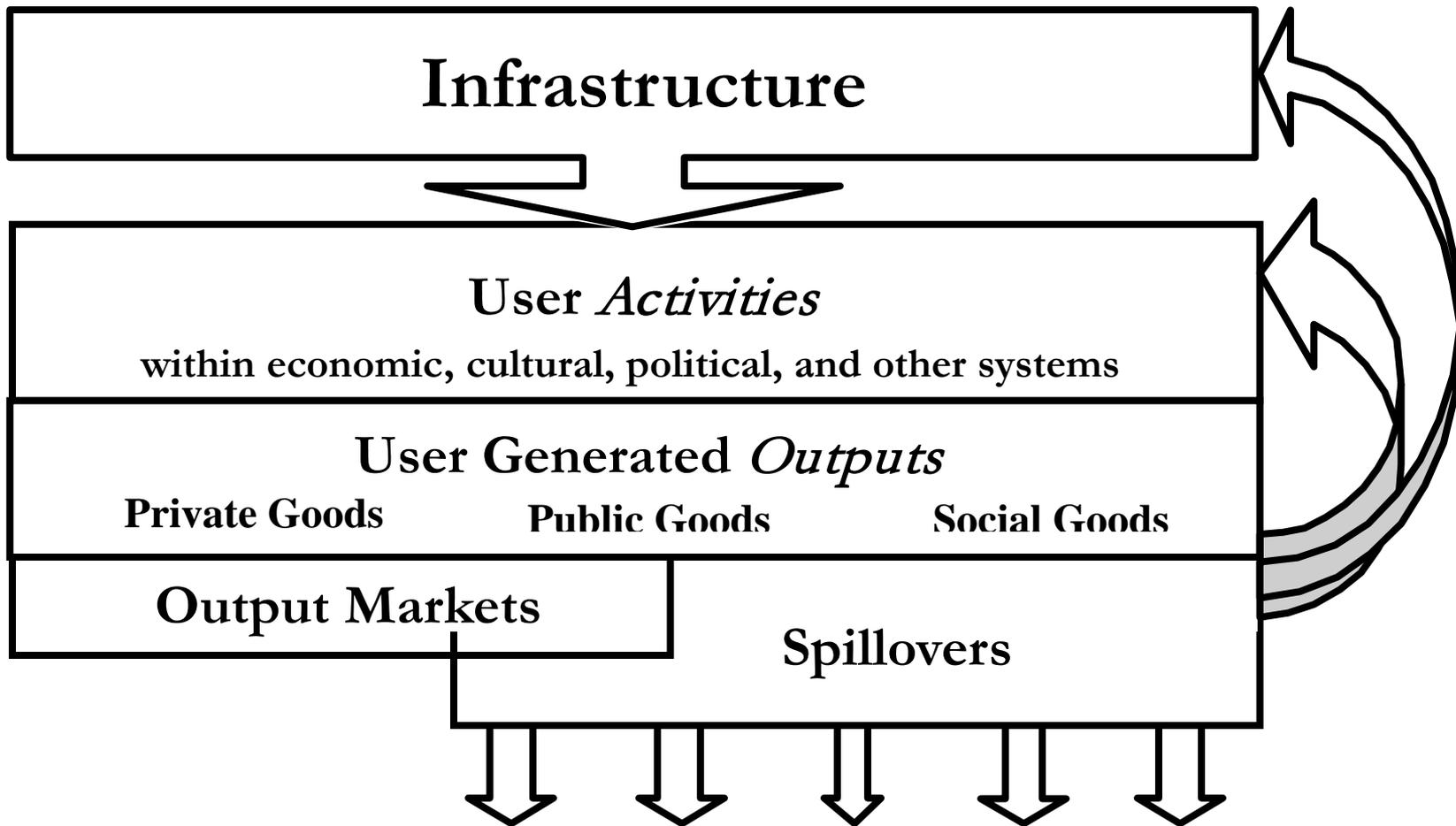
Commons Management

Focus on **nondiscriminatory sharing**

- Various institutional regimes
- Lack of exclusion & member/nonmember boundaries
- Not necessarily free

Background

1. Government intervention / infrastructure markets fail
2. Commons management is the norm
- 3. Positive externalities / large social surplus**
 - **Class question: Do you agree? Take a moment to think about an example. Why does this matter?**



Background

- **Comedy of the commons**
 - Connecting commons management with the positive externalities and social surplus.
 - Sharp contrast with more well known allegory: the *tragedy of the commons*
- **Class question: Which have you heard of or studied in the past? Which have you experienced? Any examples?**

- Simple thesis:
 - If Infrastructure, then commons?
 - *NO: Too simple!*
 - *But decent organizing principle*
- More complicated set of arguments:
 - Depends upon the mix of outputs
 - Infrastructure typology helps sort arguments
 - Need to consider value of commons management more carefully

Microeconomic Building Blocks

1. Public and Private Goods: (Non)rivalry and (Non)excludability
2. Consumption Goods and Capital Goods
3. Externalities: Incomplete and Missing Markets
4. Social Goods: Nonmarket Goods, Merit Goods, Social Capital, and Irreducibly Social Goods
5. Speech

1. Public/Private Goods: (Non)rivalry and (Non)excludability

- *Apple*
 - exclusion?
 - consumption?
- *Idea*
 - exclusion?
 - consumption?
- *Road ... Atmosphere*
 - exclusion?
 - consumption?
- **Start with basic resource characteristics.**
 - **Definitions**
 - **Illustrate with these resources**

1. Public/Private Goods: (Non)rivalry and (Non)excludability

Class questions:

- *Apple*
 - exclusion?
 - consumption?
 - *Idea*
 - exclusion?
 - consumption?
 - *Road ... Atmosphere*
 - exclusion?
 - consumption?
- **How should we manage these resources?**
 - **How do we get the most social welfare?**
 - **What do the economic concepts mean and why are they important?**

1. Public/Private Goods: (Non)rivalry and (Non)excludability

- *Apple*
 - exclusion?
 - consumption?
- *Idea*
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 - consumption?
- *Road ... Atmosphere*
 - exclusion?
 - consumption?

Takeaways (on pp. 32-33):

- Nonrivalry → potential sharing; degree of freedom
- Boundary / partial nonrivalry
- Broad efficiency principles

2. Consumption Goods and Capital Goods

		Demand	
		Consumption	Derived
(NON)RIVALROUSNESS OF CONSUMPTION	Nonrival or Partially (Non)rival	Public consumption good	Public capital good
	Rival	Private consumption good	Private intermediate good or raw material

Another definitional distinction ...

2. Consumption Goods and Capital Goods

		Demand	
		Consumption	Derived
(NON)RIVALROUSNESS OF CONSUMPTION	Nonrival or Partially (Non)rival	Public consumption good	Public capital good
	Rival	Private consumption good	Private intermediate good or raw material

Class questions:

- How should we allocate steel?
- How should we allocate resources to produce steel?
- Same analysis for ideas? roads? atmosphere?
- Why does it matter whether or not demand is *derived*?

3. Externalities

- Definition
- Problem?

Examples?

3. Externalities: *Incomplete and Missing Markets*

- Definition
- Problem?
- Solution?

Examples?

- Pollution from factory
- Garden

Students: Think of an example

3. Externalities: *Incomplete and Missing Markets*

- Definition
- Problem?
- Solution?
 - Internalization
 - Why? How?

Examples?

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3. Externalities: *Incomplete and Missing Markets*

- Definition
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- Solution?
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 - Why? How?
- Binary solution set:
 - Government ... (Pigou)
 - Market ... (Coase)

Examples?

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Students: Think of an example

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 - Market ... (Coase)
 - **Other solutions? ...** (Ostrom)

Examples?

- Pollution from factory
- Garden

Students: Think of an example

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- Binary solution set:
 - Government ... (Pigou)
 - Market ... (Coase)
 - **Other solutions?** ... (Ostrom)

Examples?

- Pollution from factory
- Garden

Students: Think of an example

If time permits, brief digression on lessons from Elinor Ostrom

3. Externalities: *Incomplete and Missing Markets*

- Definition
- Problem?
- Solution?
 - Internalization
 - Why? How?

Examples?

- Pollution from factory
- Garden

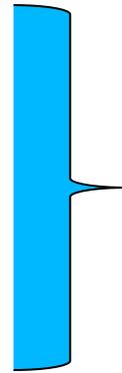
Students: Think of an example

• My challenge to conventional theories:

- Not always a problem!
 - How so?
- Solutions may backfire and make matters worse.

4. Social Goods

- Nonmarket Goods
- Merit Goods
- Social Capital
- Irreducibly Social Goods



Demand side issues not well captured in conventional economic categories, but social value by virtue of social interdependence

- Differences between Social and Public Goods
- Relationship to externalities

5. Speech

If time permits, brief class discussion of how ideas are nonrival capital that often serve as inputs into the generation of public and social goods and correspondingly generate different types of externalities

Class: Why is speech socially valuable? How does it generate value? How do markets for speech work? How do they not work? ...

Microeconomic Building Blocks

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5. Speech

Infrastructural Resources

1. The resource may be consumed nonrivalrously;
2. social demand for the resource is driven primarily by downstream productive activity that requires the resource as an input; and
3. the resource is used as an input into a wide range of goods and services, including private goods, public goods and/or social goods.

		CAPACITY	TYPE OF GOOD
(NON)RIVALROUSNESS OF CONSUMPTION	Nonrival	<ul style="list-style-type: none"> • Infinite • Sharable • Not congestible 	Pure public good (idea)
	Partially (non)rival	<ul style="list-style-type: none"> • Finite • Potentially renewable • Potentially sharable • Congestible • Depreciable 	Impure public good (lake, road, the Internet)
	Rival	<ul style="list-style-type: none"> • Finite • Nonrenewable • Not sharable 	Private good (apple)

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Infrastructural Resources

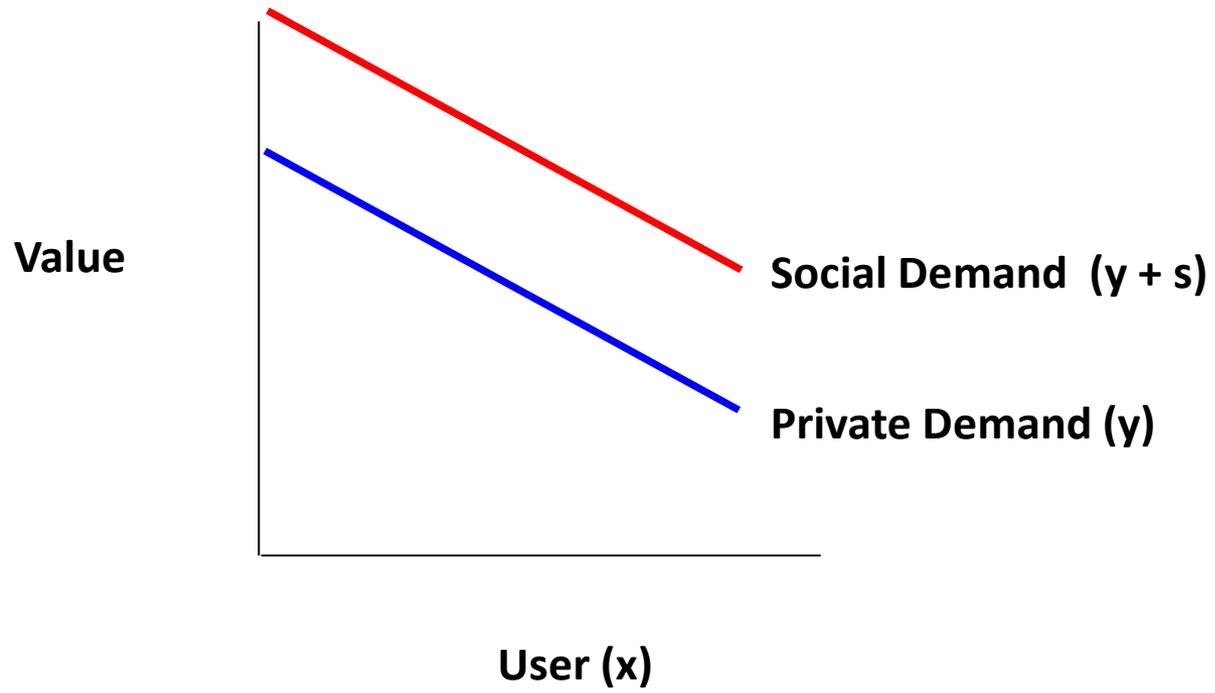
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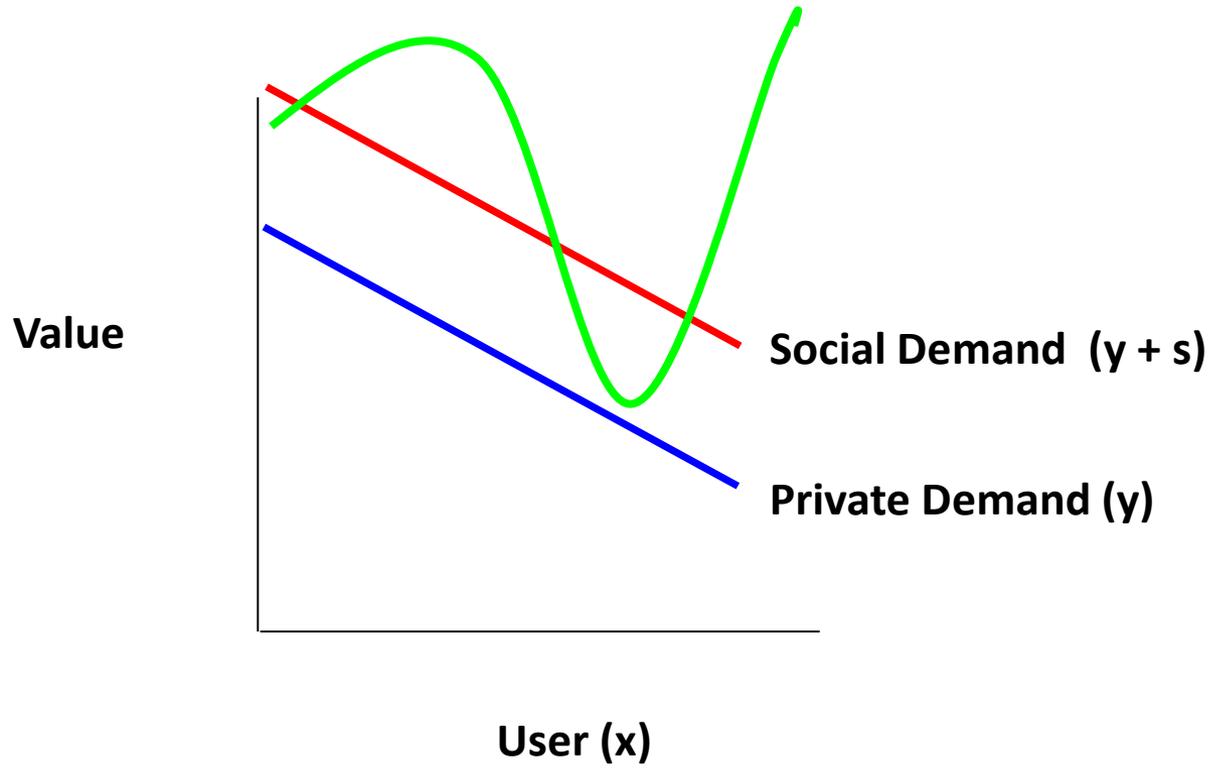
		Demand	
		Consumption	Derived
(NON)RIVALROUSNESS OF CONSUMPTION	Nonrival or Partially (Non)rival	Public consumption good	Public capital good
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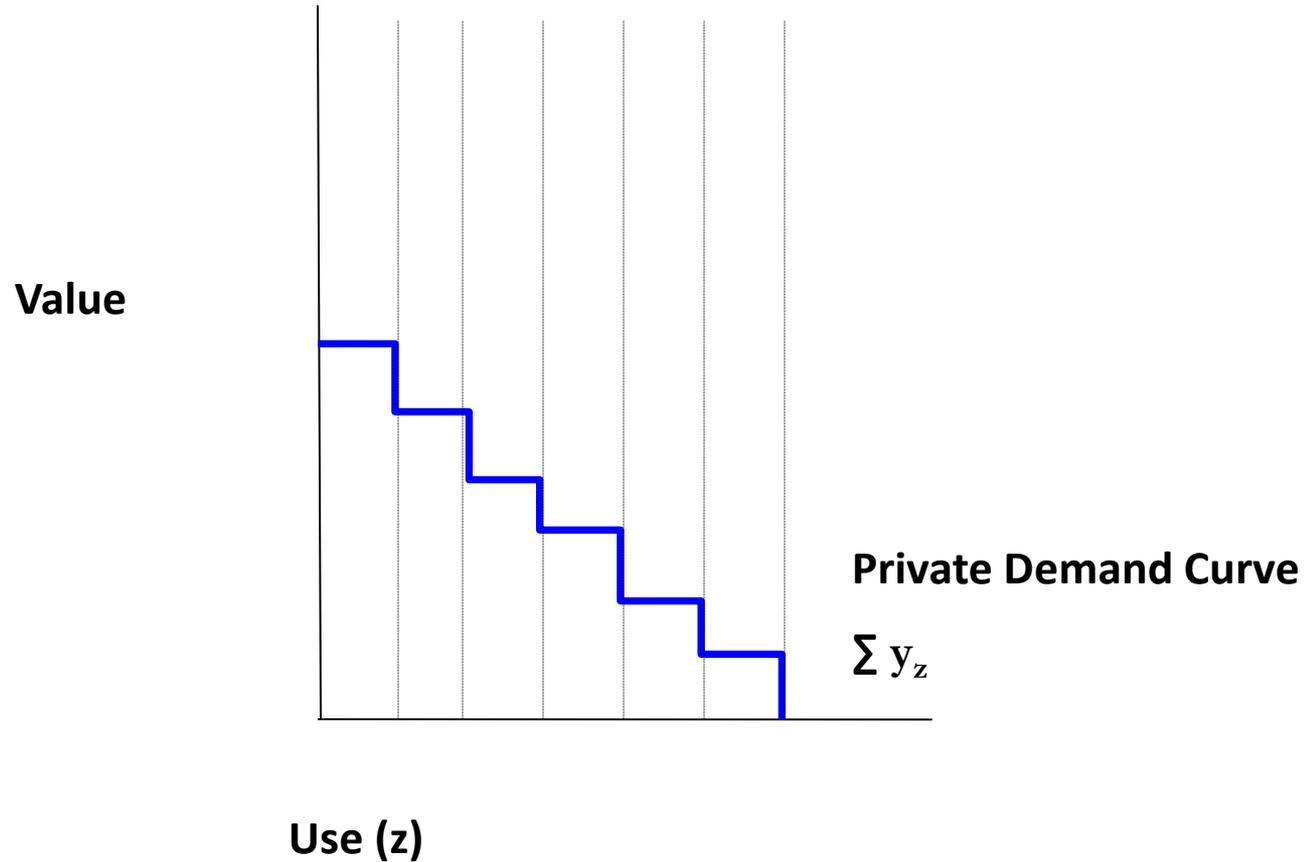
Infrastructural Resources

1. The resource may be consumed nonrivalrously;
2. social demand for the resource is driven primarily by downstream productive activity that requires the resource as an input; and
3. **the resource is used as an input into a wide range of goods and services, including private goods, public goods and/or social goods.**

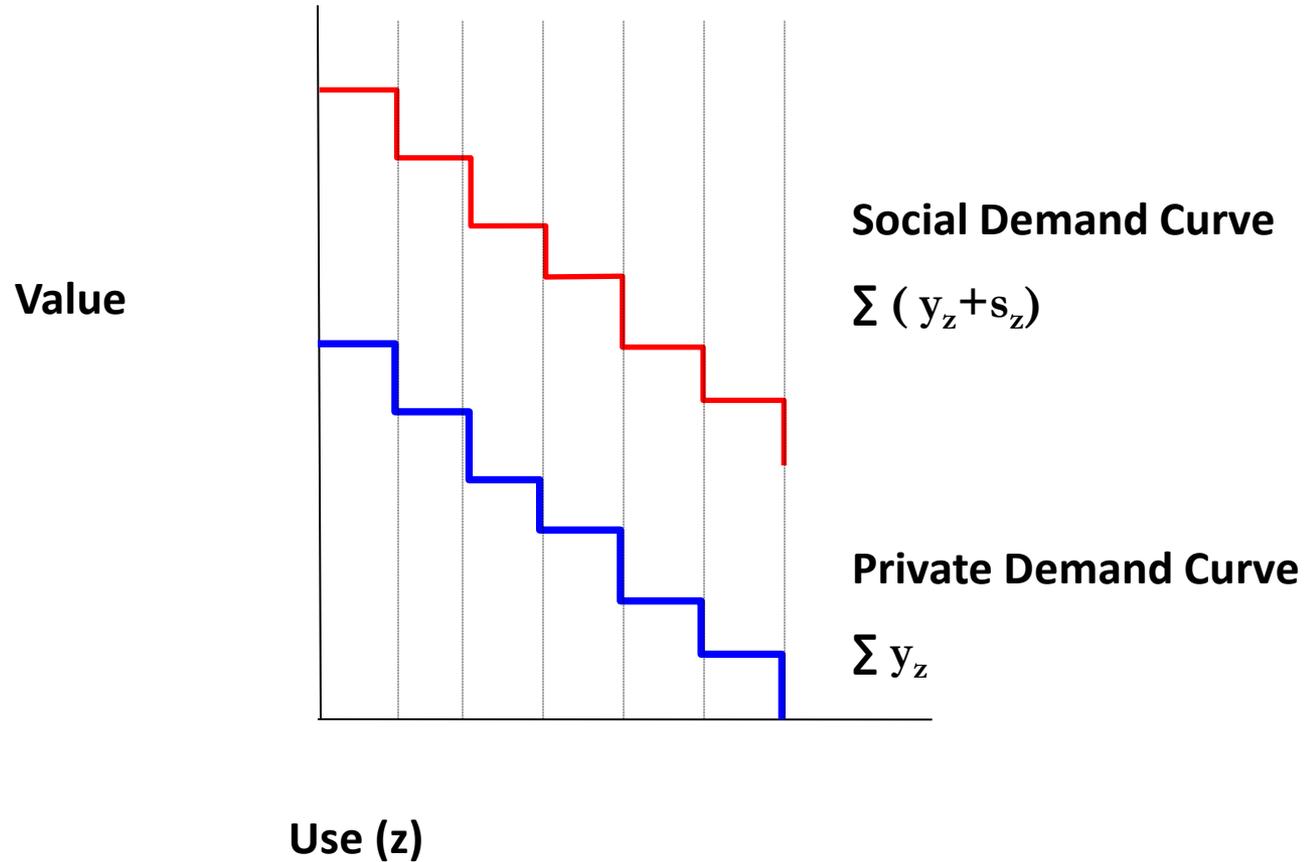
- Infrastructure enable many systems (markets and non-markets) to function and satisfy demand derived from many different types of users.
- Infrastructure are *not* special purpose resources, optimized for a particular user or use to satisfy the demand derived from a particular downstream market or set of markets.
- Infrastructure provide basic, multi-purpose functionality.



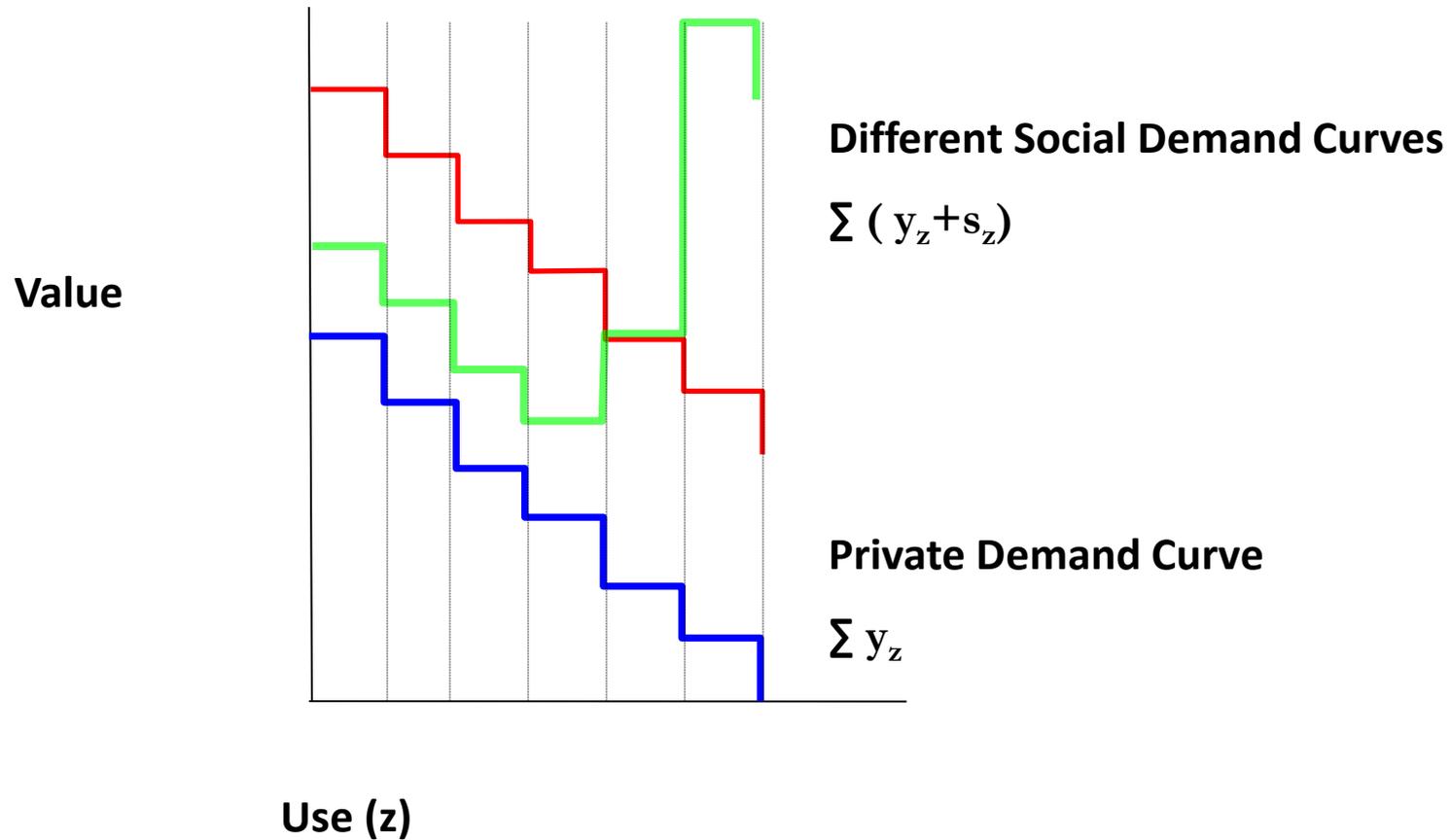




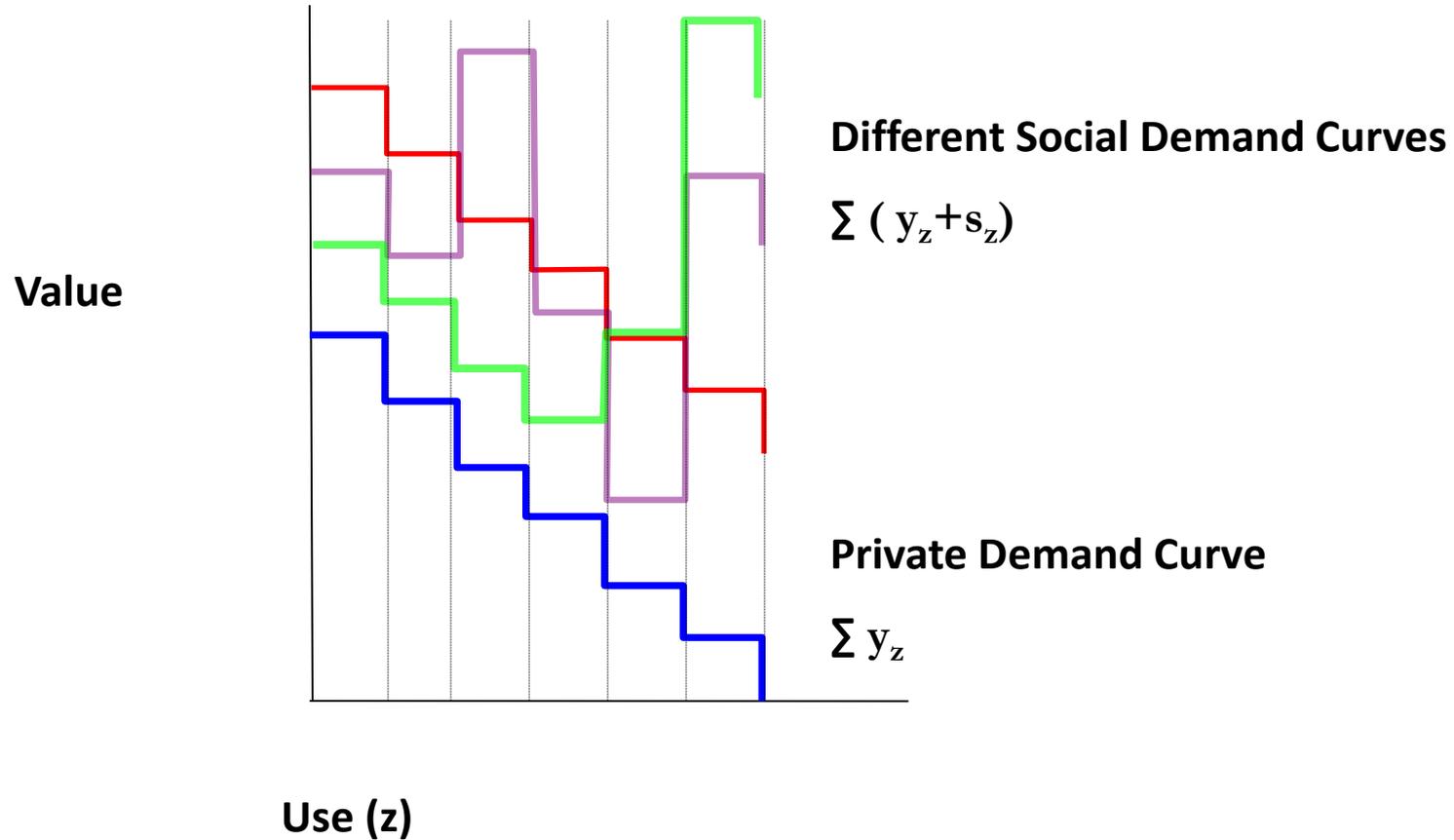
Uses z_1, z_2, z_3, \dots ranked according to aggregated willingness to pay.



Note: Uses z_1, z_2, z_3, \dots ranked according to aggregated willingness to pay.



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YouTube

Matthew's Birthday Party Video:

<http://www.youtube.com/watch?v=2PcxxiDvgRc>

stats:

168 views

0 likes, 0 dislikes

0 comments

Intended audience? Maybe 25?

Charlie bit my finger -- again! Video:

http://www.youtube.com/watch?v=_OBlgSz8sSM

stats:

469,739,454 views

934,803 likes, 131,326 dislikes

754,333 comments

Intended audience? 1? Maybe 25?

YouTube

Matthew's Birthday Party Video:

<http://www.youtube.com/watch?v=2PexxiDvgPc>

Small scale spillovers add up when activity is widespread.

0 comments

Intended audience? Ma

Charlie bit my finger -- ag

<http://www.youtube.com/watch?v=JGhUgkzYdYk>

stats:

469,739,454 views

934,803 likes, 131,320

754,333 comments

Intended audience? 1? M

Substantial spillovers from a single video.

Ma

<http://www>

Small scale
is widespread

Ex ante, neither
market nor
government will
efficiently select or
support either type.

en activity

Charl

<http://www>

Open infrastructure,
however, supports
basic user capability.

tial
s from a

934,803 likes, 131,320

754,333 comments

single video.

Intended audience? 1? M

Infrastructure typology

- Output focused
- Potential to generate positive externalities
- Potential for demand side market failure because output producers will not fully represent societal demand

Infrastructure Typology

Commercial:

Nonrival or partially (non)rival input into the production of a wide variance of *private goods*.

Public:

Nonrival or partially (non)rival input into the production of a wide variance of *public goods*.

Social:

Nonrival or partially (non)rival input into the production of a wide variance of *social goods*.

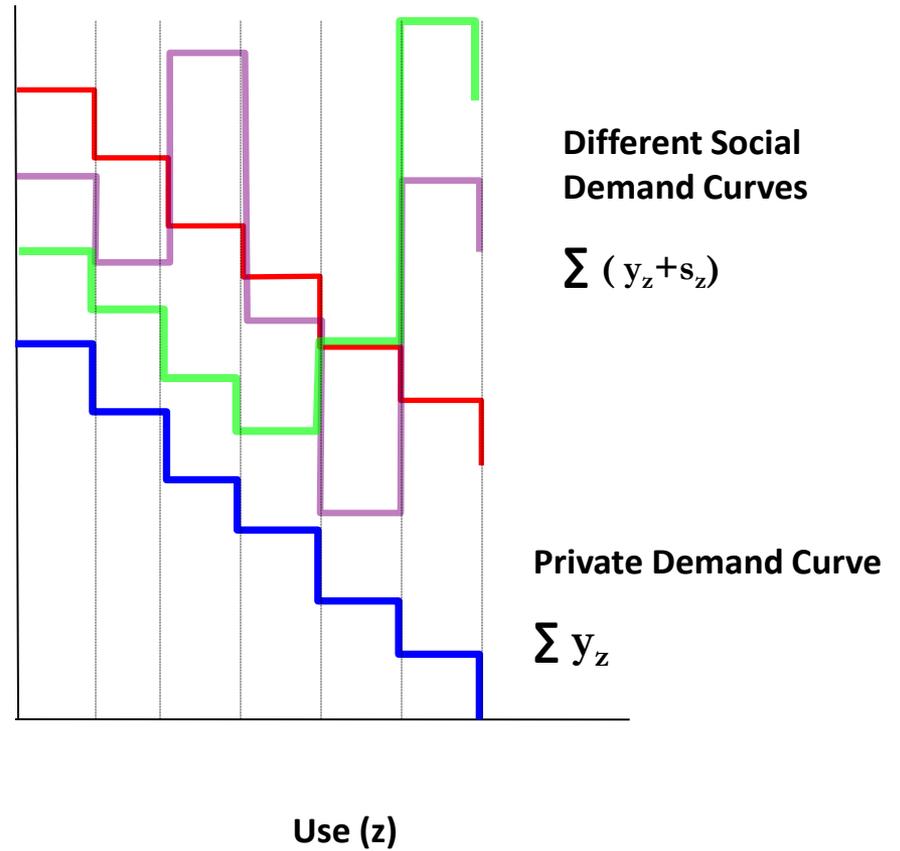
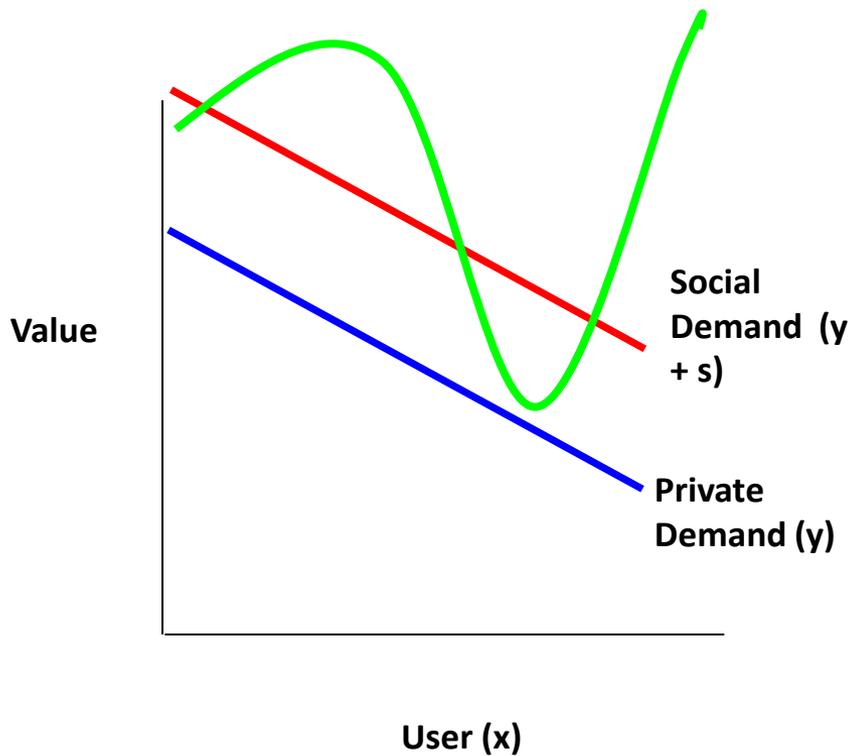
Demand side problems?

- Commercial Infrastructure
 - competitive markets (for both inputs and outputs) should work well
 - rely on antitrust principles
 - from the demand-side, there is less reason to believe that government intervention into markets is necessary, absent anticompetitive behavior

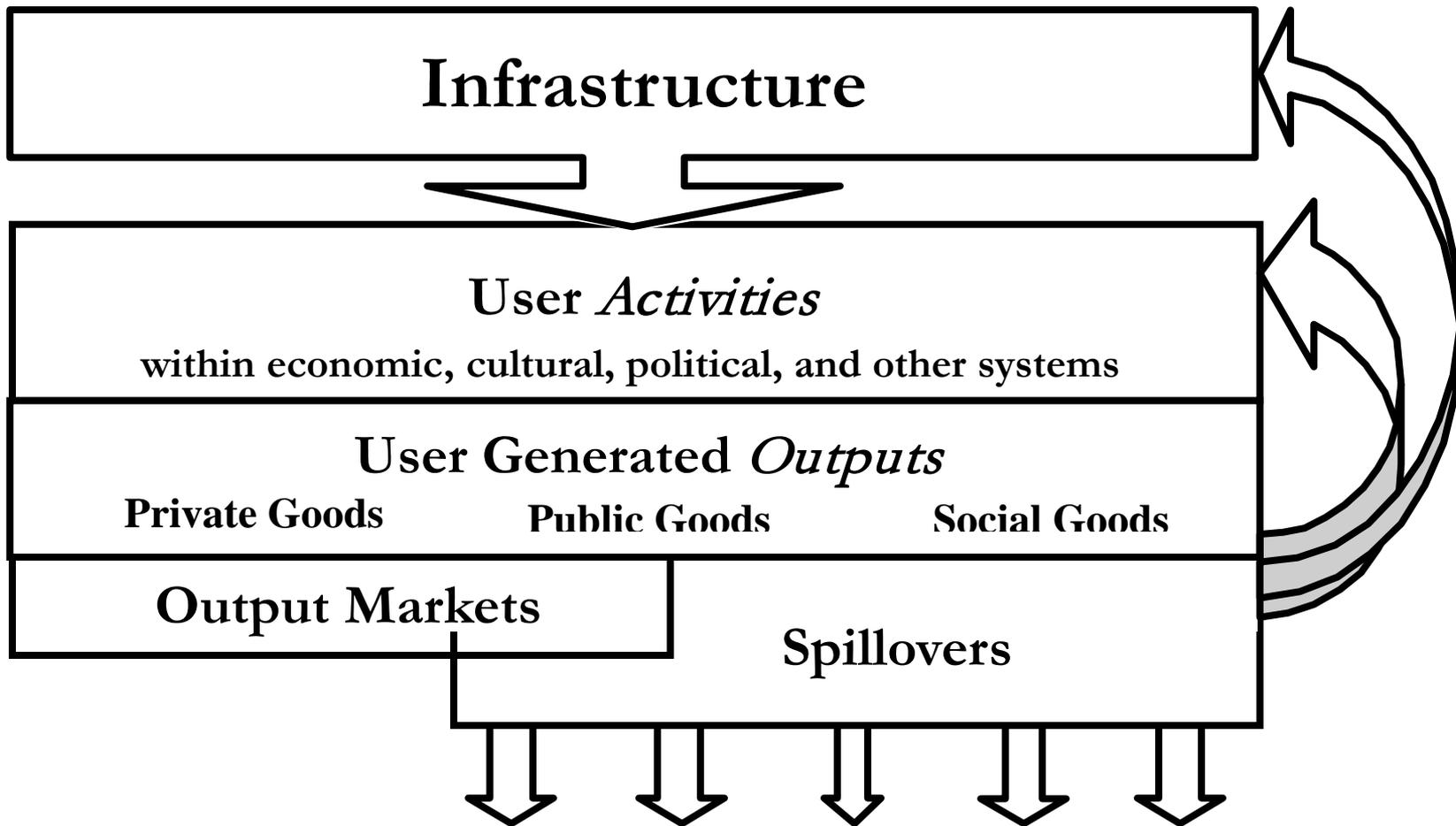
Demand side problems?

- Public and Social Infrastructures
 - Market bias / Optimization for
 - Applications/uses that generate observable and appropriable value (rather than spillovers)
 - Known or expected applications/uses
 - Demand manifestation problems may lead to undersupply of public and social goods and/or misoptimization of infrastructure

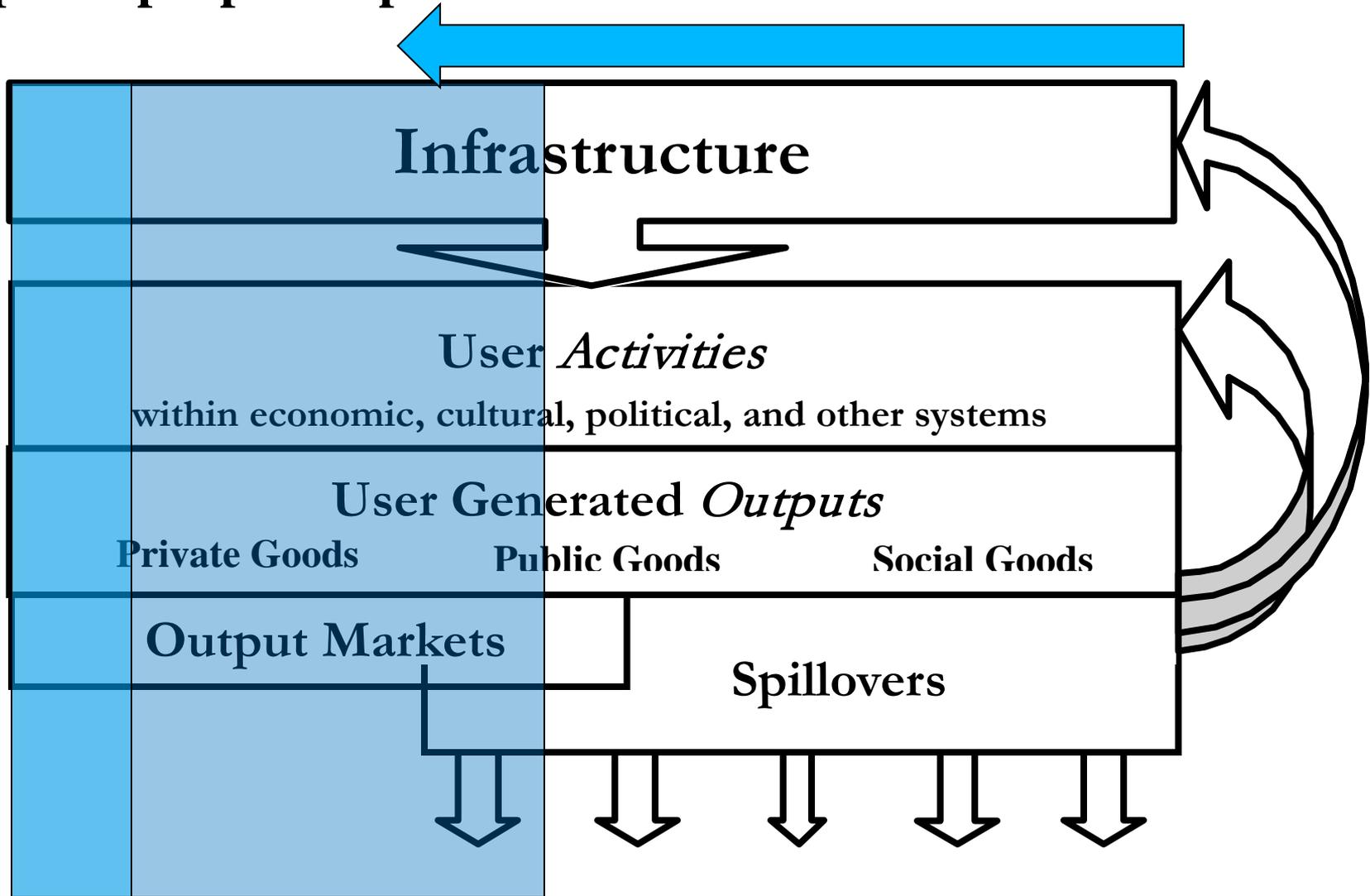
Why does this matter?



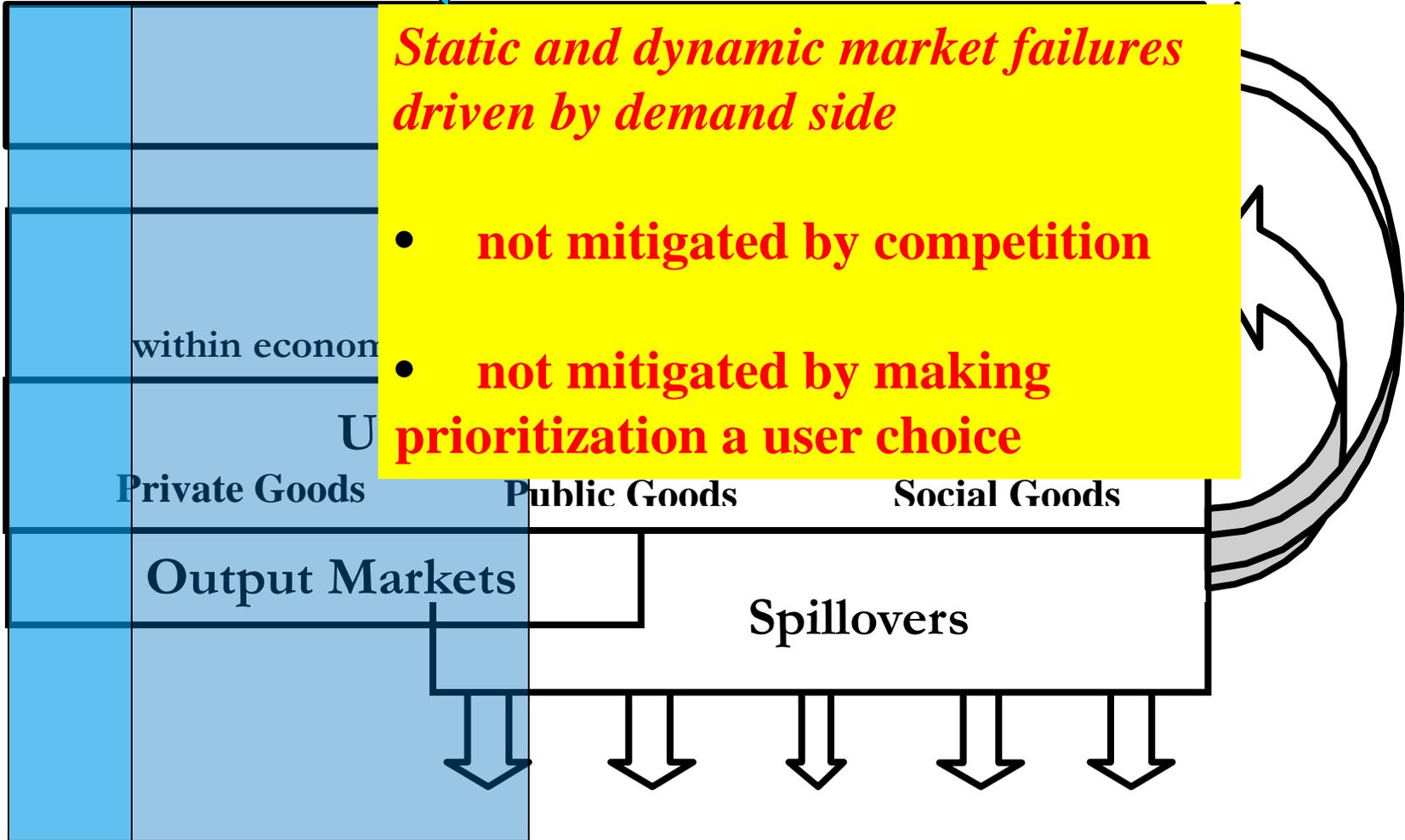
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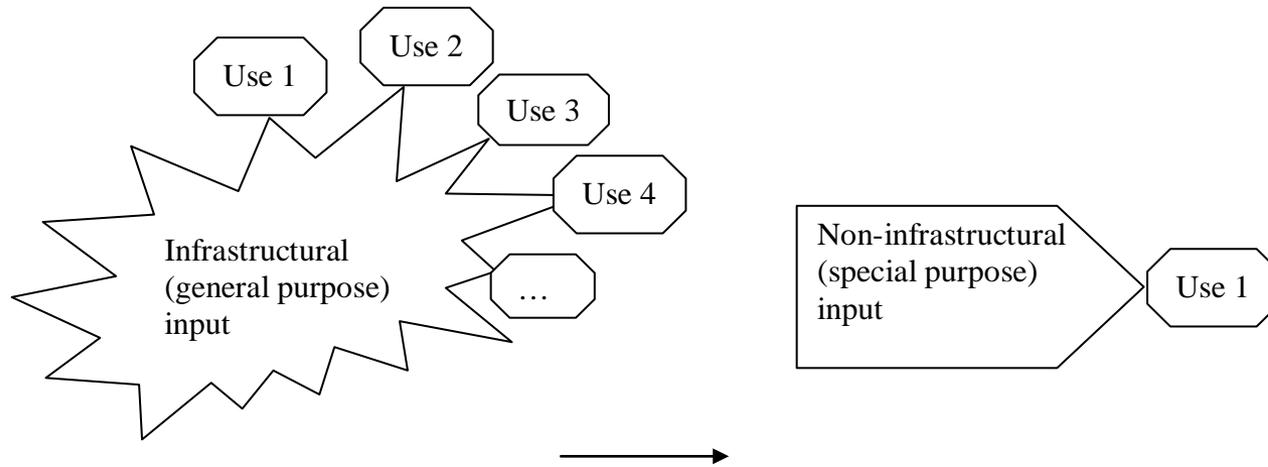
Special purpose input? Commercial infrastructure?



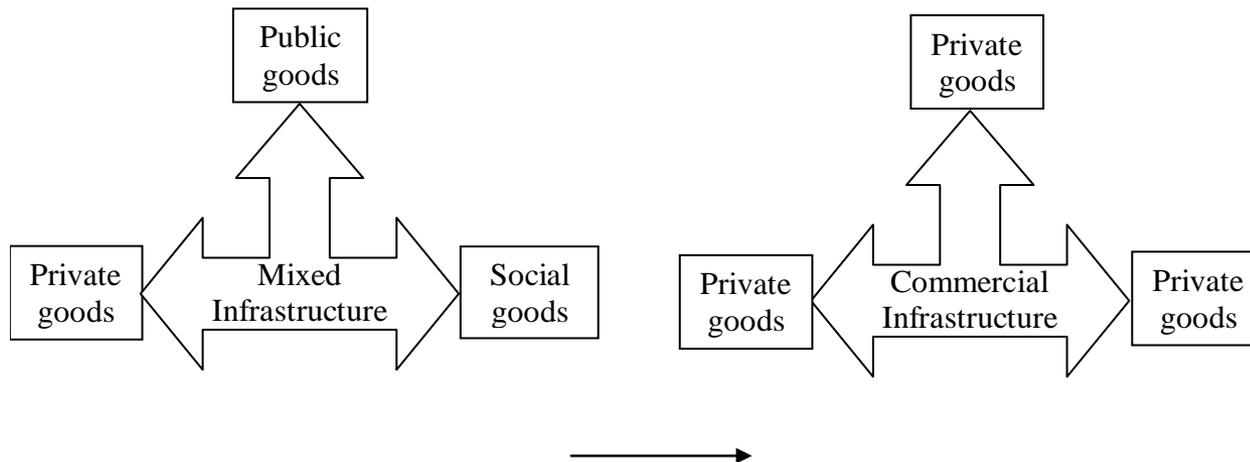
Special purpose input? Commercial infrastructure?



First, evolution from infrastructure to non-infrastructure:



Second, evolution from mixed infrastructure to commercial infrastructure:



Infrastructure

COMMONS MANAGEMENT

User Activities

within economic, cultural, political, and other systems

User Generated Outputs

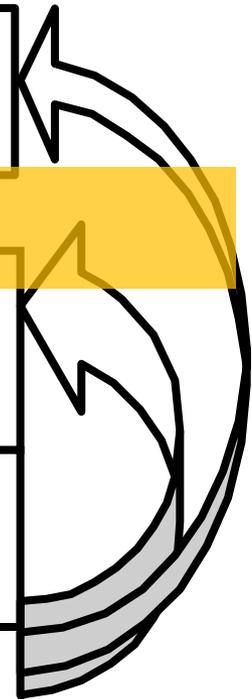
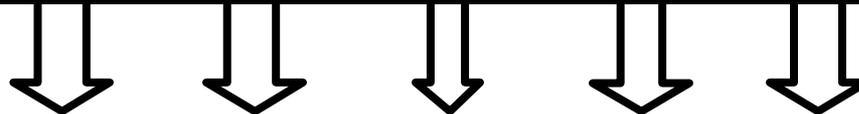
Private Goods

Public Goods

Social Goods

Output Markets

Spillovers



- Commons alleviates the need to rely on either the market mechanism or the government to “pick winners”
 - Market allocates access to infrastructure based on appropriability of returns from outputs
 - *Market failures w/r/t public and social goods*
 - Could rely on the government to figure out which public good or social good outputs are worthy of subsidization or special treatment
 - *Government failures w/r/t with public and social goods*

Option Theory

- Option theory
 - When to optimize or specialize?
 - When to wait and see?
 - What variables drive decision making?
- Social option
 - High uncertainty regarding which users or uses will generate social value

Infrastructural Resources

1. The resource may be consumed nonrivalrously;

COMMONS MANAGEMENT

2. social demand for the resource is driven primarily by downstream productive activity that requires the resource as an input; and
3. the resource is used as an input into a wide range of goods and services, including private goods, public goods and/or social goods.



Small Group Discussion / Reflection

- How do the concepts discussed apply to your specific area of study?
- What examples come to mind?
- What are the implications of this type of economic analysis for the examples?

Discuss in small groups for 5 minutes.

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**What about roads,
computer networks
and other
infrastructures that
are congestible?**

Managing congestion

Partial nonrivalry, congestion, and the tragedy of the commons

Target Variable / Cause of Congestion	Solution
Resource capacity / insufficient capacity	Capacity expansion / maintain excess capacity
Number of users / too many users	Limit community membership / user population
External cost / distorted price	Congestion / usage-sensitive pricing
Heterogeneous uses / cross-crowding	Use restrictions

Hardin (1968: 1244):

Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. As a rational being, each herdsman seeks to maximize his gain. Explicitly or implicitly, more or less consciously, he asks, "What is the utility to me of adding one more animal to my herd?" This utility has one negative and one positive component.

- 1) The positive component is a function of the increment of one animal. Since the herdsman receives all the proceeds from the sale of the additional animal, the positive utility is nearly +1.
- 2) The negative component is a function of the additional overgrazing created by one more animal. Since, however, the effects of overgrazing are shared by all the herdsman, the negative utility for any particular decision-making herdsman is only a fraction of -1.

Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another; and another.... But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit--in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all.

Ostrom (2007: 15183):

Hardin envisioned a pasture open to all in which each herder received a direct benefit from adding animals to graze on the pasture and suffered only delayed costs from overgrazing. Translating his metaphor into a theory requires five assumptions:

- (i) the resource system is a pasture;
- (ii) no governance system is present related to the resource system;
- (iii) the mobile individual resource units (the animals grazing on the pasture) can be identified and are the property of their owners and, when fattened, can be sold for cash;
- (iv) a sufficient number of users, given the size of the pasture, are using the pasture to adversely affect its long-term productivity; and
- (v) the resource users independently make decisions to maximize their own short-term returns.

These five assumptions ... lead to a theoretical prediction of very high harvesting of the pasture grasses and severe overharvesting or destruction of the ecological system.

Situations characterized by these assumptions, in which individuals independently make anonymous decisions and primarily focus on their own immediate payoffs, do tend to overharvest open-access resources. Researchers have repeatedly generated a “tragedy of the commons” in experimental laboratories when subjects make independent and anonymous decisions in a common-pool resource setting.

Making one small change... in the structure of laboratory experiments, a change that is predicted by game theory to make no difference in the predicted outcome, has repeatedly had major impacts on interactions and outcomes. Simply enabling subjects to engage in face-to-face communication between decision rounds enables them to approach socially optimal harvesting levels rather than severely overharvesting the commons. In the face-to-face discussions, participants tend to discuss what they all should do and build norms to encourage conformance.

Managing congestion

Relationship between commons management and congestion management

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Chapter 12: Intellectual Infrastructure

- A. The Cultural Environment as Infrastructure (Meta- or Infra-
infrastructure)
 - B. Economic Characteristics of Intellectual Resources
 - 1. Supply-side problems
 - a. (Non)excludability
 - b. Nonrivalry
 - 2. Intellectual resources and activities, products and processes
 - C. Intellectual Infrastructure
 - 1. Applying the criteria to delineate intellectual infrastructure
 - 2. Ideas
 - a. Ideas as Infrastructure
 - b. Commons Management via First Amendment, Copyright, and Patent
Jurisprudence
 - D. Intellectual Property Laws as Semi-commons Arrangements
- Appendix: Basic Research

What is intellectual infrastructure?

Nonrival inputs into wide variety of outputs

Examples

1. Ideas
2. Basic Research
3. Research Tools
4. Programming Languages
5. Operating Systems
6. Others – Some business methods,
manufacturing processes,
7. Public Domain(s)
8. ...

How might the law differentiate between
infrastructure and non-infrastructure?

Subject matter exclusion

Breadth / scope of rights

Use rights of others

Channeling doctrines (*Sony*)

Ideas

If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea.

— jefferson (1813)

The general rule of law is, that the noblest of human productions — knowledge, truths ascertained, conceptions, and ideas — become, after voluntary communication to others, free as the air to common use. Upon these incorporeal productions the attribute of property is continued after such communication only in certain classes of cases where public policy has seemed to demand it.

— ins v. ap

Nonrival inputs

- Ideas

Uses / User Activities / Processes

- Expression/communication/education
- Implementation / transformation of the physical or social world
- Further idea production / research

Wide Variety of Outputs

- Expressions
- Implementations
- Knowledge, more ideas, etc.

Commons Management via First Amendment, Copyright, and Patent Jurisprudence

1st Am: Ideas are in the public commons

Patent: (Abstract) ideas are not patentable,
but a specific application, implementation, or use
of an idea can be

Copyright: Ideas are not copyrightable,
but a specific expression can be

Semi-commons at different scales

Macro level, the cultural environment constitutes mixed infrastructure managed as a semi-commons (*commons default*).

Meso level, patent and copyright regimes constitute and construct semi-commons

Micro level, individual inventions and works are managed as semi-commons

Interdependent mix of private rights and commons at all levels!!!

Chapter 13: Network Neutrality

A. Internet Infrastructure and Commons Management through End-to-End Design

B. The Network Neutrality Debate

1. Network “Neutrality”

2. The Role of Antitrust and Regulatory Economics

a. The Supply-Chain View of the Internet

b. The False Supplier/Consumer Dichotomy

c. The Competition Red Herring

3. Innovation

C. Reframing the Debate

1. The Internet as Mixed Infrastructure

2. Commons Management

D. A Proposed Nondiscrimination Rule and Various Complications

1. Proposed Rule

2. Managing Congestion

3. Managing Unlawful, Hazardous, or Otherwise Harmful Traffic

Internet

- What makes the Internet valuable to society?

Layer	Description	Examples
Social	Relations and social ties among users	Social networks, affiliations, groups
Content	Information/data conveyed to end-users	E-mail communication, music, web page
Applications	Programs and functions used by end-users	E-mail program, media player, web browser
Logical Infrastructure	Standards and protocols that facilitate transmission of data across physical networks	TCP/IP, domain name system
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e2e architecture:
voluntary adoption of standards by various networks (physical infrastructure providers)

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Leads to what Barbara van Schewick calls application blindness!

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*Or what I call an
infrastructure commons!*

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Technologies and business practices that enable cheap deflection

Infrastructure commons under threat!

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Why? By whom?

Discuss: money, power, politics

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Suppose you have a problem at this layer?

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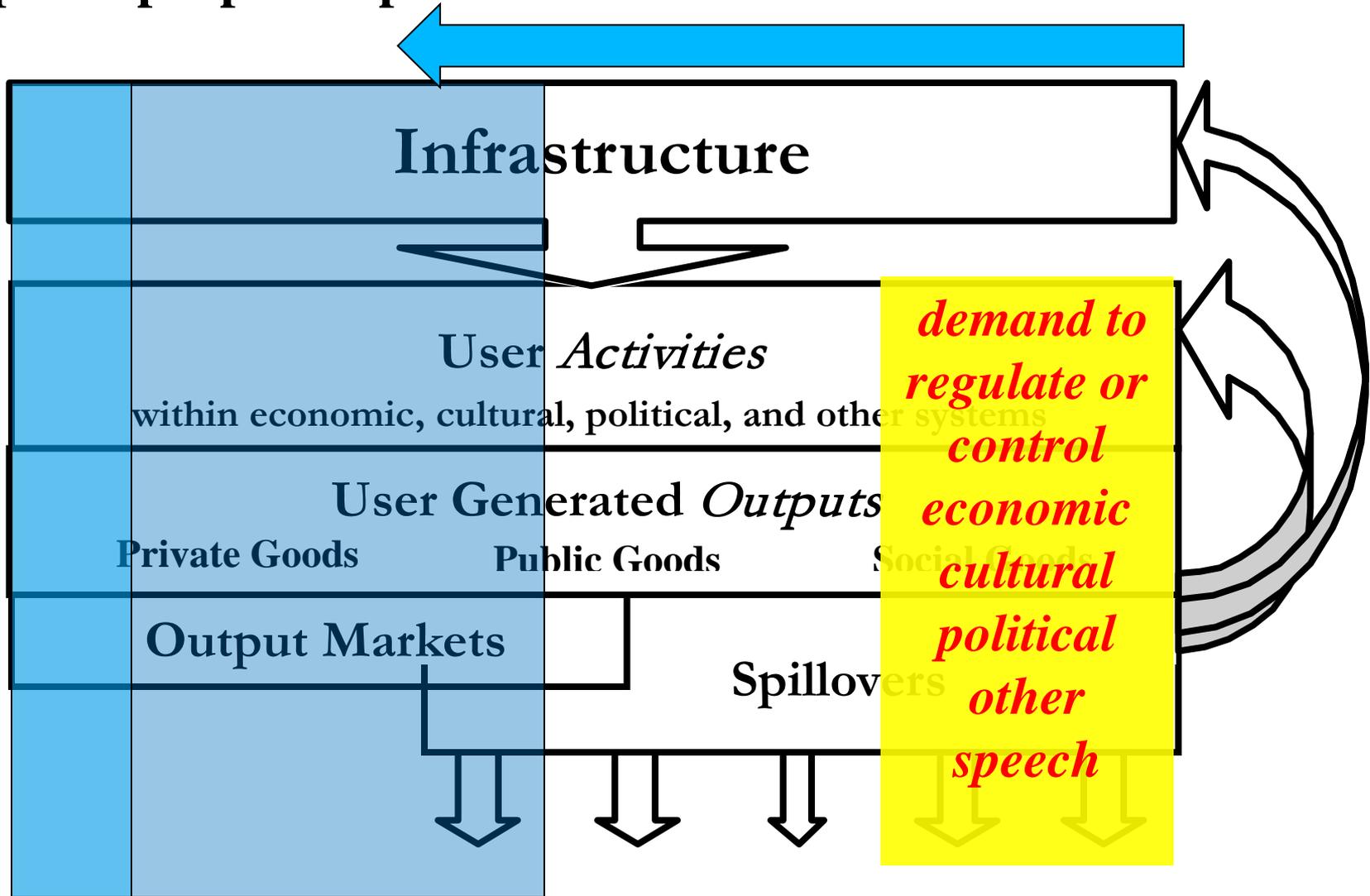
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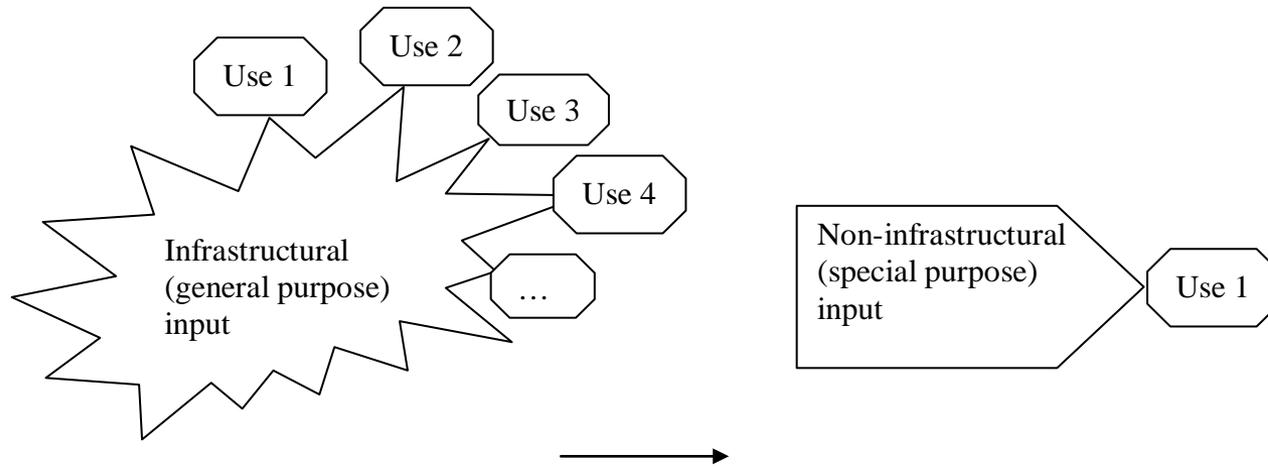
- *Why? By whom?*
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Five-Layer Model of the Internet

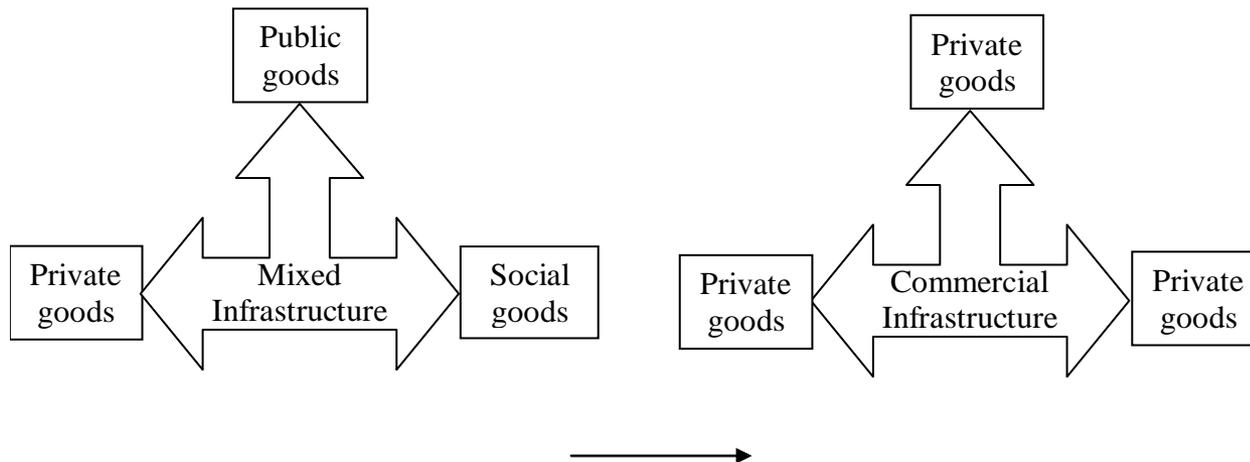
Special purpose input? Commercial infrastructure?



First, evolution from infrastructure to non-infrastructure:



Second, evolution from mixed infrastructure to commercial infrastructure:



Thank you!

**(switch slides for
GKC)**