Project on
Innovation and Access to Technologies for Sustainable Development

Sustainability Science Program, Harvard Kennedy School
Fellows' Orientation

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Presented by Suerie Moon

On behalf of the Project Co-Directors:
Laura Diaz Anadon (HKS), Kira Matus (LSE), Suerie Moon (HSPH)

smoon@hsph.harvard.edu

Overview

1. **Motivation**
2. **Key concepts**
3. **Project research questions & approach**
4. **3 Main Contributions**
   - Scalable model of innovation system
   - Sociotechnical conditions (STCs) for comparative analysis of technologies and system barriers across sectors
   - Typology of transnational functions

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Sustainable Development Objectives

Among others:

- **Food** security
- Access to sustainable **energy** for all
- **Health** as component and indicator of sustainable development
- Access to safe drinking **water** and sanitation
- Cleaner industrial production of **goods**

For present and future generations

What technologies might help to secure these goals?

Motivation for the Research

- **Insufficient research**: Neglected diseases, neglected crops
- Indoor cookstoves **not suited** for local foods
- Water desalination and purification technology **requires infrastructure** that doesn't exist
- Vaccines to prevent cervical cancer that are **too expensive**
- A system to improve rice yield largely **ignored by experts**
- **Few firms adopt** less toxic methods to manufacture chemicals

→ Underperforming global innovation systems

→ How? Why? What to do (at transnational level)?

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Global innovation *system*: Why?

- Empirical:
  - Innovation processes increasingly transnational : intensified cross-border flows of knowledge and ideas, capital, goods, services, people, with globalization
  - Threats to sustainable development increasingly transnational: cross-border flows of pollutants, pathogens, scarcity, volatility
  - Knowledge at the heart of technological innovation – major externalities, potential to be a global public good
- Normative: Sustainable development as global goal
- Practical:
  - Realizing benefits and reducing harms of technological innovation for sustainable development likely to require transnational arrangements

Global innovation *system*: Why?

- Scholarship & Policy:
  - Innovation policies: primarily national in motivation & scope
  - Conceptual frameworks to understand, design and evaluate policies primarily national
  - Unlikely to capture the complex dynamics of increasingly globalized innovation systems,
  - Unlikely to provide adequate understanding of how to make such systems work better for sustainable development.
  - Need frameworks and research to enhance understanding of complex transnational innovation processes

Global innovation *system*: What?

- **Definition**: the **actors** and **institutions** whose interactions shape the innovation process beyond national borders.

- **Actors**: individuals and/or organizations with agency in the system
  - Individuals: farmers, scientists or entrepreneurs, and
  - Organizations: governmental bodies; intergovernmental organizations; private firms; not-for-profit entities; research organizations; community-based organizations; collaborative entities that link multiple organizations, such as public-private partnerships.
  - Public, private, academic, non-profit, or hybrid, operating local to global level.

- **Institutions**: sets of formal and informal rules, norms, decision-making procedures, beliefs, and expectations that govern the interaction of actors.
  - Formal binding intergovernmental agreements
  - Non-binding normative texts (e.g. post-2015 Sustainable Development Goals);
  - Less formally codified norms (e.g. voluntary codes of conduct among firms)
  - Emerging discourses around rights to energy, a clean environment, or sanitation.

- Sector/Technology specific: e.g. “global innovation system for seeds”

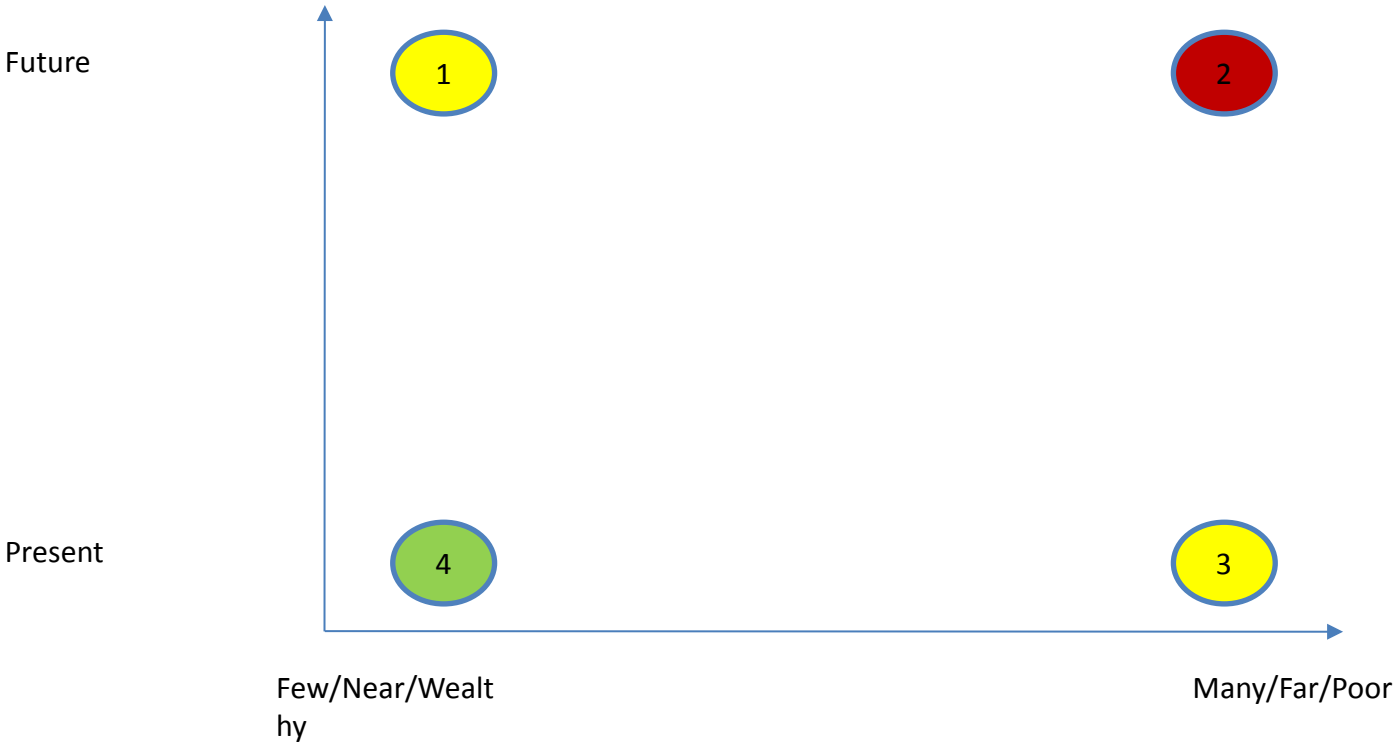
Definition of Technology

- **Technology**: “‘knowledge of how to fulfill certain human purposes in a specifiable and reproducible way (Brooks)” including devices and methods or processes, as well as “assemblages of practices and components” and the “collection of devices and engineering practices available to a culture (Arthur).”

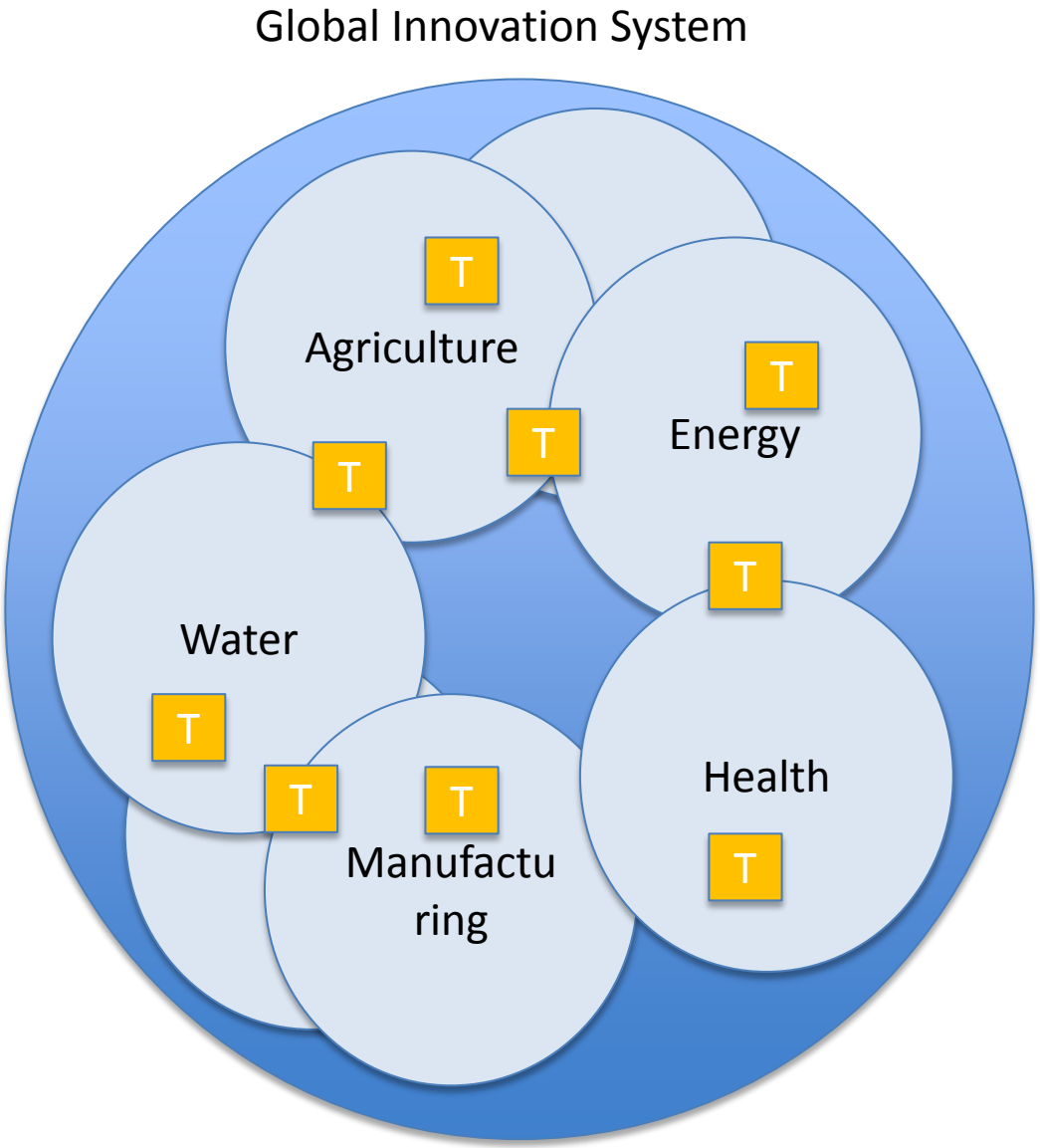
Global innovation system failures

Innovation system inadequate…

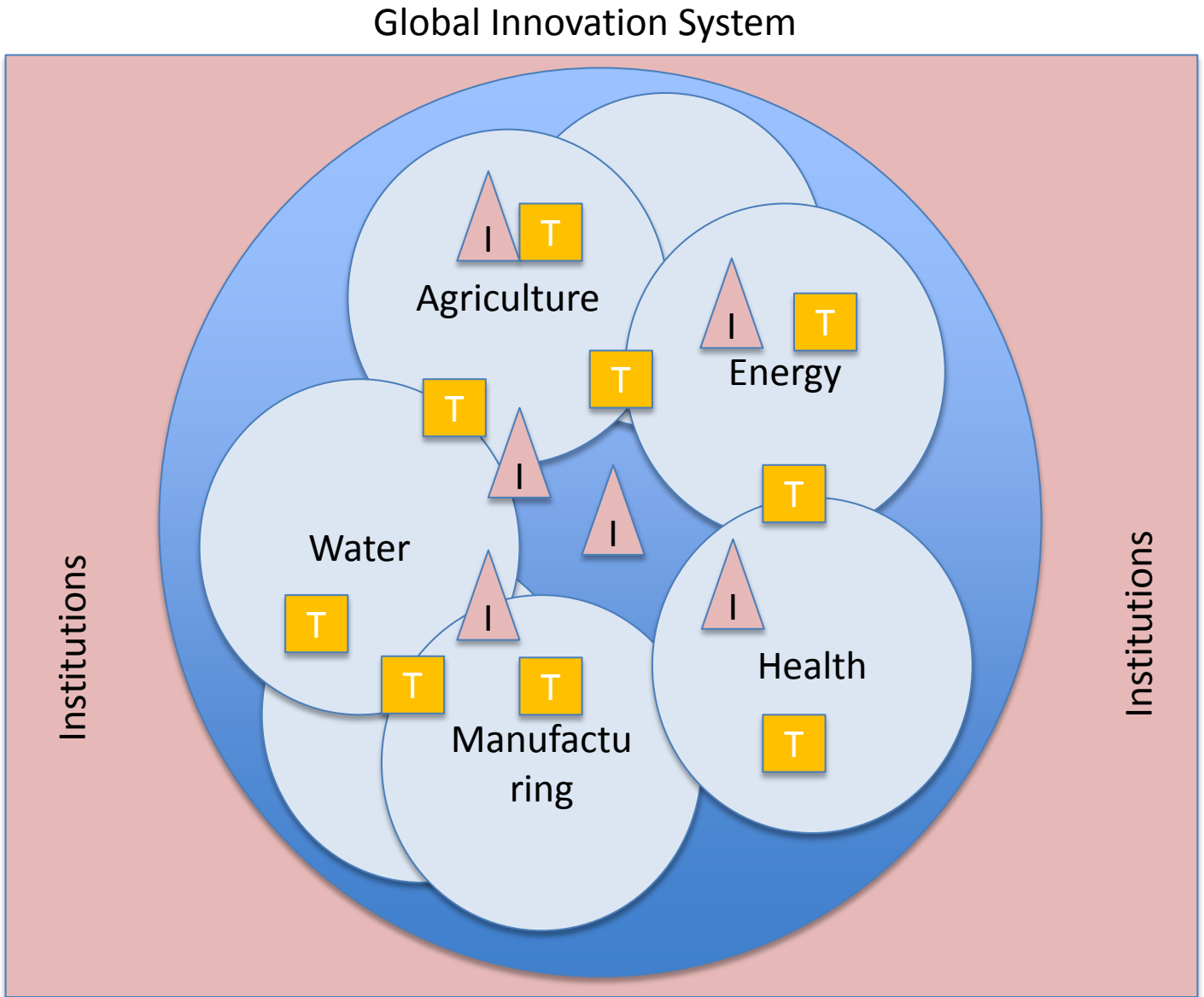
- …for problems affecting populations with relatively weak political or economic power (1,2,3)
- …for problems with large positive externalities across borders or generations (1,2,3)



Sectors & Technologies



Sectors & Technologies & Institutions



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Key Research Questions

1. How and why does the global innovation system fail to maximize the potential of science and technology to contribute to sustainable development?

2. How can the system be strengthened to do so?

Building on prior work	Project Approach
National innovation systems	*Global innovation "system"*
Focus on one stage, e.g., invention	*Incorporate all stages into a complex system*
Meet present needs, without compromising future generations' needs	*Yes…with special attention to equity*
Focus on actors, or institutions, or technologies	*Focus on actors + institutions + technologies (and on transnational interventions)*
Focus on one sector / need / field or type of technology	*Cross-sectoral comparison & learning, technologies broadly defined*

Project to Date

1. Development of common framework of actors, institutions, and innovation stages
2. Background papers on each sector building on existing literature
   - Evolution of international norms
   - Description of the key actors & institutions in each sector
   - Summary of major gaps in information needed to understand the system
3. 18 case studies
4. Synthesis Paper
5. Spring ‘14 Major academic workshop with workshop report

18 cases across 5 sectors

Spanning different technology development phases, technology types, and novel strategies

Energy

- Rural PV - Bangladesh
- Cookstoves - Sudan & Ethiopia
- Carbon capture and storage - USA
- Geothermal - Kenya

Health

- Heat stable vaccines – USA, global
- Ready to use therapeutic foods – France, global
- AMF Malaria - SSA, etc
- Cancer treatment - India

Manufacturing

- Industrial symbiosis – Denmark, S Korea
- Higg Index

Agriculture/Food

- Biopesticides - Kenya
- Cassava bread - Nigeria
- Cocoa genome - USA
- Drip irrigation – India, Africa
- System of rice intensification - India

Water

- Wastewater reuse – Australia, Middle East
- Ceramic pot filters – Ghana
- Apps for water sanitation - global

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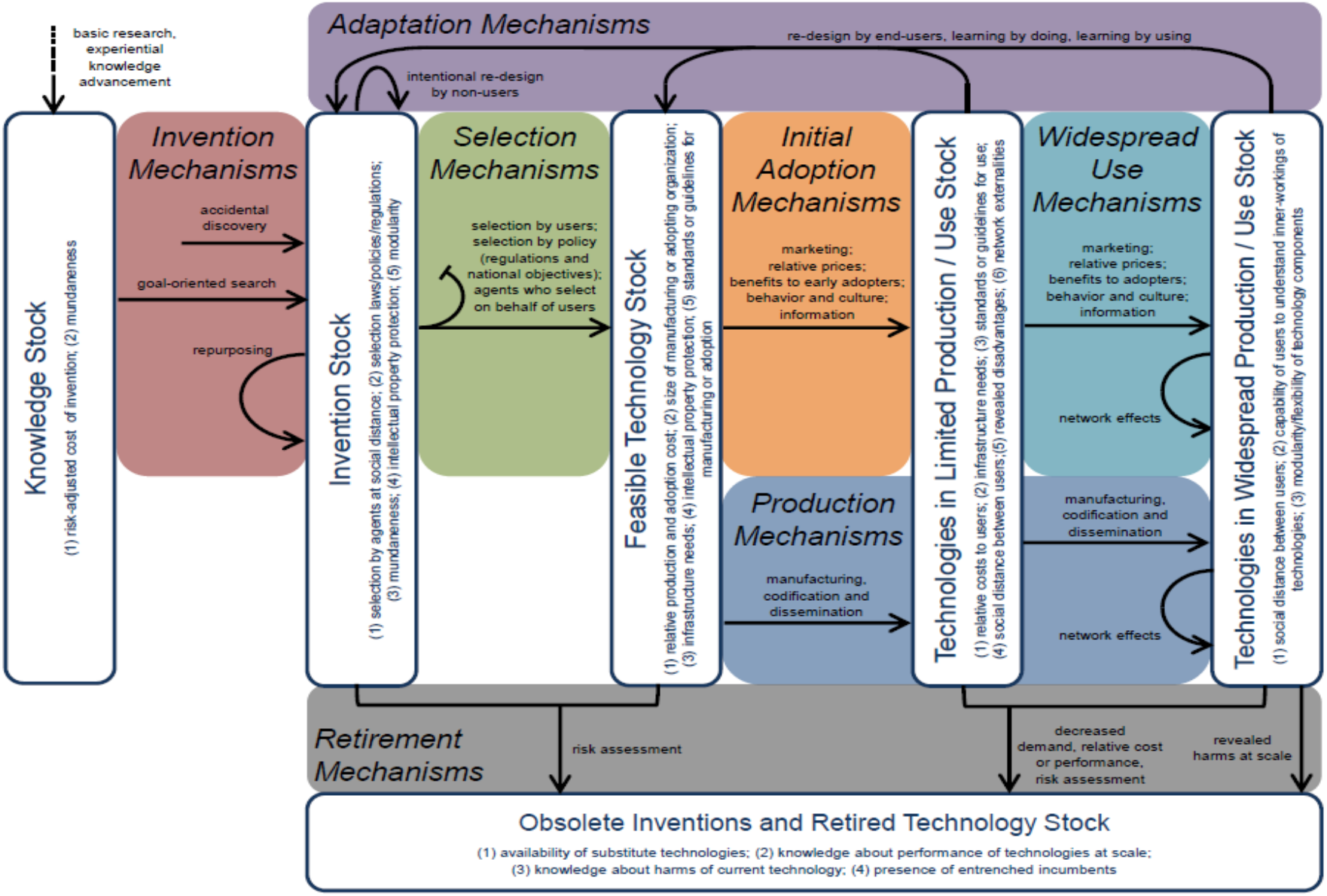
   - Typology of transnational functions **(recommendation)**

Scalable model of innovation systems



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Process for identifying commonalities across cases

1. Tried to compare cases across the whole innovation process
2. We then hypothesized that cases may share features at different points in the innovation system

What are socio-technical conditions (STCs)?

- Properties relevant for explaining the extent to which different technologies were able to flow and evolve between stocks
- "Socio-technical" encompasses both technological aspects, and the social practices and context that relate to the technology
- Certain STCs can inhibit the flow of technology between stocks

Sets of socio-technical conditions by flow

From Knowledge to Invention Stock (invention)

- Risk-adjusted cost of invention
- Mundaneness

From Invention to Feasible Technology Stock (selection)

- Selection by agents, selection by laws
- Mundaneness
- IP
- Modularity

From Feasible Tech. to Tech. in Limited Use Stock (production/initial adoption)

- Relative prod. & adopt. cost
- Size of adopting entity
- Infrastructure needs
- IP
- Standards and guidelines

From Tech in Limited Use to Widespread Use Stock (production/adoption)

- Relative prod. & adopt. costs
- Infrastructure needs
- Standards and guidelines
- Revealed disadvantages
- Network externalities

From Widespread Use to Other Stocks (adaptation)

- Social distance between users
- Capability of users
- Modularity of technology

Flow into Obsolete Stock (obsolescence)

- Availability of substitute technologies
- Knowledge about performance and harms at scale
- Presence of incumbents
- Standards and guidelines

Identified sets of conditions that inhibit flows

e.g., ceramic water filters and cookstove cases

- Invention
  - Both: high risk-adjusted cost of invention and mundane
  - Developed in an ad-hoc fashion by researchers in the US in their “free time” due to funding scarcity and lack of incentives
  - Generally they do not get invented through ‘goal-oriented search’
- Selection
  - Ceramic filters selected by agents, cookstoves by agents working with users
  - Cookstoves seem to have resulted in greater and more long-lasting demand

Uses of the innovation framework and the concept of socio-technical conditions

- STCs allow us to identify what successful strategies in some of our cases may be applicable to others within our set of cases
- Checklist of things to think about when deciding to promote a particular technology (at all scales) ➔ diagnosis
- Common terminology to enable discussions across practitioners and scholars in various sectors
- Applied at the global level, we have tentatively identified system gaps for technologies with specific STCs

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3 types of transnational functions

1. **Core functions**: cannot be performed by any one nation-state alone (e.g. cross-border externalities)
2. **Facilitating functions**: can make the system work more efficiently or effectively (e.g. economies of scale)
3. **Supportive functions**: to support countries with shortage of necessary resources (e.g. information, expertise, skills, financing, normative authority, or convening power).

Functions

Type	Sub-function
Core	1. Negotiating norms, rules, standards
	2. Managing transnational externalities
Facilitating	3. Setting transnational/global goals, priorities and agendas
	4. Reducing information asymmetries
Supportive	5. Reducing social distance between local populations and transnational actors
	6. Building capacity
	7. Reducing (financial) costs
	8. Reducing risk

Using STCs to prescribe functions

Sociotechnical condition	Transnational function	Case study examples
High relative costs to users (impeding flow from limited to widespread use)	Reduce costs	-Global subsidy on malaria medicines -Drip irrigation
Absence of standards and guidelines (impeding flow from feasible technology to limited use)	Negotiate norms, rules, standards	- Higgs Index for “cleaner” clothing manufacturing

Resource needed to perform function	Transnational Functions
a) Normative authority	Set goals, priorities & agendas Reduce transaction costs Internalize externalities
b) Convening power	Reduce transaction costs Reduce social distance Build capacity Internalize externalities
c) Information	Reduce transaction costs Reduce information asymmetries Reduce social distance Reduce risks
d) Expertise/skills	Build capacity
e) Finance	Internalize externalities Reduce (net) costs Reduce risks Build capacity

Some proposals for consideration:

When invention involves high costs or risks (eg medicines, cookstoves)

→ internationally-pooled funds to reduce R&D costs and risks.

When end-user is a small organization or entity (eg farming household)

→ international support for training and information provision, eg extension services.

When high relative prices to end-users for highly beneficial technologies

→ international subsidization in the short- or longer-run.

When high social distance between inventors and selectors

→ transnational convening or information provision

Summary & Conclusions

1. Common framework (across sectors, stages, technologies) for describing, diagnosing and recommending policies to strengthen the global innovation system for sustainable development

2. Not a blueprint for monolithic global system → recommendations specific to technology, &context

3. Emerging global innovation system → more robust transnational institutional arrangements needed

Project Lead: William Clark

Project Co-Directors (sector leads): Suerie Moon (health); Laura Diaz Anadon (energy); Kira Matus (manufacturing)

Sector Leads: Sharmila Murthy (water); Alicia Harley (food)

Other key Fellows in residence: Gabe Chan (energy)

Other Contributors: Ahmed Abdel Latif (International Centre for Trade and Sustainable Development), Dwayne Appleby, Kathleen Araujo (Harvard Kennedy School), Francesca Bichai (Harvard Kennedy School, Kayje Booker (Forward Montana), Hyundo Choi (Chosun University), Kristian Dubrawski (McKinsey), Ram Fishman (George Washington University), Lonia Friedlander (Stony Brook University), Christina Ingersoll (MIT Sloan), Arani Kajenthira (Harvard Kennedy School), Erin Kempster (Massachusetts Department of Public Utilities), Laura Pereira (University of Cape Town), John-Arne Rottingen (Norwegian Institute of Public Health), Jennie Stephens (Clark University), Vanessa Timmer (One Earth), Livio Valenti (Vaxess), Lee Vinsel (Stephens Institute of Technology), Mark Williams (Harvard Kennedy School), Paul Wilson (Columbia University), Alyssa Yamamoto (Harvard College)

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Questions/comments to smoon@hsph.harvard.edu or any project participant

THANK YOU