Designing property rights for biodiversity and biological information

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Lecture Outline

- Defining property rights
- The appropriable aspects of biodiversity
- Identifying owners
- The theory of optimal ownership
- Recent developments in the ownership of biodiversity and biological information
- Application: The management of biological information

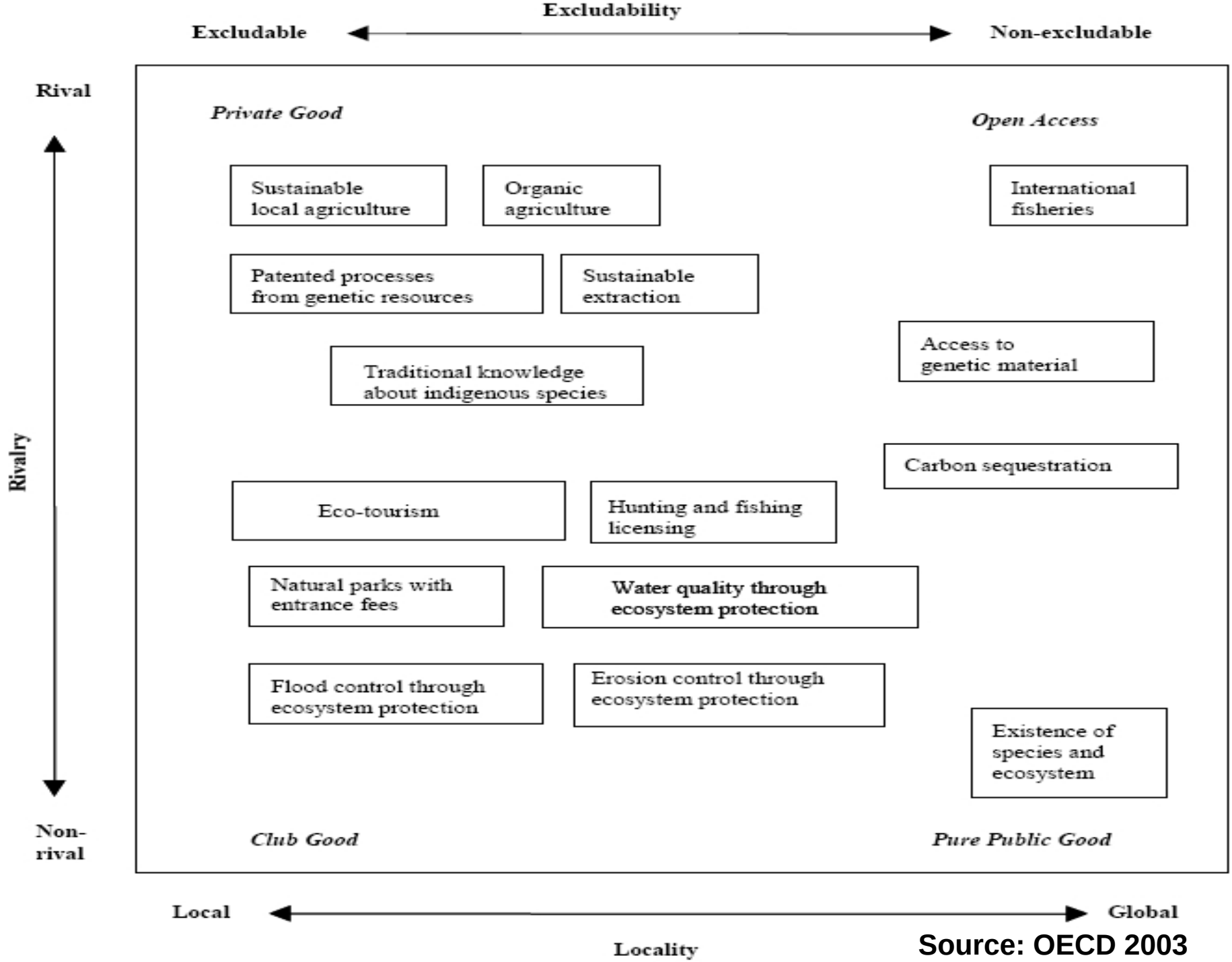
Defining property rights

Definition

- A property right is an alienable and enforceable right to exclude others from access to the flow or stock benefits generated by a specific appropriable good or service.
- Dimensions
  - Alienability => trade
  - Enforceability => security of tenure
  - Specificity => Completeness of contracts
  - Appropriable => nature of the good

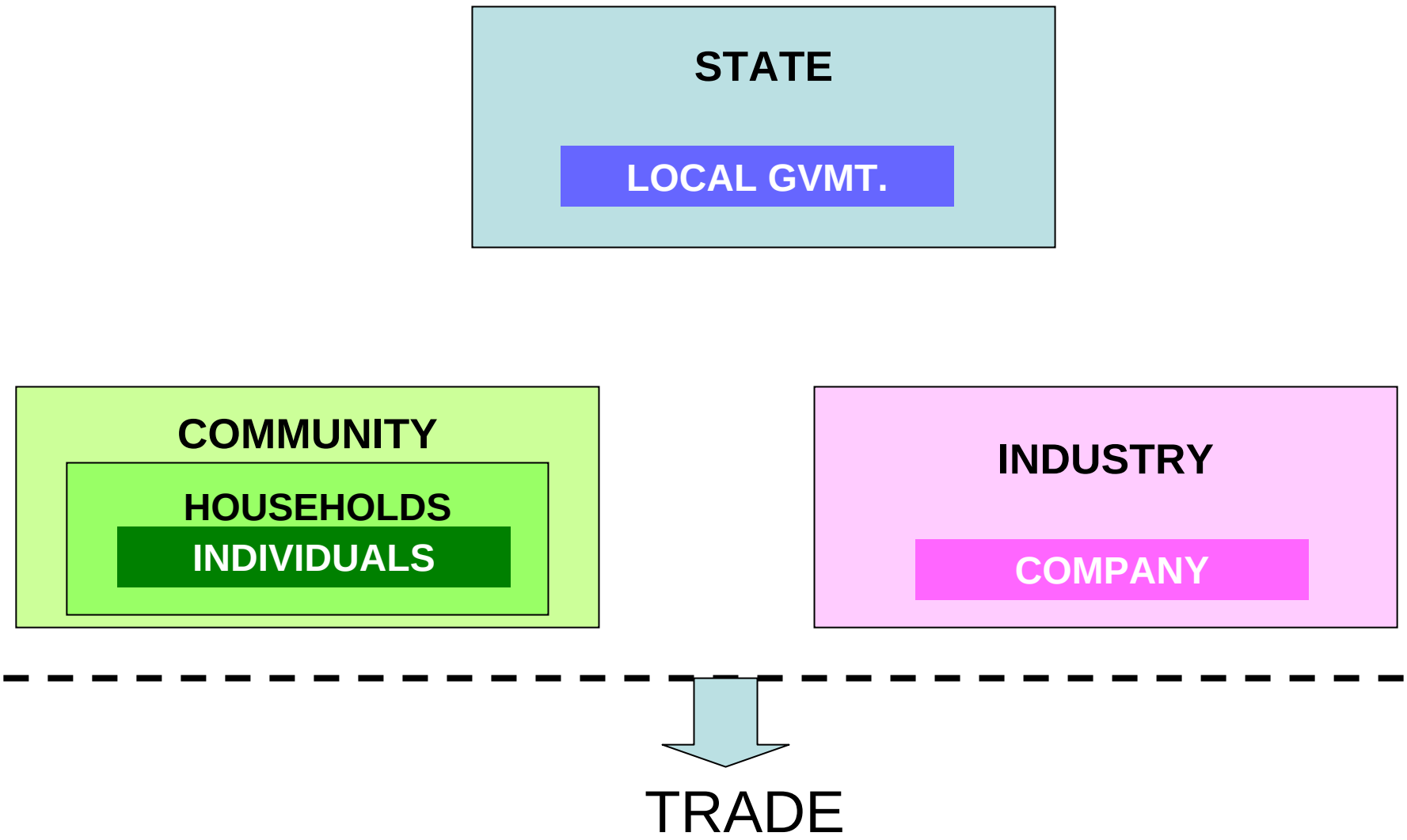
Appropriable good and services

- Biodiversity is valuable for its production of goods and services.
- Complex diversity of goods and services
- Economic perspective of
  - Rivalry: Desirability of restricting access
    - Opportunity costs of individual consumption
  - Excludability: Feasibility of restricting access
    - Costs of enforcing access restriction



Source: OECD 2003

Potential domestic owners



Potential domestic owners

Note:

- Tri-partite structure
- Conflicts between
- Conflicts within
- Impact of trade

STATE

(default owner)

LOCAL GVMT.

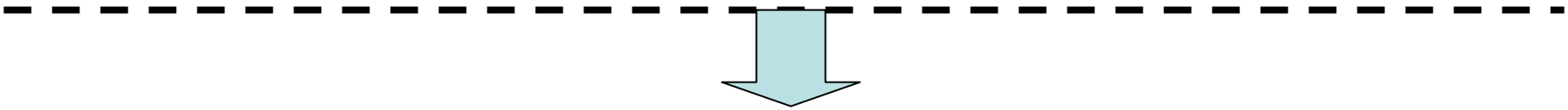
COMMUNITY

HOUSEHOLDS

INDIVIDUALS

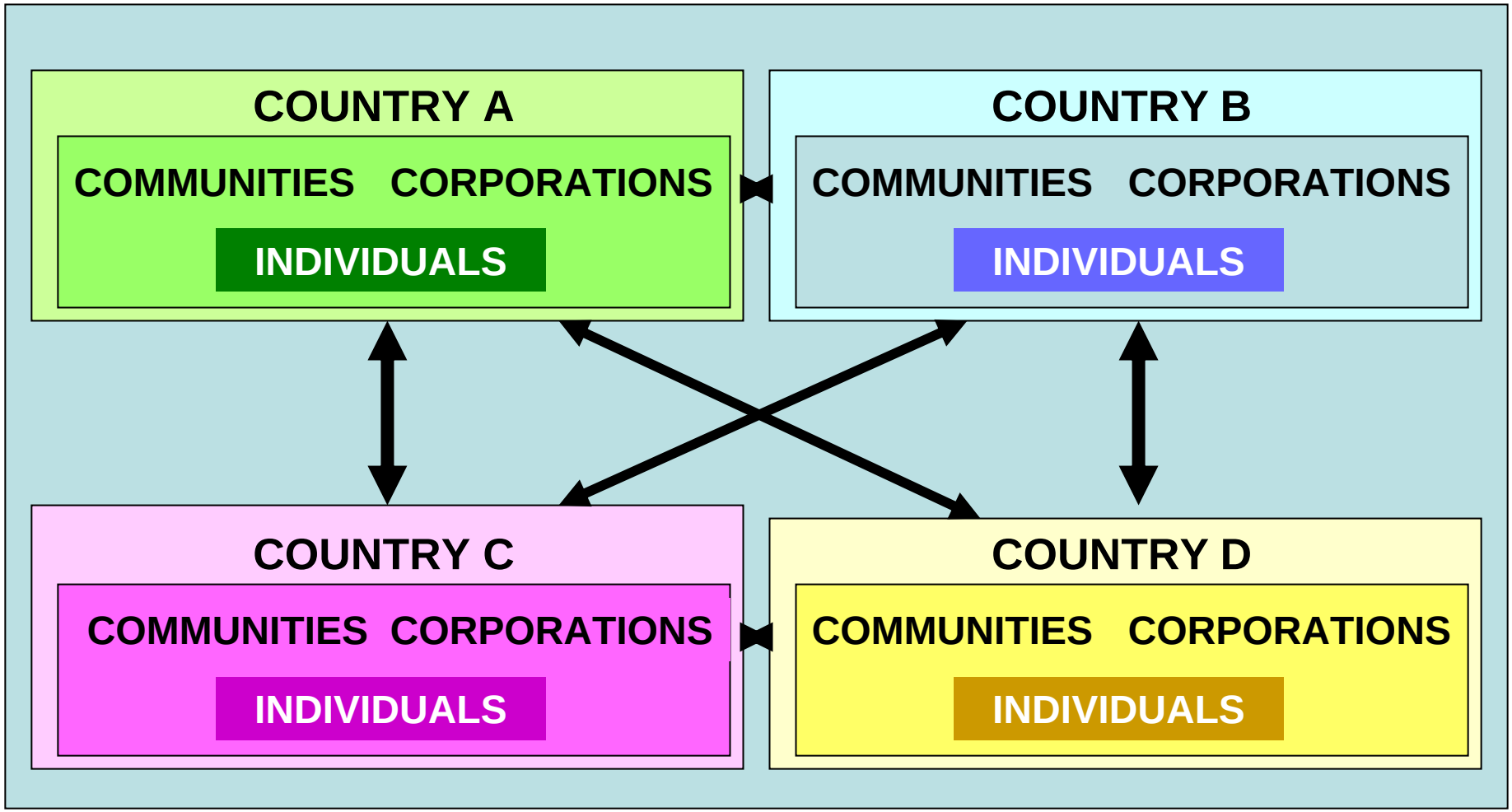
INDUSTRY

COMPANY

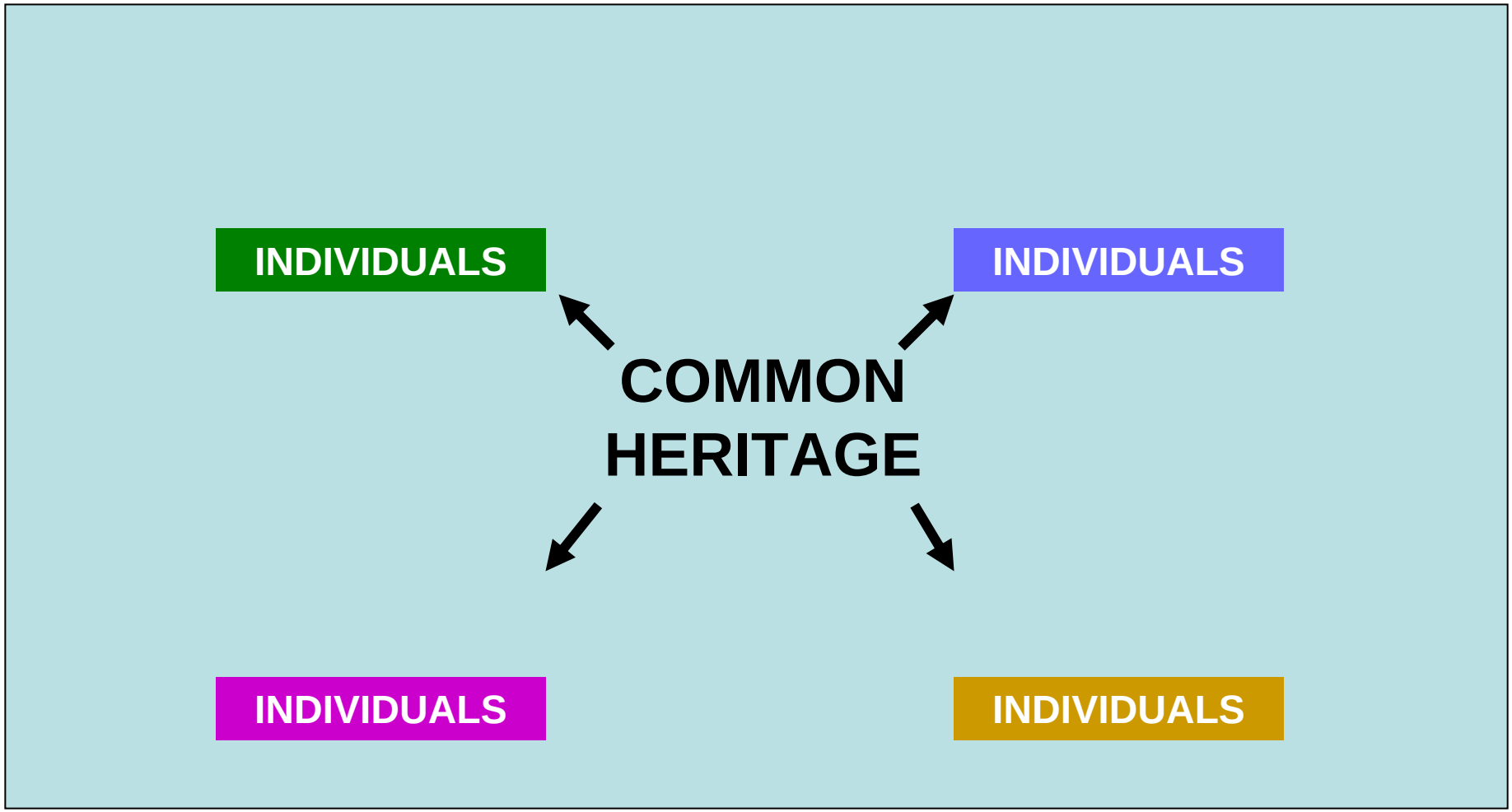


TRADE

Potential owners – international level



Potential owners – international level

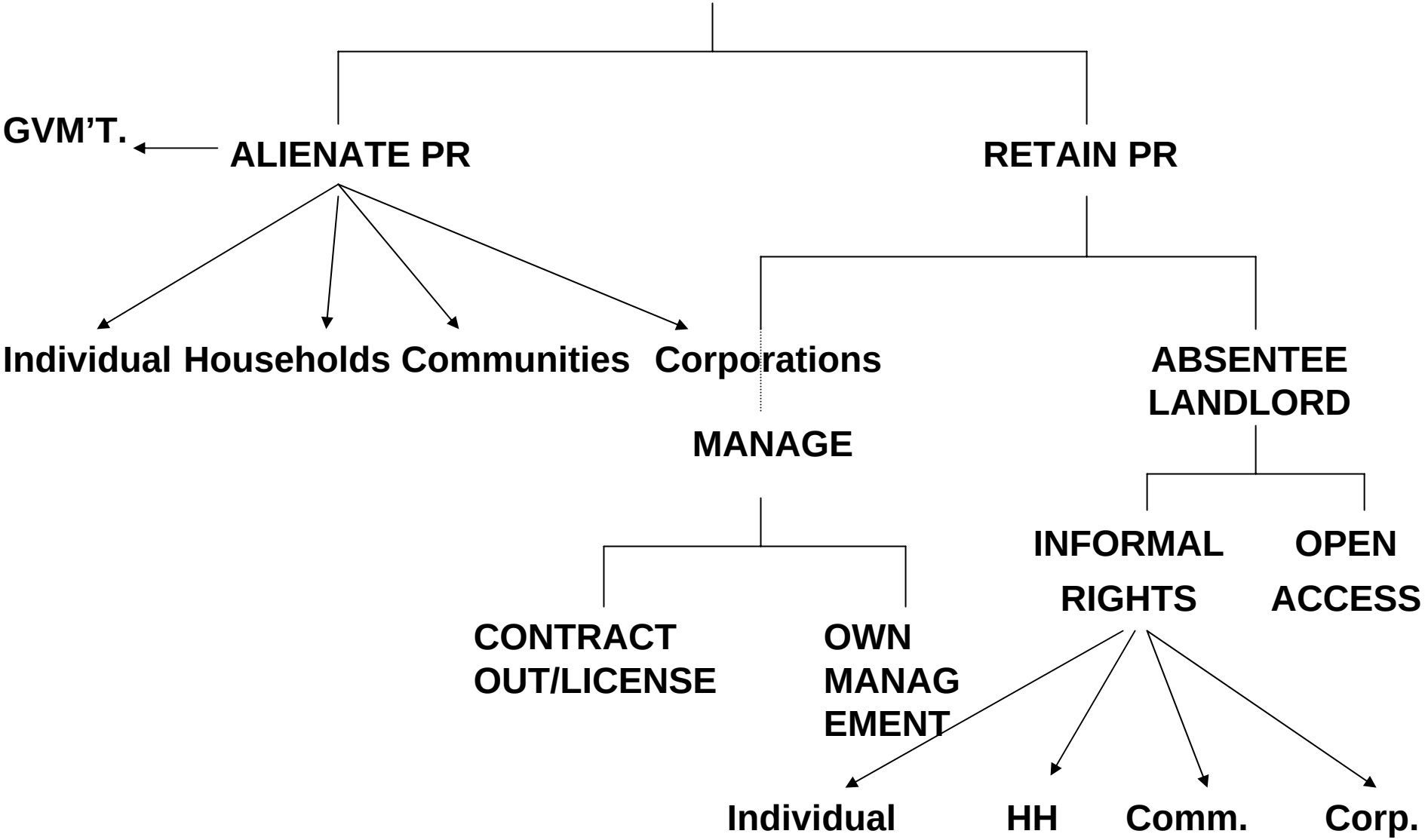


Actual owners of biodiversity

- Positive analysis: “Who owns biodiversity?”
- Difficult question to answer in practice
- Intersection of
  - formally assigned rights,
  - rights that have been contracted away and
  - informal rights

  in any good or service

Choices for the PR owner



Residuals

- Two heuristic tools for assessing ownership:
  - Residual claim and
  - residual control
- Residual claim
  - Rent (positive or negative) remaining after all contractors and right-holders have been satisfied on the basis of specific contingencies.
- Residual control
  - Decision rights for all contingencies not contained in other rights or contracts.

What choice would be optimal?

- Assume that basic requirements of PRs are met
  - Well defined
  - Enforceable (secure)
  - Alienable (tradable)
- Doctrine of private PR assignments (Demsetz 1967)
  - Static dimension: PR are most efficiently assigned to **individuals** on an exclusive basis.
    - Reason: Individuals are the most able to make efficient use of assets.
  - Dynamic dimension: PR evolve to internalize externalities arising as a result of exogenous changes.

What choice would be optimal?

- Resultant doctrine of the irrelevance of the initial assignment of PR for efficiency
  - Given perfect markets, PRs will travel to the individual that values the PR most
  - => Role of the state: C.A.S.E.
- General validity?
  - Competitive markets
    - The efficient monopolistic CPR (Cornes et al. 1986)
  - Enforcement costs
    - Asset choice: Trees versus cattle (Cheung 1970)
    - Equity: Conflicts (Albers and Greenspoon 1997)
  - Completeness of rights
    - Incomplete internalization (Haro et al 2005)
    - Incomplete forward contracting (Seabright 1993)

What choice would be optimal?

- General validity
  - Commitment
    - PR creation diminishes expectations that government can commit (Field and Torero 2005)
  - Information
    - Inefficient state intervention can outperform private bargaining outcome if information if imperfect (Farrell 1987)
  - Core
    - With more than 2 parties and a depletable externality, bargaining might not lead to a stable solution (Dasgupta and Mäler 1990).
  - Transaction costs
    - Costs involved in moving PR between individuals may be prohibitively high (Coase 1960).

Transaction costs

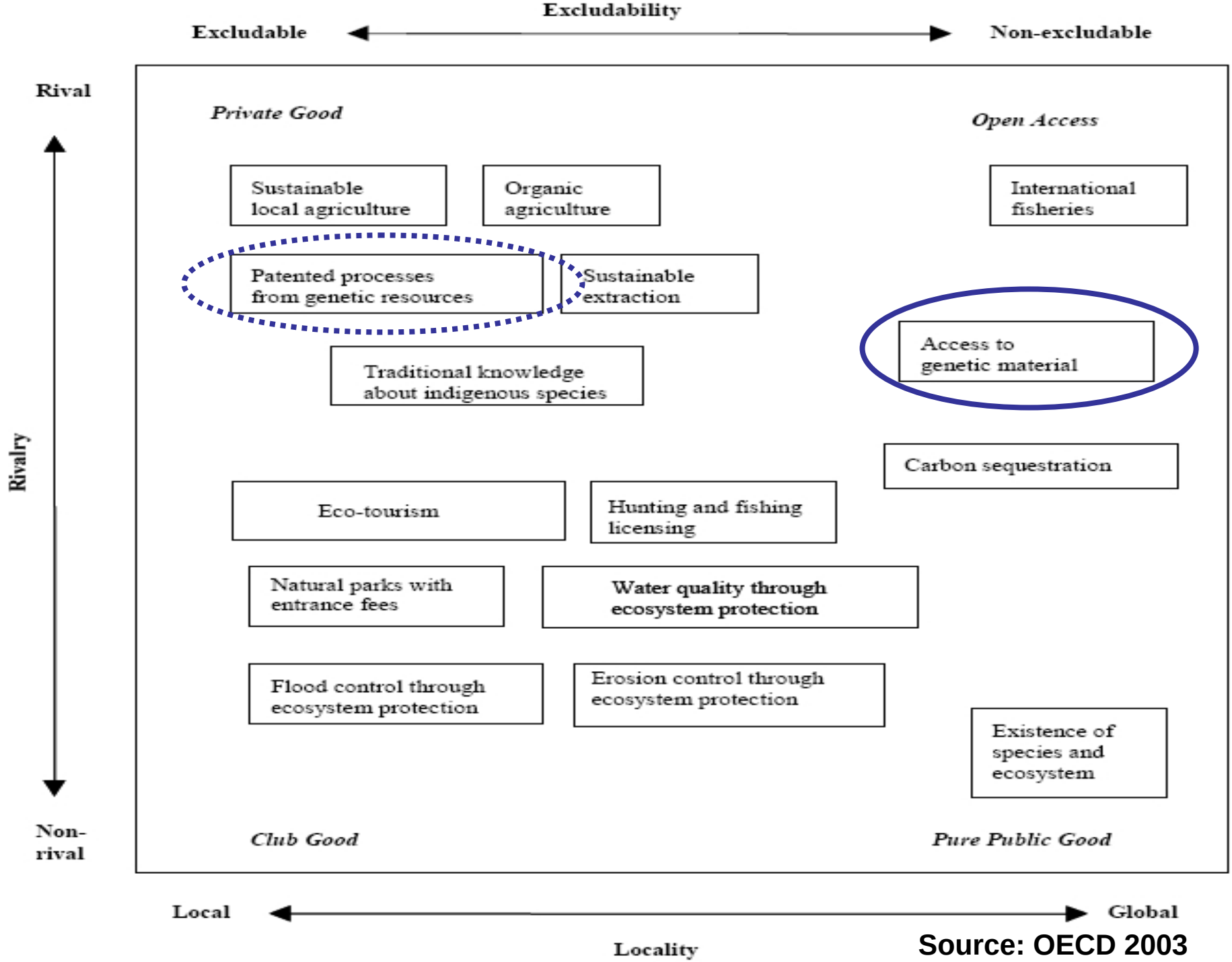
- Bargaining, enforcement, etc. require resources to be spent
- How to assign in the presence of transaction costs =>' Transaction cost school'
  - Calabresi and Melamed (1972): Assign to best briber
  - Grossman and Hart 1986: Assign to most productive agent
  - Hart and Moore 1990: Assign to best investor
  - Milgrom and Roberts (1992): In a framework of incomplete contracts, best investor is the agent in which residual claimant and residual controller coincide.
- If coincidence not achieved, efficiency losses apparent.

Key developments since 1990

- Recognition of national governments as default owner of biodiversity's goods and services
  - Art. 4, CBD (1992)
- The rise and exercise of formal property rights
- Emergence and enforcement of novel property rights and PR restrictions
  - Usufruct rights
  - Extractive rights
  - Easements
  - Intellectual property rights (IPRs)
  - Zoning laws
- Decentralization of public ownership
- Devolution of property rights
- Intensification of trade links

Illustrative example

- Ownership of genetic resources
- Use values => biodiversity as input into R&D
- R&D outputs
  - Crop varieties
  - Agrochemicals (pesticides, herbicides, fungicides,…)
  - Pharmaceuticals



Source: OECD 2003

IPRs as organisational determinants of R&D process

- Various ways of analyzing the organisation of the R&D process in which biological information is an input
- Property rights perspective, esp.intellectual property rights (IPRs):
  - PRs over informational goods
  - Examples:
    - Copyrights
    - Patents
    - PVPs, but also patents for new crop varieties (*Chakrabarty* and *Hibberd*) if possible
  - Challenges in IPR design

The R&D process

OUTPUT

NATURE
- *Lands and diverse genetic resources*
- *Evolutionary interaction*

Selected Traits

‘Traditional Farmer’
- *Observation and Selection*
- *Discriminatory selection and use*

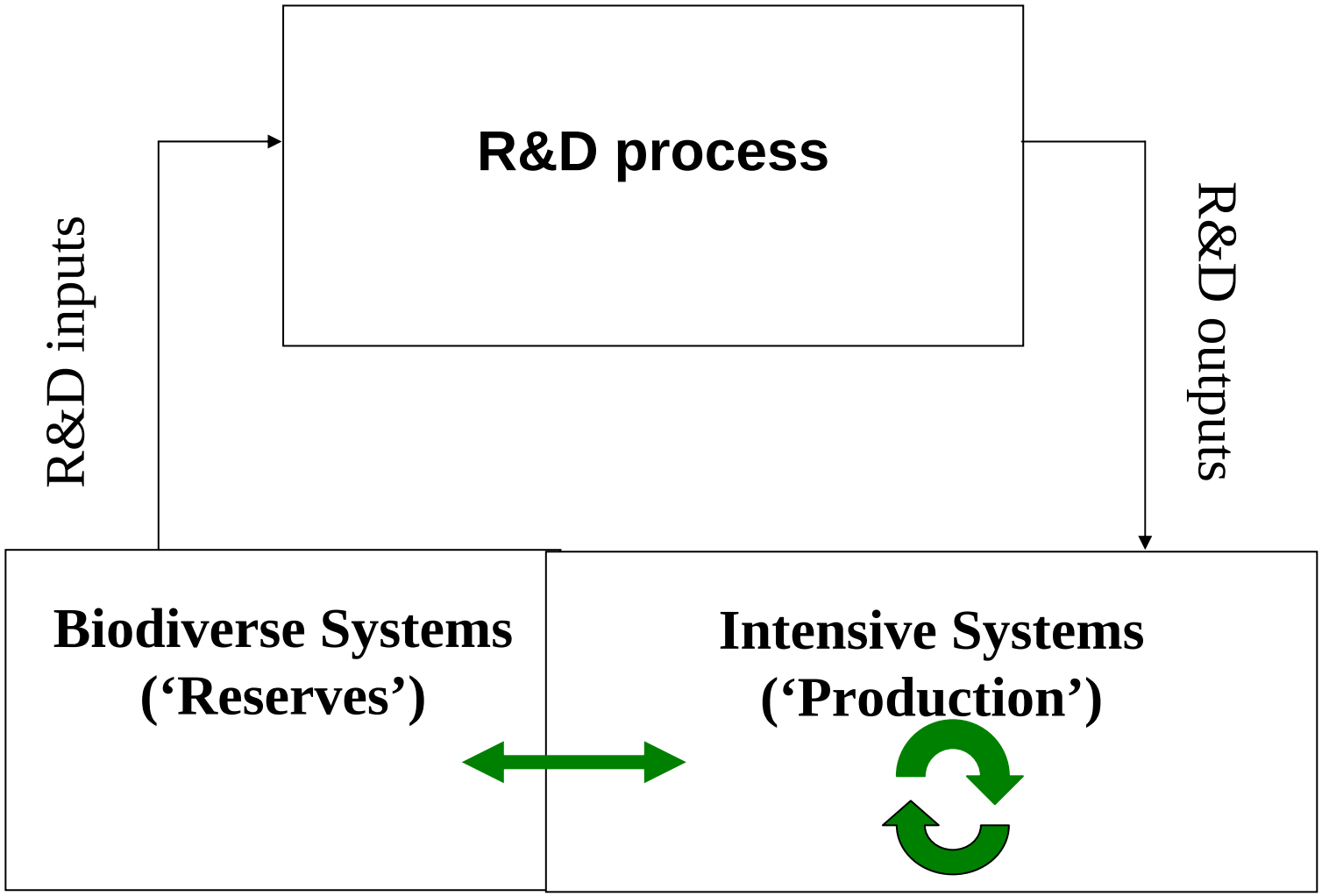
Landraces

‘Plant Breeder’
- *Human and physical capital*
- *Existing varieties*

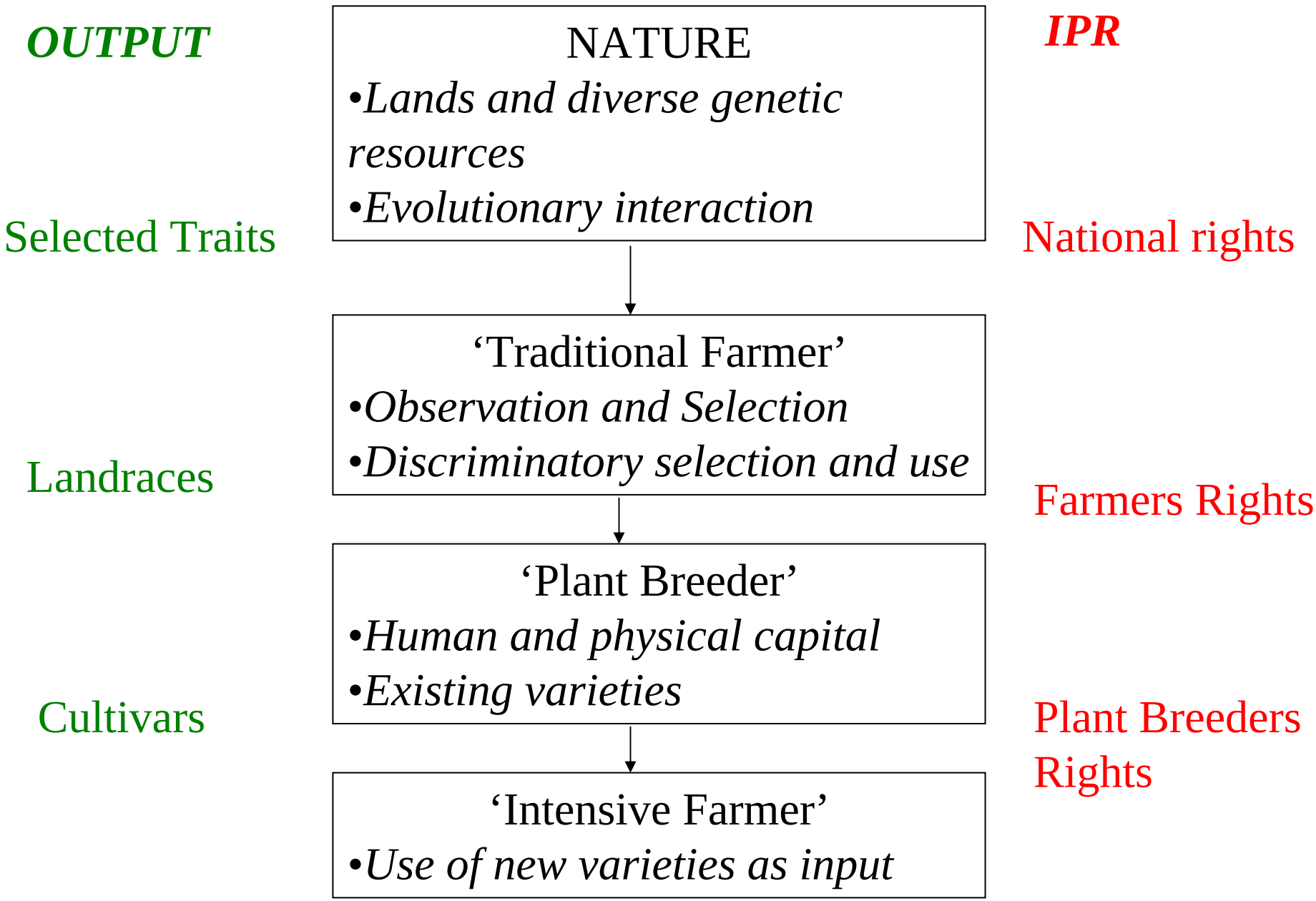
Cultivars

‘Intensive Farmer’
- *Use of new varieties as input*

Environmental relevance



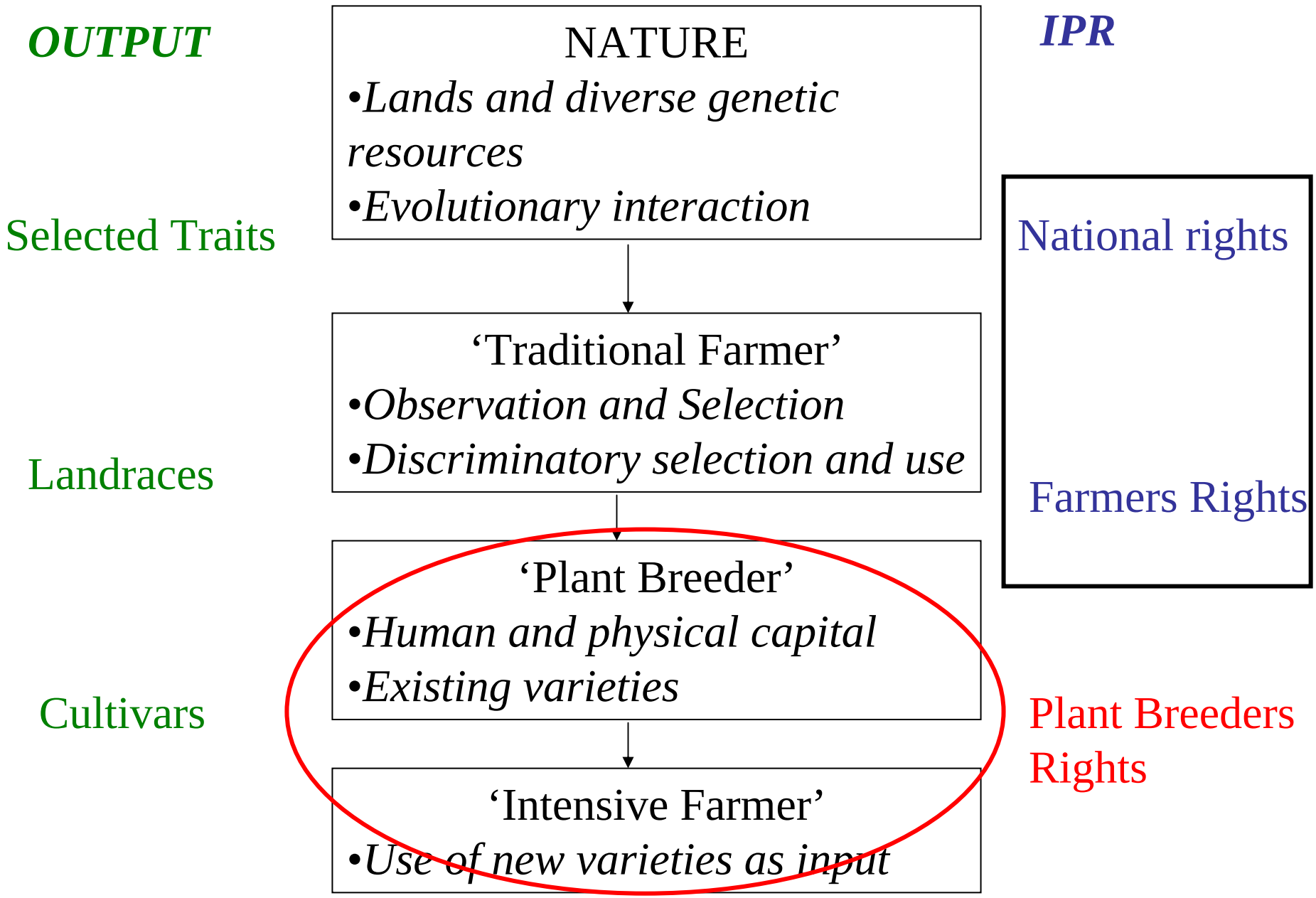
IPRs in the crop R&D process



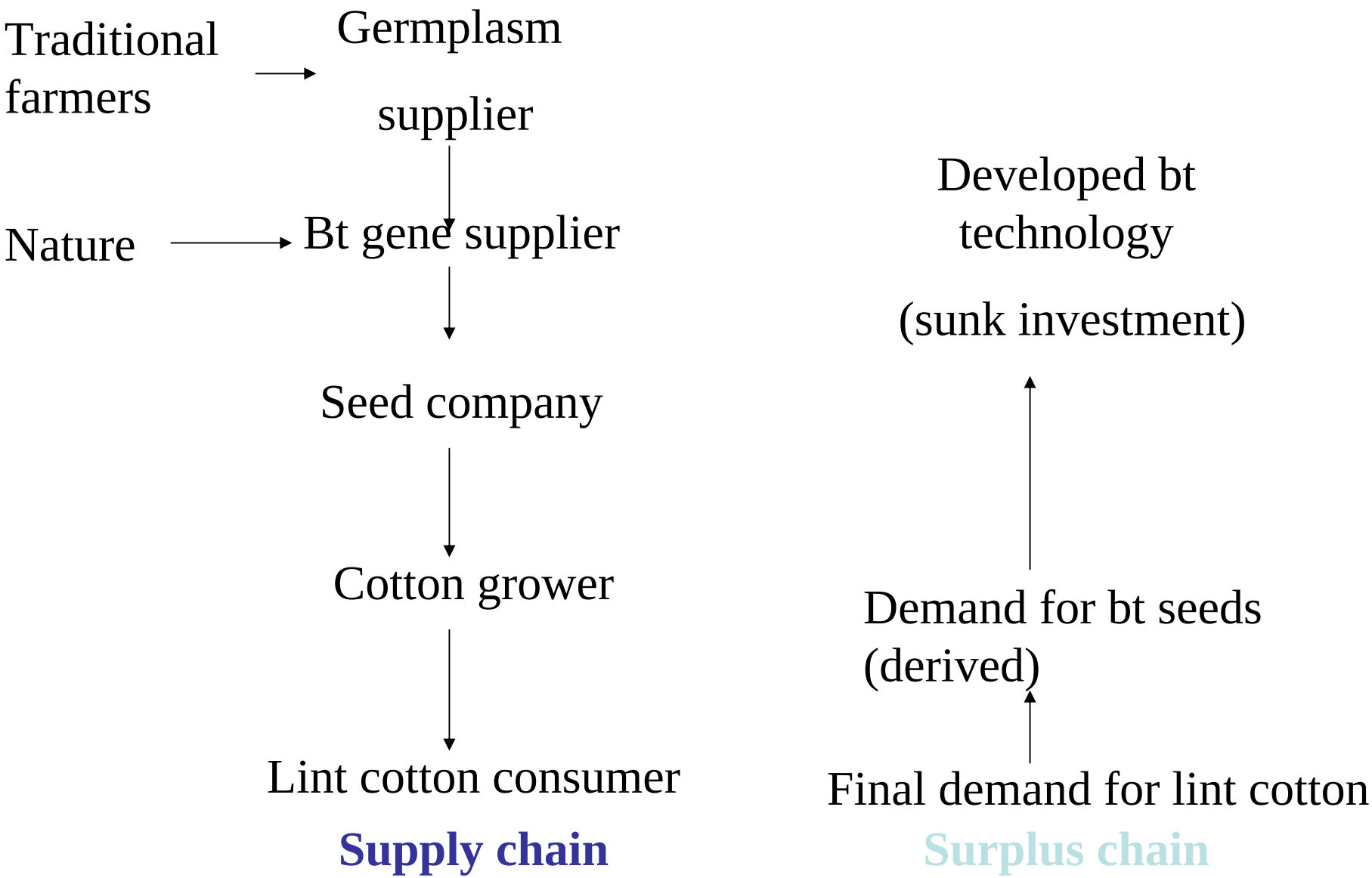
Three issues

- Sectoral
  - Asymmetric distribution of property rights within the vertical industry (Swanson and Goeschl 2000).

IPRs in the crop R&D process



Vertical Industry – bt cotton



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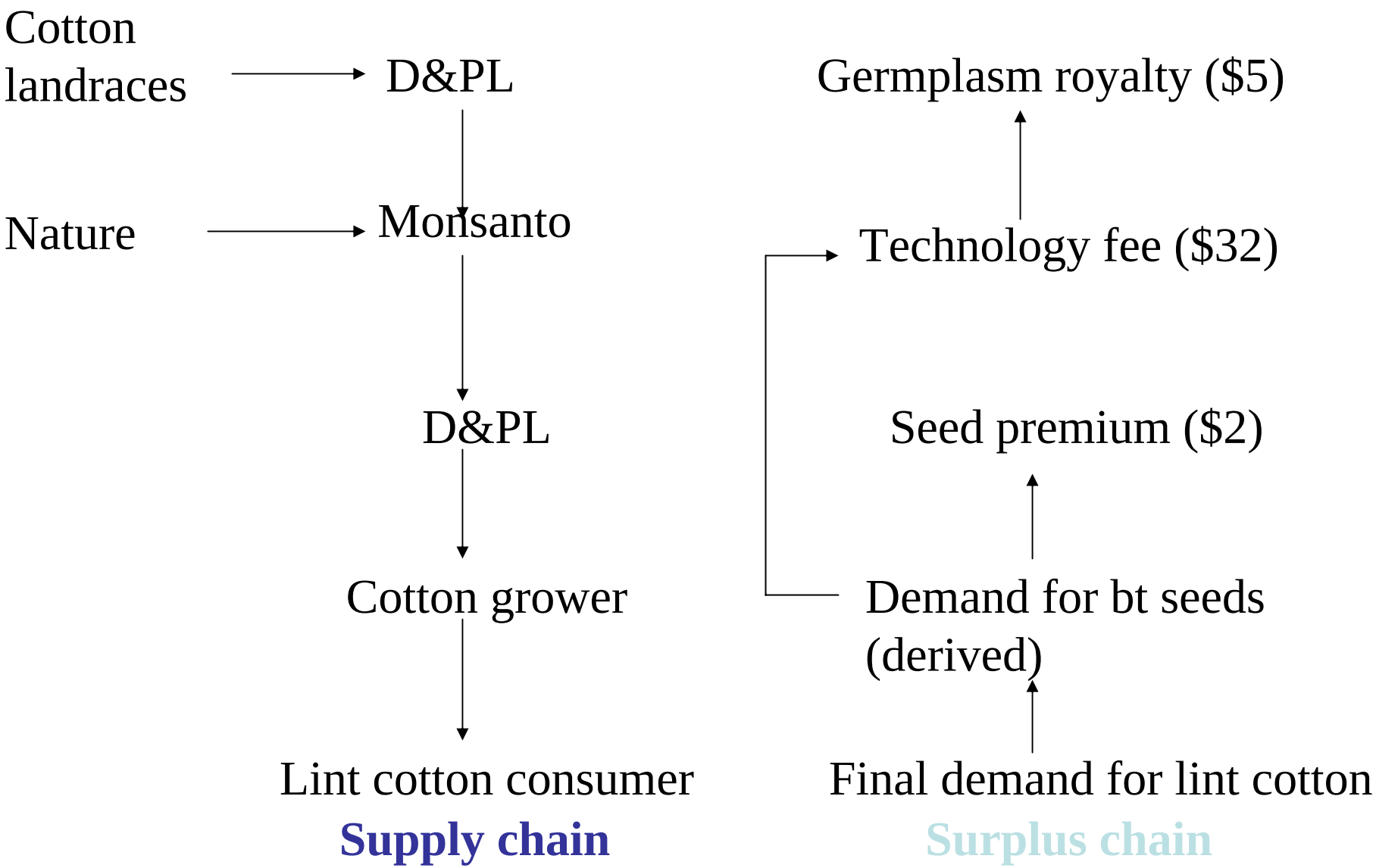


Related figures

- Creation of national institutions
  - Only 26 national access laws and regulations specifically designed to meet CBD (Ogolla 2005)
  - Study of access regulations in the Pacific basin (Carrizosa 2004):
    - only 29 access permits were granted between 1994 and 2004 in the 9 countries that had some form of access regulations
- Resources moving up the surplus chain
  - Global value of global markets for biochemical resources about US$500 billion per year (Artuso 2002)
  - more than US$50 billion devoted to R&D annually (Artuso 2002)
  - documented shared benefits remains extremely low
    - Costa Rica´s INBio benefit income about US$9 million since 1989, after about a decade of experience in access contracts

Explaining the PR failure

- Markets essentially ruled out by lack of PR at other stages, but contracts as alternatives
- Candidates for explaining the low number
  - Enforcement:
    - Cost of enforcement is high (case-by-case)
    - Once GR have left the country, little enforcement of contractual compliance possible => spillover into restrictive access conditions
  - Costs of complete contracting
    - Future use of GR unknown at time of access => contract contingencies incomplete
  - Information asymmetries:
    - User better informed about potential value than provider => provider may suspect strategic underreporting by user.

Three issues

- Sectoral
  - Asymmetric distribution of property rights within the vertical industry
- Spatial/International
  - Asymmetric distribution of rents across countries within which parts of the vertical industry are located (Gatti et al. 2007).

International management

- General recognition of the need for global cooperation in the conservation of biological diversity.
- In stylized terms: The (developed) North highly values biodiversity, which exists mainly in the (developing) South.
- Decisions about
  - Land use
  - Access and benefit sharing

  Should be take into account the global nature of the benefits.

International management

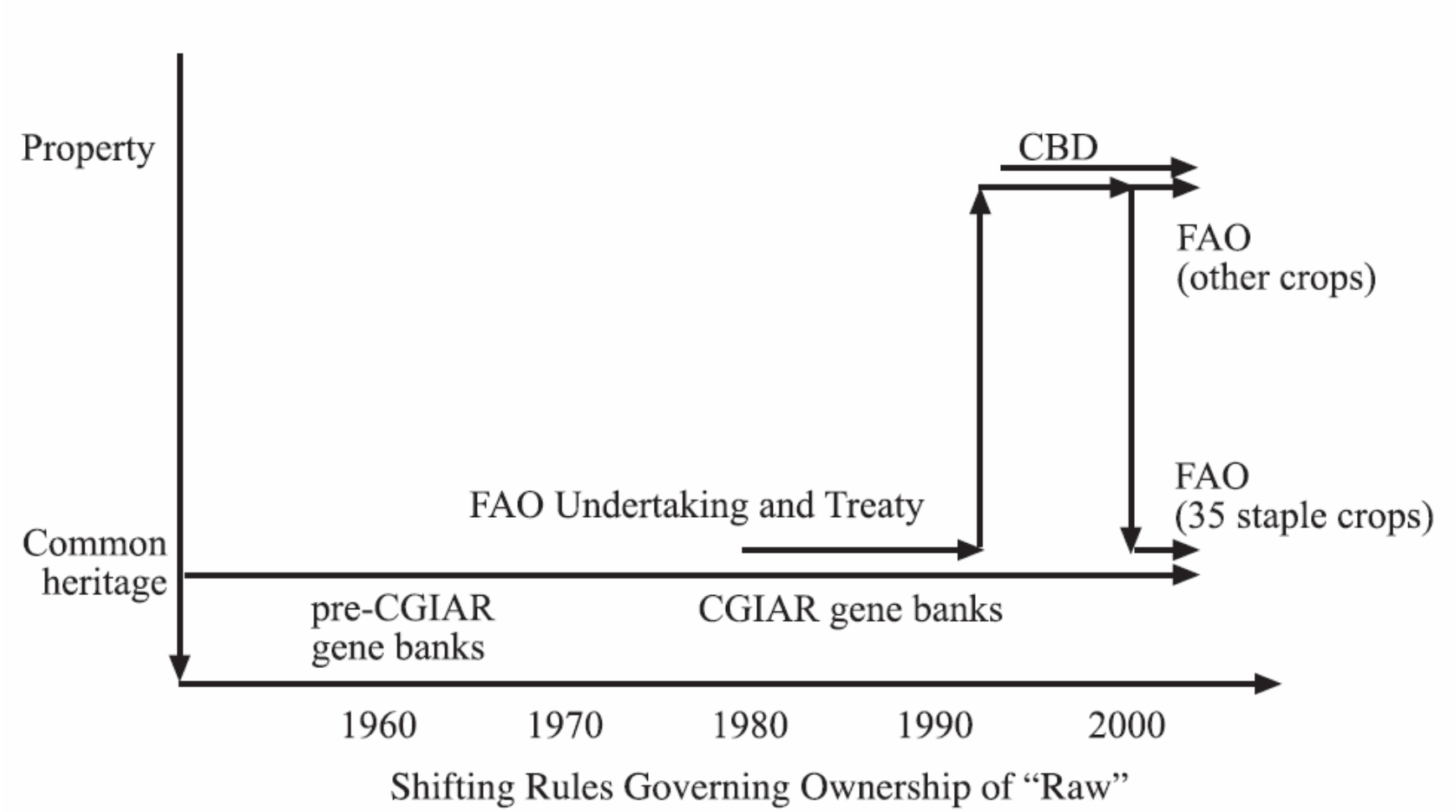
- In genetic resources, the mutual dependence and need for cooperation is particularly palpable:
  - North: requires biodiversity as R&D inputs
  - South: requires R&D outputs
- Note: Inputs **and** outputs are *informational* goods.
- Coordination through markets?
- Instead, coordination through International Agreements

Institutional Responses

Ownership of Plant Genetic Resources and Mechanism for Allocating Benefits

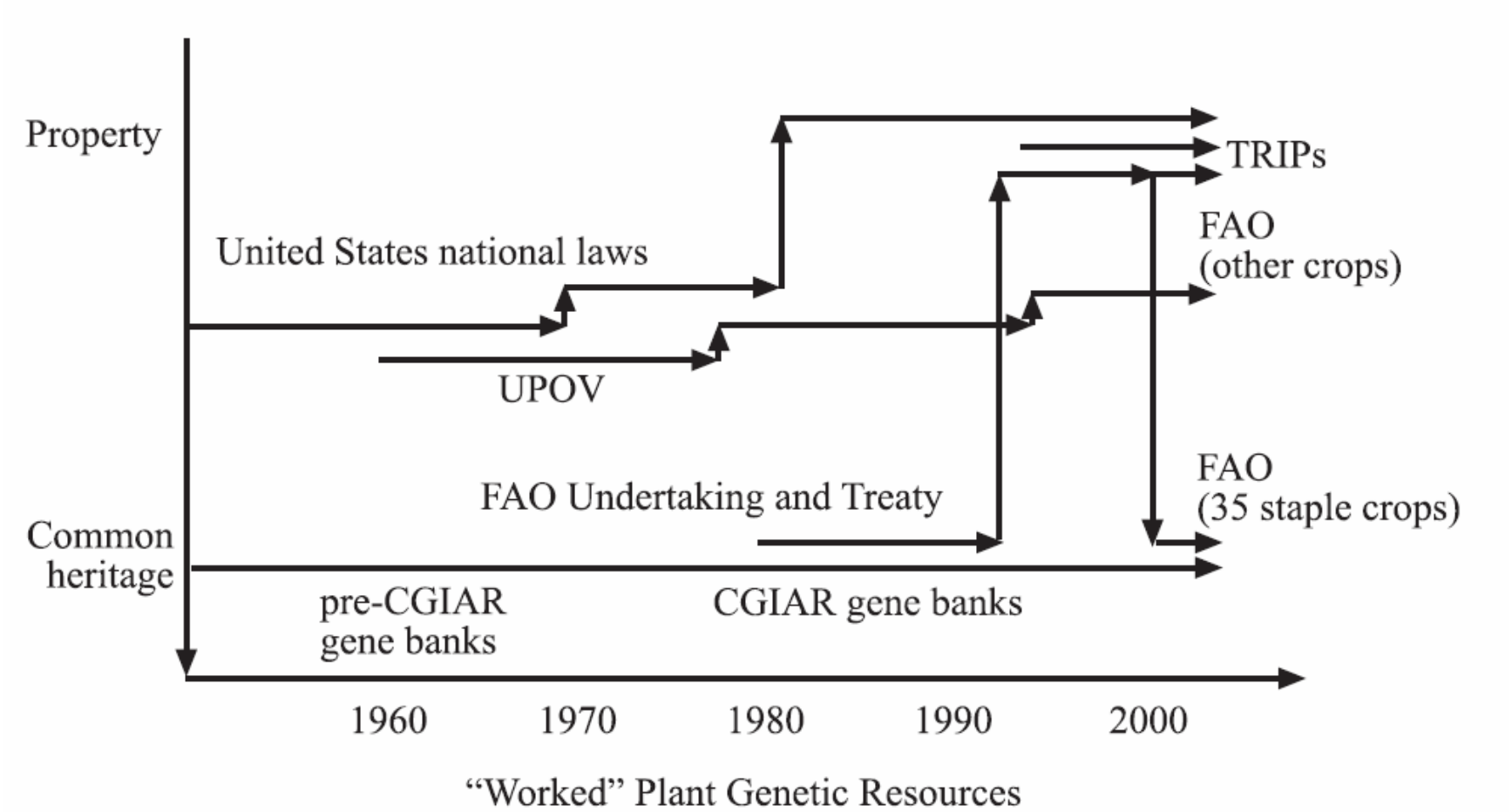
Mechanism for allocating benefits from PGR	Common heritage	Property rights: Sovereign (state-controlled)	Property rights: Private and community
Market-based	Traditional 19th-century system		Late 20th-century national patents: U.S. EU TRIPs UPOV treaties
Regulated	FAO 1983 Undertaking FAO 2001 Treaty (R35, W35) CGIAR gene banks	FAO 1989 and 1991 revisions to Undertaking CBD (1992) FAO 2001 Treaty (other raw) CGIAR gene banks (immediately post-1992, before FAO 2001 Treaty)	FAO 2001 Treaty (other worked)

International dynamics - inputs



Source: Raustiala & Victor 2004

International dynamics - outputs



Source: Raustiala & Victor 2004

The outcome

- Result:
  - Joint international regulation of the conservation and use of biodiversity
  - Incremental cost contract: Compensates South for additional reserves above and beyond its baseline supply.
- Specific incremental cost outcome

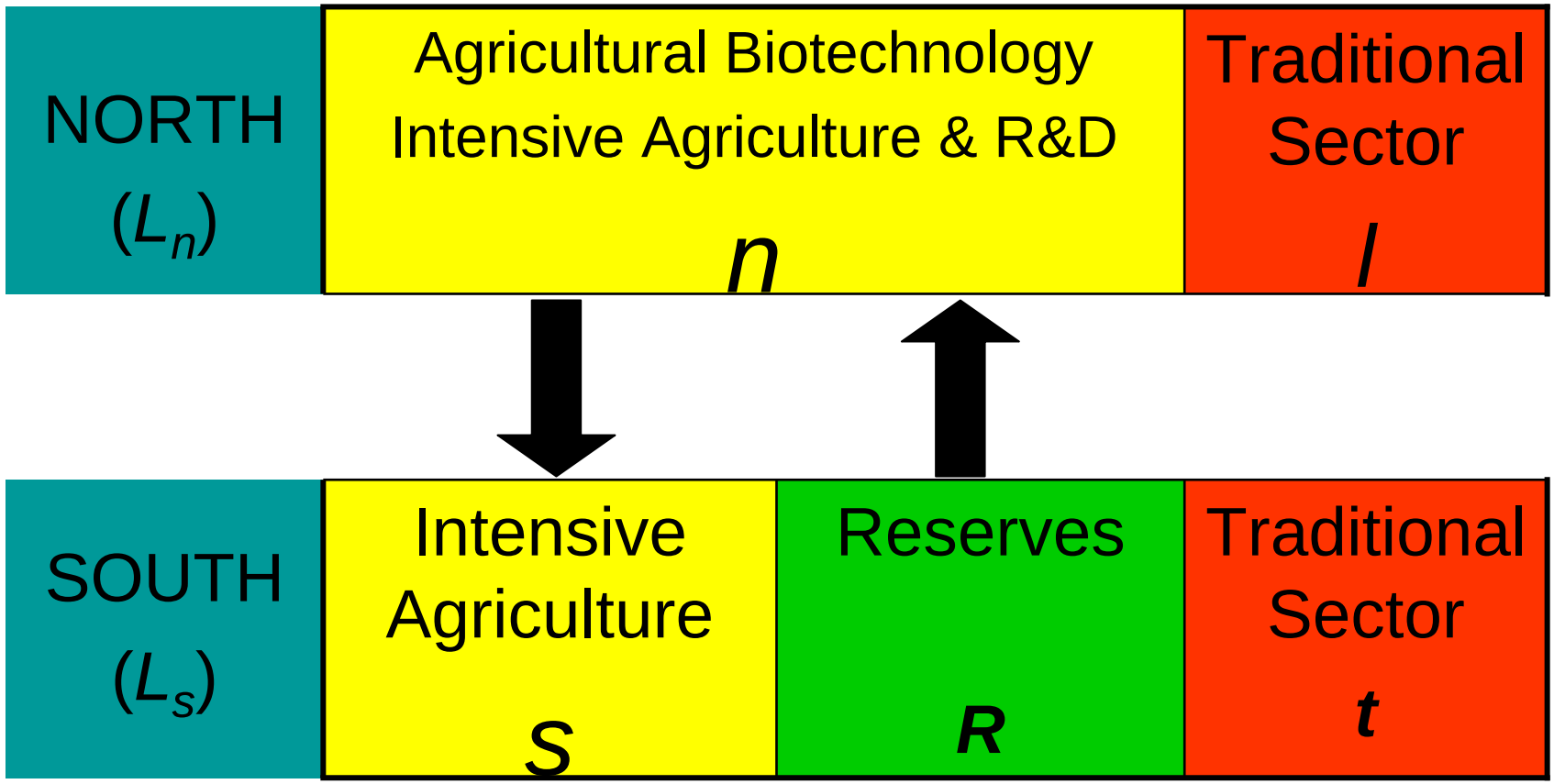
.[the costs of] **additional** national action beyond what is required for national development [the baseline] that imposes additional [or incremental] costs on countries beyond the costs that are strictly necessary for achieving their own development goals, but nevertheless **generates additional benefits that the world as a whole can share** ....

Explaining the outcome

What explains this outcome?

- Physical asymmetries?
- Bargaining power?
- Pre-commitment?

N-S Land Use Model



Motivation

- Gatti et al. (2007): Study the institutions used to resolve the biodiversity bargaining problem.
- Approach: Use cooperative bargaining theory to
  - Determine the bargaining frontier and possible solutions
  - Characterize the present outcome
  - Explain the present outcome by reference to ‘rational threats’ for the South and pre-commitment by the North

Results

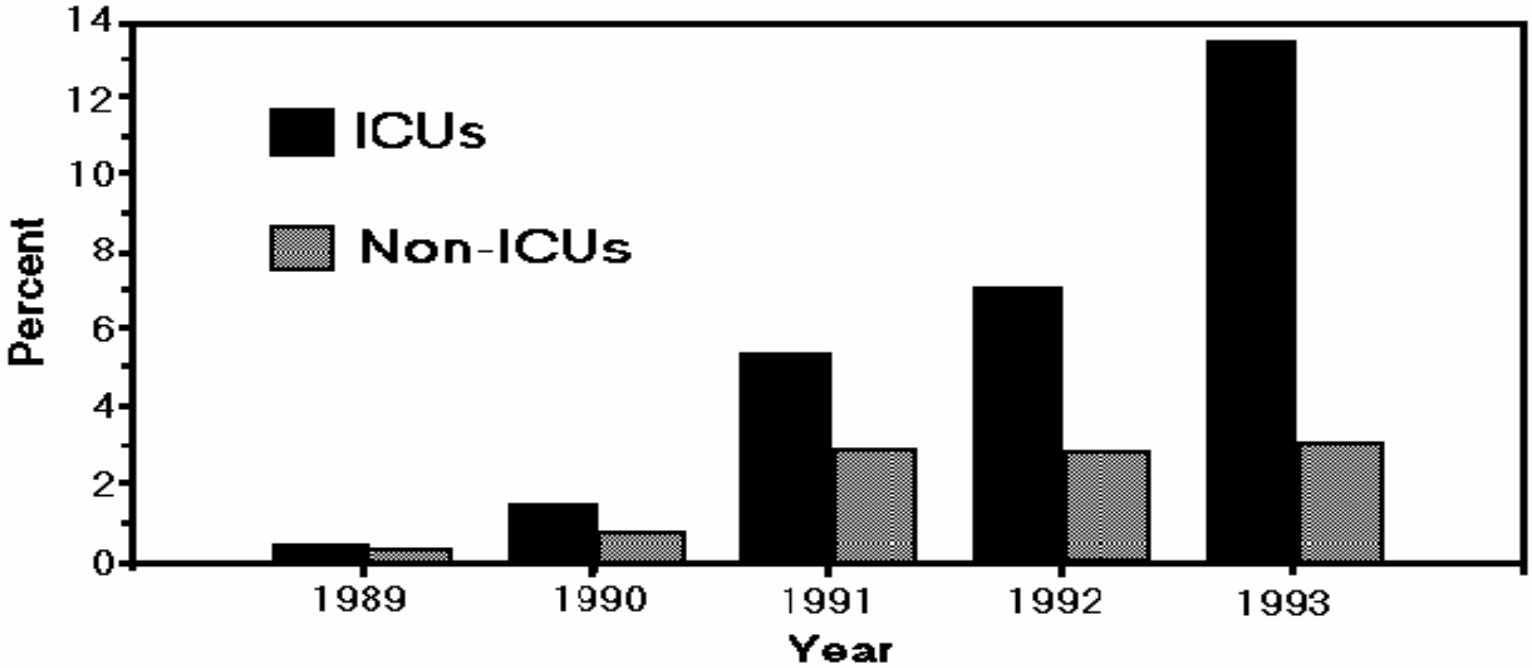
- Diagnostic
  - Current solution is most consistent with the features of an ‘extreme point contract’.
  - However, physical differences favor the South.
  - Bargaining power of North compromised by rational threats by the South
- Possible explanation
  - Precommitment by North possible through adherence to sharing rules established in different contexts
  - Source of IC rule: Montreal Protocol
- Problem
  - IC rule does not provide stable solution for biodiversity bargaining game.

Three issues

- Sectoral
  - Asymmetric distribution of property rights within the vertical industry
- Spatial/International
  - Asymmetric distribution of rents across countries within which parts of the vertical industry are located
- Intertemporal
  - Particular incentives that a patent-style IPR gives to innovating companies in a biological environment (Goeschl and Swanson 2003).

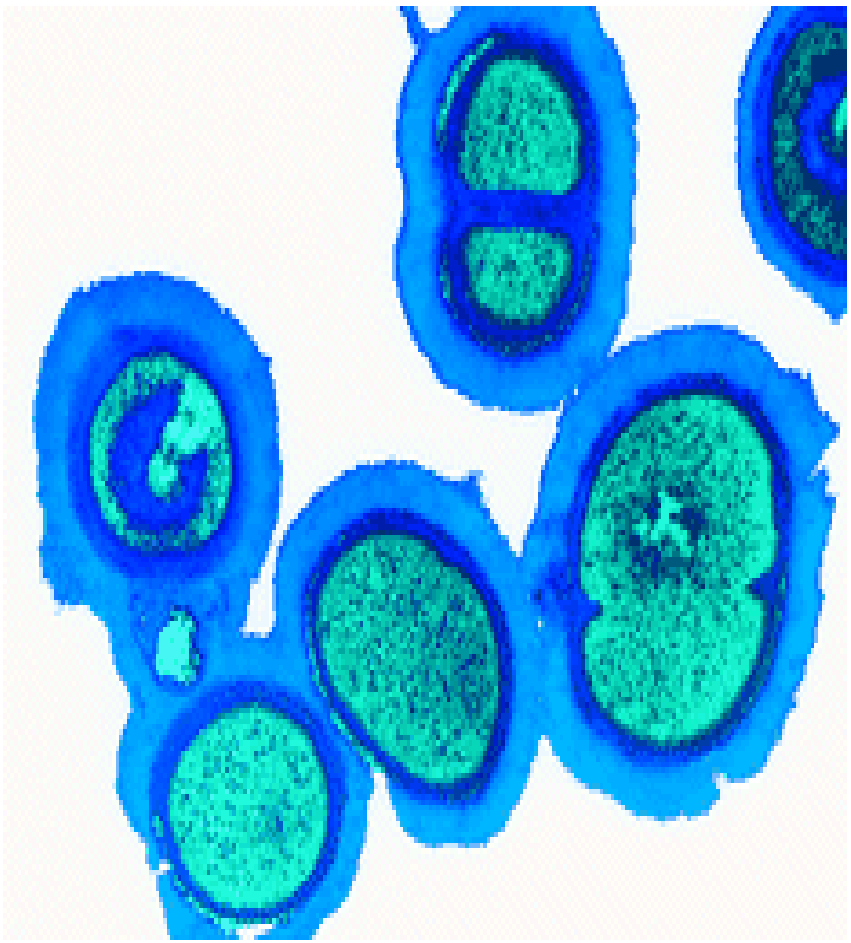
The evolutionary race: Health

FIGURE 1. Percentage of nosocomial enterococci reported as resistant to vanomycin isolated frm infections in patients in intensive-care units (ICUs) and non-ICUs, by year — National Nosocomial Infections Surveillance system, 1989-March 31, 1993 *



* Treatment options for patients with nosocomial infections associated with vancomycin-resistant enterococci are limited, often to unproven combinations fo antimicrobials or experimental compounds.

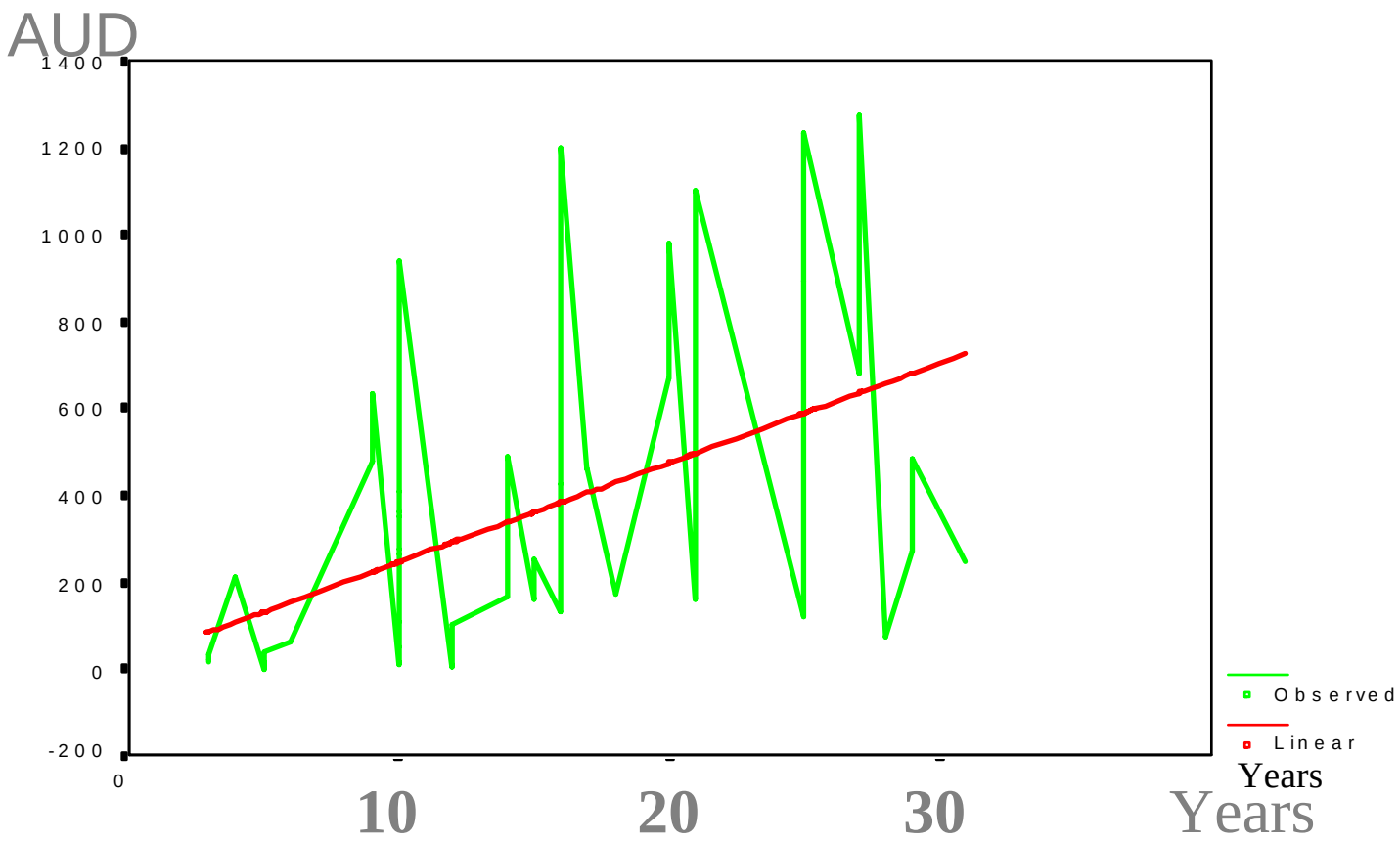
Pathogens



- Case-specific costs of resistance
  - amoxicillin in outpatient use: $225 million (Elbasha 2003)
- Annual cost of resistance in total
  - $4 billion (ASM 1995)
  - $7 billion (John and Fishman 1997)
- R&D cost of new ABX
  - $892 million (Di Masi et al 2003)

The evolutionary race: Agriculture

Susceptibility of Wheat Varieties as a Function of Usetime



Source: Singh and Rajaram 1991

The implications of this race

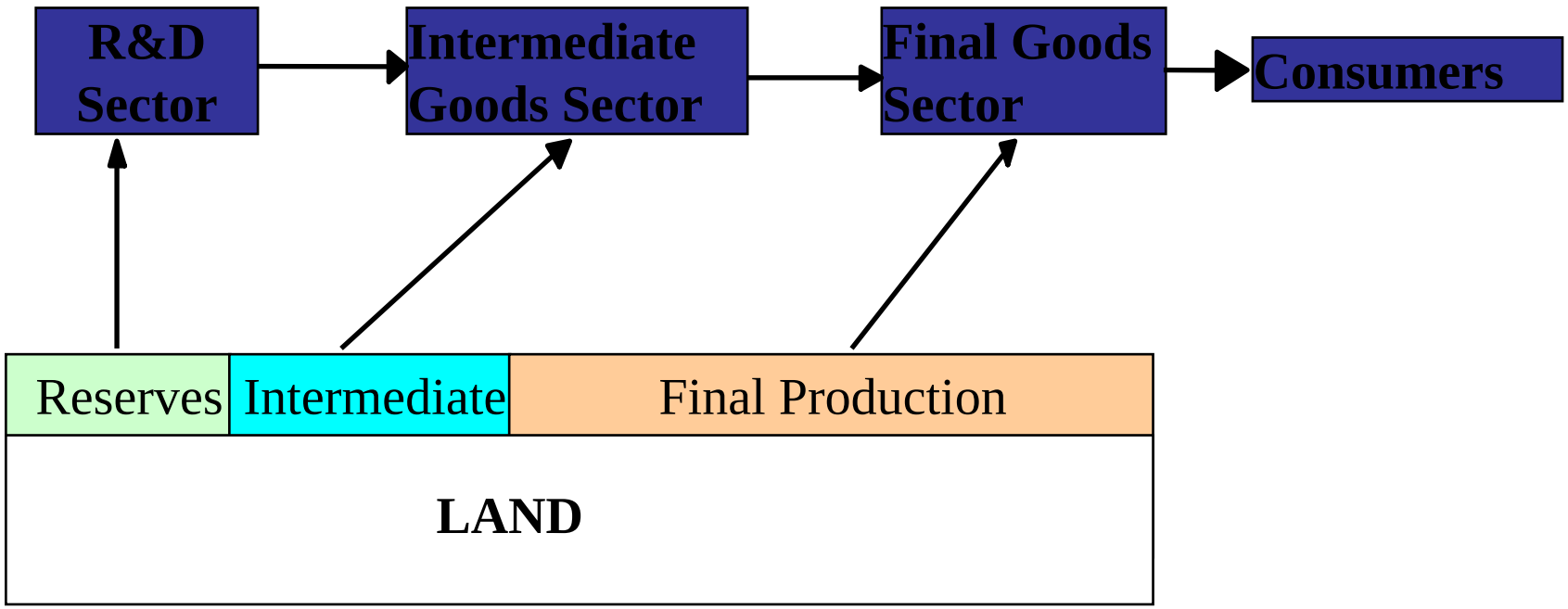
- Permanent need to come up with new solutions to pathogen problems
- No prior knowledge of the specific nature of the pathogen problem
- Current gains accrue at the cost of future losses

Implications for plant valuation

- Industry perspective: Individual firms operating under IPR are engaged in a contest of innovation not only against economic competitors, but also biological ones.
- Social perspective: Humanity is engaged in a permanent battle to protect human health.
- Different value of outcome => different valuation of underlying resource (Brown and Swierzbinsky 1988).

Structure of a biotech industry

Example of an agricultural biotechnology industry with essential input land.



Final Goods Sector

- The final goods sector has a production function of the form

$$y_t = A_t \cdot F\left(x_t\right)$$

with *F(0)=0, F'>0* and *F"<0*.

Intermediate sector is characterised by a Leontieff production function.

R&D Sector I

Commercial innovations

- Assume Poisson process with arrival rate $\phi\, i(v,\gamma)$
- Probability of innovation in time interval $[t,\ t+dt]$ is increasing and concave in the level of investment in R&D (v)
- Innovations are ‘drastic’.
- With index *I* denoting the current level of technology in use in final goods production, productivity shifts up according to

$$A_{I+1} = A_I \cdot \gamma$$

R&D Sector II

Biological adaptions

- Poisson process with arrival rate $\lambda\, a(x,\gamma)$
- Probability that pathogens adapt to and overcome the current technology in the time interval $[t, t+dt]$ is increasing and convex in scale of application (x)
- With index *D* denoting the stage of biological innovations (i.e. depreciation), productivity shifts down according to

$$A_{D+1} = A_D \cdot \gamma^{-1}$$

Society's problem

- Technological net stage

$$A_S = A_0 \gamma^S = A_0 \gamma^{I-D}$$

- Optimization problem

$$\max_{v} \int_{\tau=0}^{\infty} e^{-r\tau} A_t F(v) dt$$

subject to $1 = v + g + d$ (resource constraint)

and the joint probability distribution of

Innovations: $\Pi(I,t) = \frac{1}{I!}[\phi i(v)t]^I e^{-\phi i(v)t}$

Adaptions: $\Pi(D,t) = \frac{1}{D!}[\lambda a(v)t]^D e^{-\lambda a(v)t}$

The Impact of the Biotech Sector

$$U = \frac{A_0 F(\bullet)}{r - \left[\phi i(v) - \lambda a(v)\gamma^{-1}\right](\gamma - 1)}$$

Considerations:

- Numerator: Current level of technology at time of decision A_0.
- Denominator: Trajectory of production
- Production vs. maintenance of production
- Instantaneous output vs. growth trajectory
- Absolute perspective on ‘technological progress’
- Optimal trade-off involving both production and R&D investment

Private Incentives to Invest in Biotechnology

- Efficiency criterion of R&D investment:

$$\underbrace{rV_{I+1}}_{\text{Opportunity cost of capital}} = \underbrace{\pi_{I+1} - (n-1)\phi i(v_{I+1})V_{I+1}}_{\text{Industrial Patent Race}} \underbrace{- \lambda a(v_{I+1})V_{I+1}}_{\text{Biological Race}}$$

- Considerations
  - ‘Perfect’ patent
  - Relative perspective on ‘technological progress’
  - No shelving of innovations (cf. FEEM paper)
  - Restriction to steady-state equilibria
  - Market clearing in essential input

Comparison of Optimal R&D Investment

- Social:

$$\frac{F'(\bullet)}{\beta + z} = \frac{\left[\phi i'(v) - \lambda a'(v)\gamma^{-1}\right](\gamma - 1)F(\bullet)}{r - \left[\phi i(v) - \lambda a(v)\gamma^{-1}\right](\gamma - 1)}$$

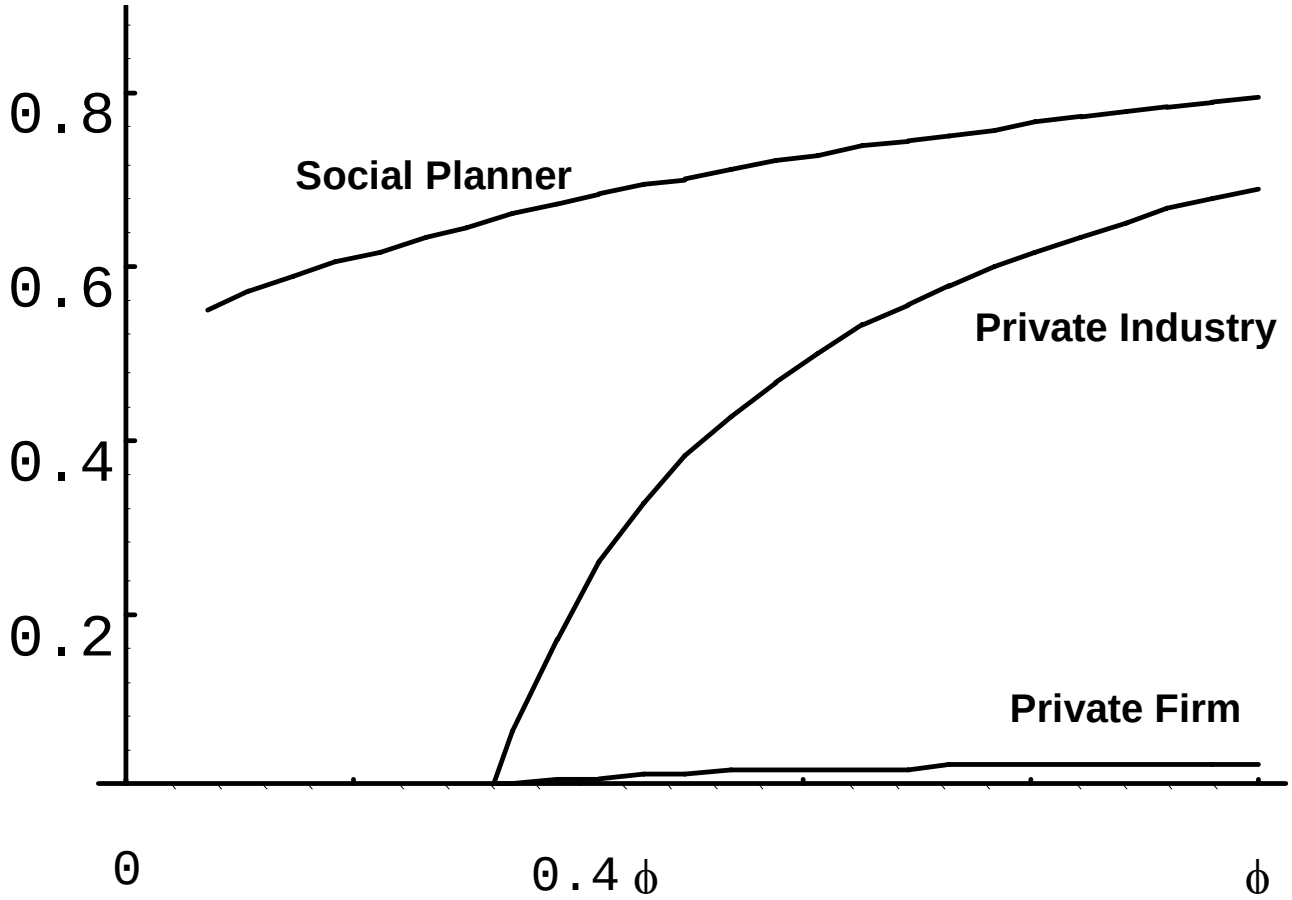
- Firm:

$$\frac{F'(\bullet)}{\beta} = \phi i'(v) \cdot \frac{\gamma \dfrac{[F'(\bullet)]^2}{-F''(\bullet)}}{r + (n-1)\phi i(v) + \lambda a((n-1)v)}$$

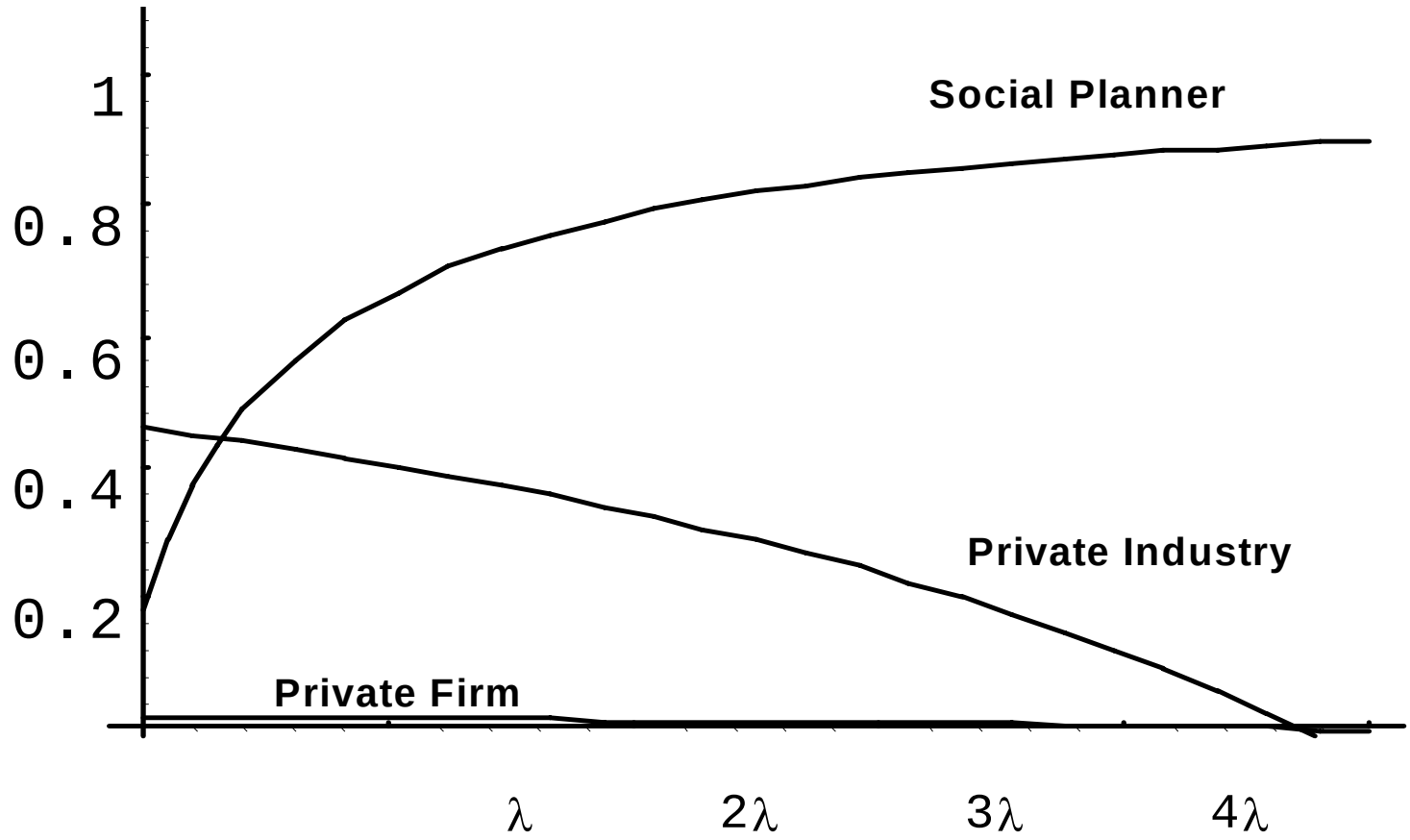
Differences

- ‘Business Stealing’ effect (+)
- ‘Single Supplier’ effect (-)
- ‘Appropriability’ effect (-)
- ‘Differential Internalisation’ effect (-)
- ‘Own Discount Rate’ effect (-)
- ‘Collateral Cost’ effect (-)
- Relative vs. absolute perspective

R&D investment under varying productivity of R&D



R&D investment under varying rate of adaptation



Implications

- Bioprospectors value biodiversity as an input into R&D
- But: Value of R&D to bioprospectors is much lower than the value of R&D to society as a whole
  - Patent system
  - Relative versus absolute perspective
- Spillover of imperfections of IPR system into valuation of biodiversity.

Who owns genetic resources?

- Difficult question in practice
- Mixture of
  - formally assigned rights,
  - rights contracted away, and
  - informal rights
- Problems
  - Informational good: Non-excludability and the cost of enforcement
  - Complex good: Bounded rationality and the cost of institutional design

Conclusion

- Design of PR determines the organization of the process of knowledge creation in the biotech sector
- Multiple challenges
  - Defining rights
  - Spatial dimension
  - Intertemporal dimension
- Significant externalities remain to be internalized