Shared Renewable Resource and International Trade: Technical Measures for Fisheries Management

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Shared Renewable Resources

- *Fish* and other *wildlife* stocks that straddle (or migrate) the boundaries of the territory or the Exclusive Economic Zones (EEZs) of two or more countries.
- Internationally shared (transboundary) *aquifer* and *river basin* resources
  - Biological conditions and national boundaries

Shared Fishery Resources

- Categories: *FAO (2004) Fisheries Technical Paper No.465*

1. Highly migratory stocks, which in fact refer to tuna.
2. The so-called “straddling” fish stocks, i.e., those stocks that migrate between the EEZs of one or more coastal states and the high seas.

- The number of such resources: *Caddy (1997)*

1. An estimate of 1000 to 1500 kinds in the world.
2. Only a small percentage of those is subject to effective and cooperative management.

Purpose of Fisheries Management

- Control over-exploitation
  - Direct control: output controls
  - Actual catch including by-catches and discards
  - Indirect control: restrict “catching capacity” of fishing fleets
  - Catching capacity is the product of the fishing effort and the combined efficiency of the fishing gear and the fishing vessel (e.g., loading capacity, engine power, range capacity, fish finding and navigational equipment) as well as the skills of the crew.

FAO (2002) A Fishery Manager’s Guidebook, Fisheries Technical Paper No.424

⟵ Monitoring, control and surveillance

Measures of fisheries management

Input controls

Restrictions on the total intensity of use of the gear: Fishing effort = Number of vessels × Catching power × Intensity × Days at sea

Technical measures

Restrictions on fishing gears,

Area and time restrictions

Output controls

IFQ (individual fishing quota):

IQ (individual quota),

ITQ (individual transferable quota),

VQ (vessel quota)

Technical Measures for Fisheries Management

- Examples of technical measures
  - restrictions on vessel size, engine power, gears (a minimum mesh size and prohibition on bottom trawling), fishing area, a minimum landing size, etc.

- Effects of technical measures

1. reduce catches of small juvenile fish and unintended by-catches species (e.g., turtles, marine mammals and sea birds)
2. avoid disrupting the spawning process
3. conservation of ecosystem

  - Encourage recovery of stock
  - It costs more to catch a certain quantity of fish.

Research Questions

- Welfare effects of international trade under technical measures for fisheries management
- Effects of trade on resource management
- Effects of trade on shared fishery stock under resource management
- Cooperative resource management

Outline

- Backgrounds
- Related literatures
- Main results
- Basic model
- Preliminary analysis
- Bilateral resource management: cooperative or non-cooperative management
- Unilateral management
- Summary

Backgrounds (1)

- Depletion of fishery resources

1. *FAO (2009) The State of World Fisheries and Aquaculture 2008* : fully exploited stocks, 50%; overexploited+depleted+recovering stocks, 25%-30%;
2. *Worm et al. (2006)* : the global collapse of all currently fishes will occur at the middle of the 21st century (in the year 2048).

- Increase in consumption and production of fishery resources
- Stock ↓ → productivity ↓ → economic loss

Figure 21

Global trends in the state of world marine stocks since 1974

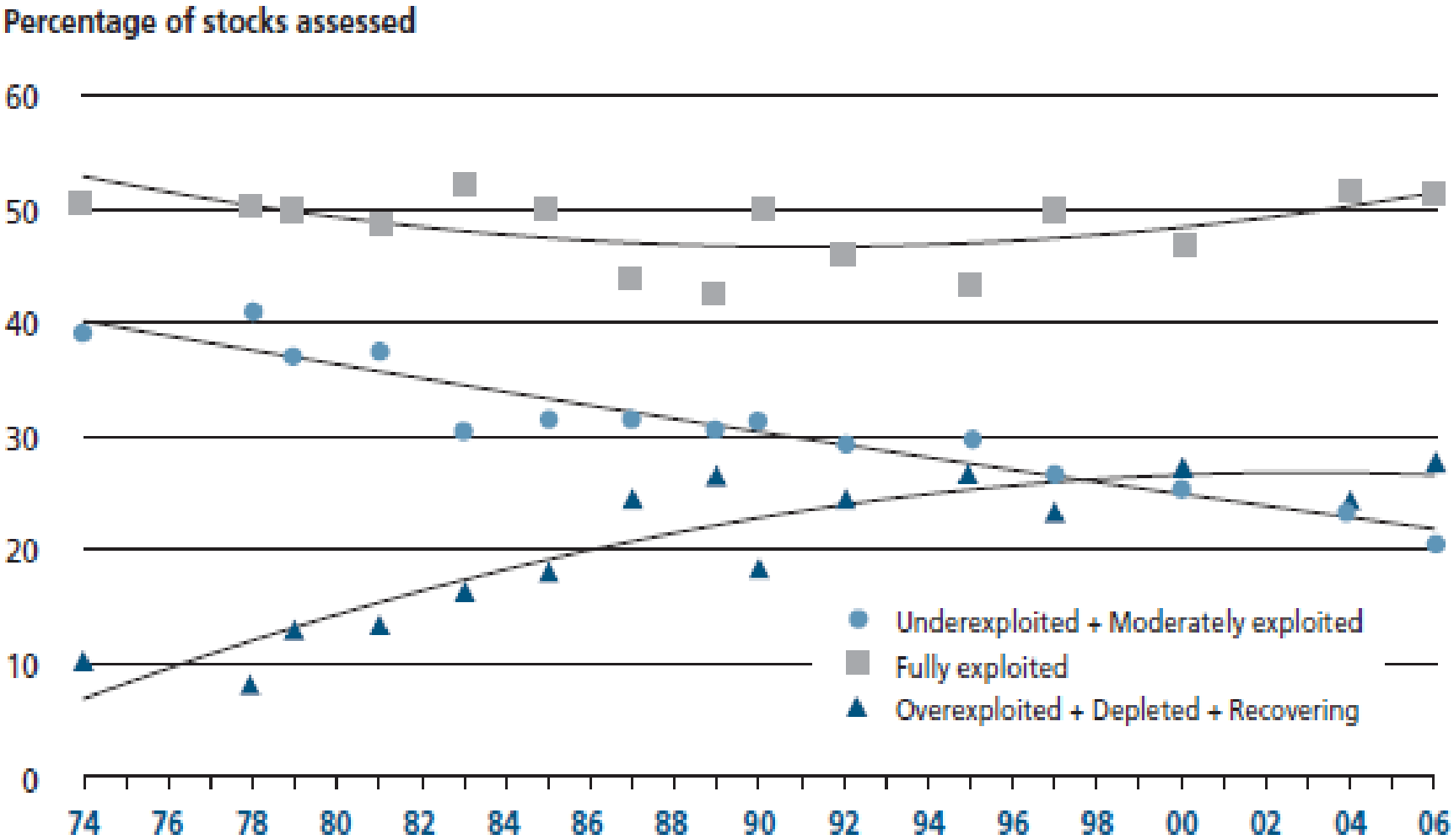
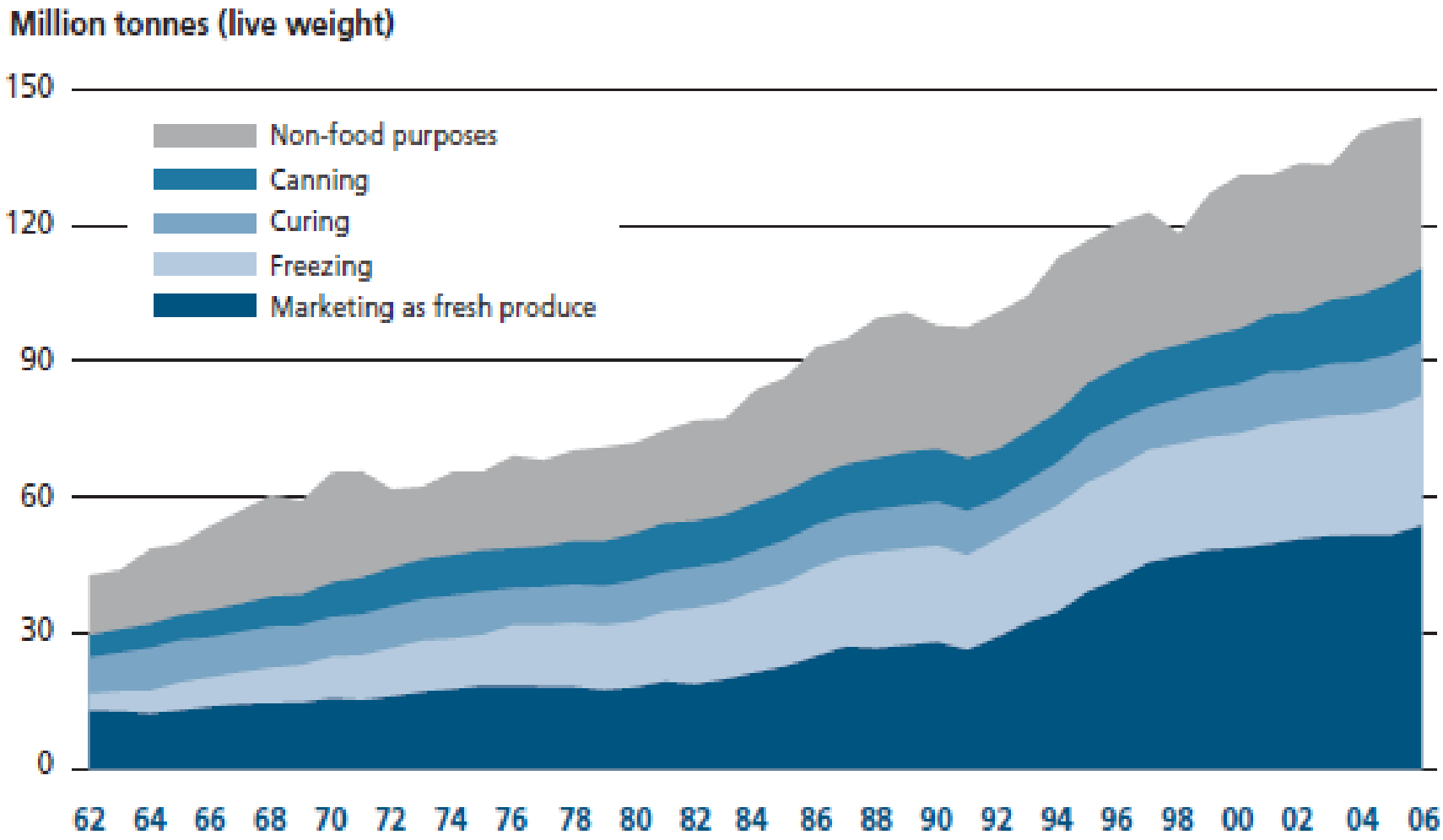


Figure 28

Utilization of world fisheries production (breakdown by quantity), 1962–2006



Backgrounds (2)
International Trade of Fishery Resources

- Fish and fishery products are highly traded with more than 37% (live weight equivalent) of total production. *FAO (2009)*
- Over 75% of the world marine fishery catch (over 80 million tons per year) is sold on international markets. *Watson and Pauly (2001) Nature* 414
- By 2006, 194 countries reported exports of fish and fishery products, and world exports reached US$85.9 billion (an increase of 9.6% on 2005 and of 62.7% on 1996). *FAO (2009)*

Figure 31

World fishery exports by major commodity groups

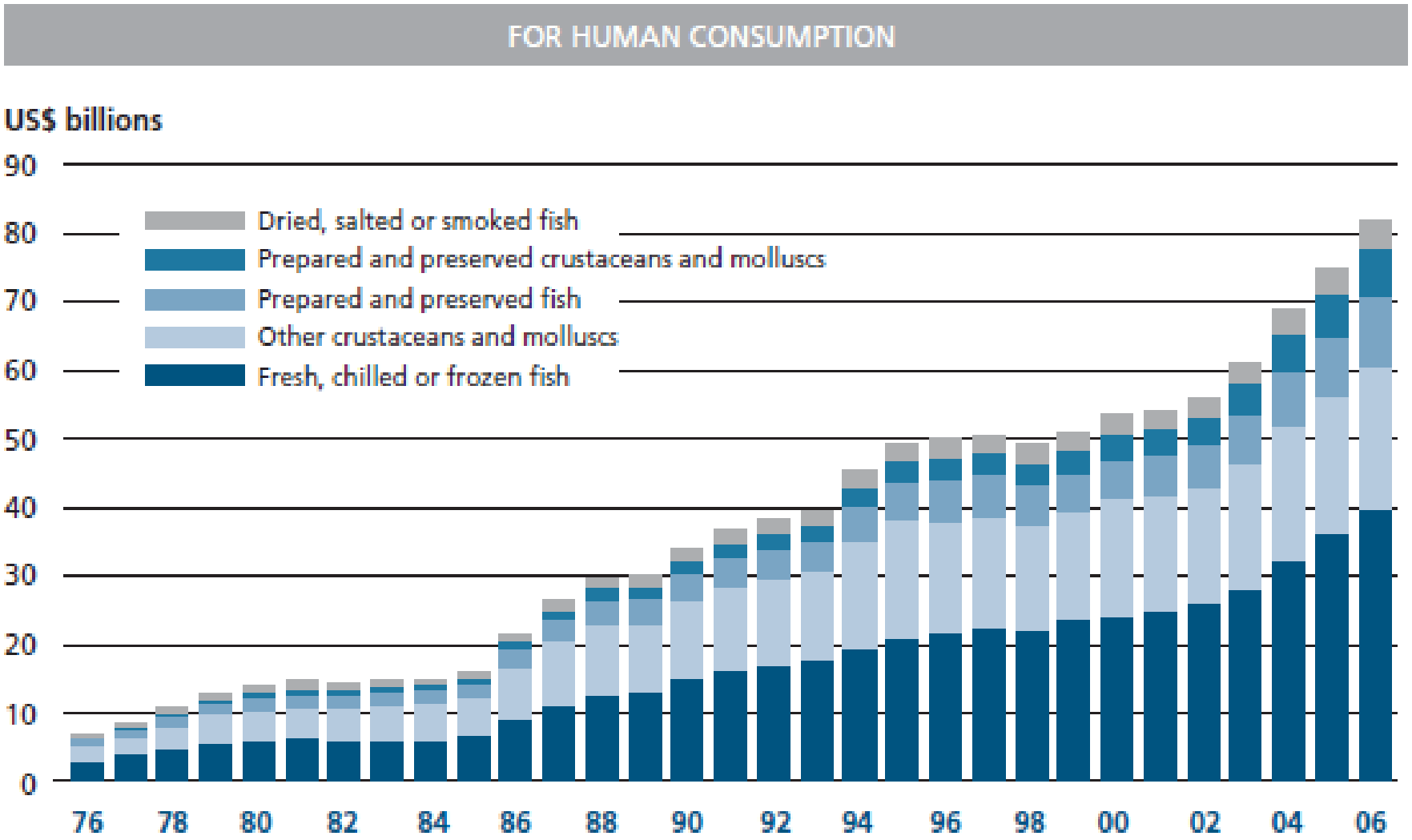
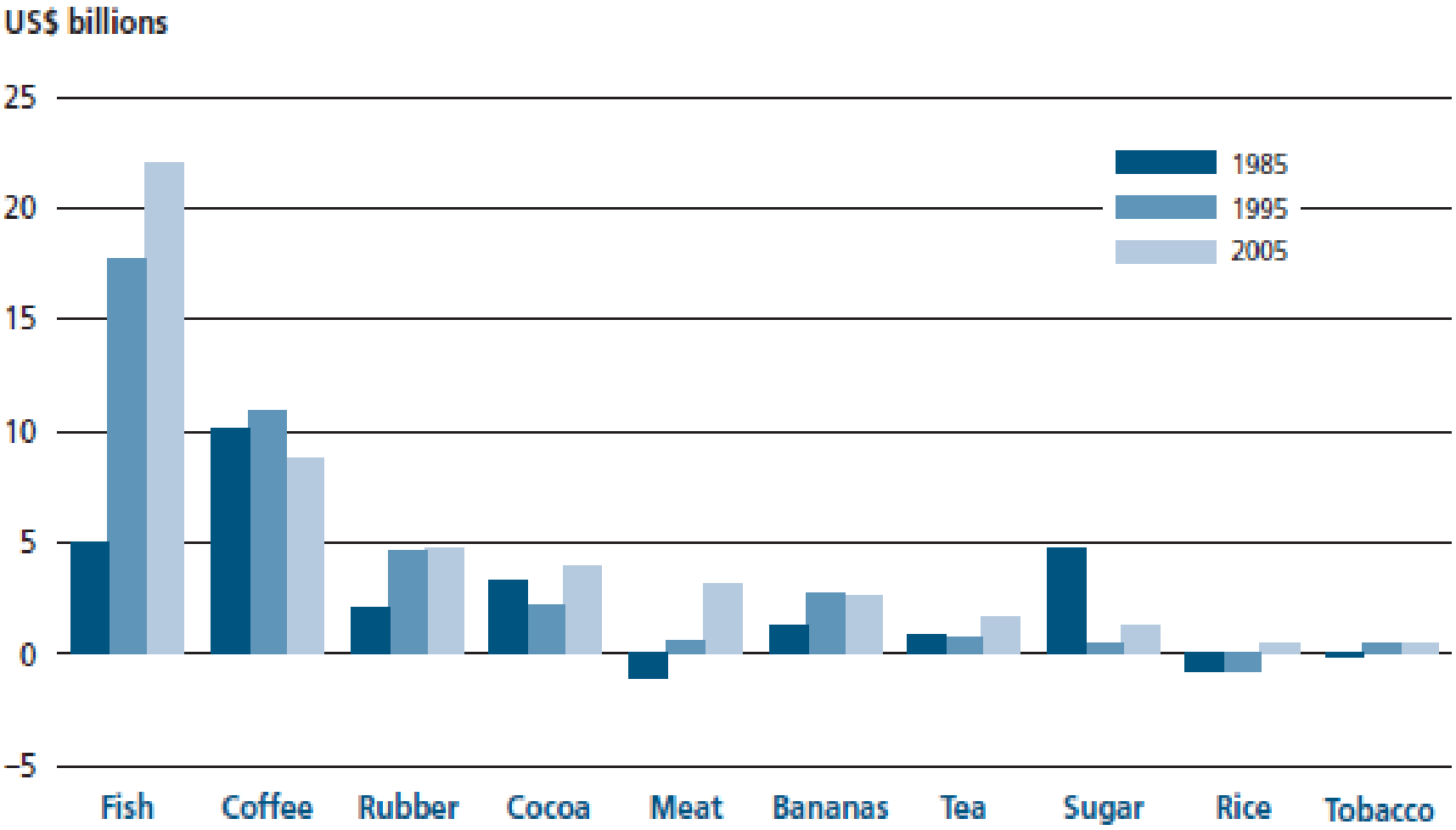


Figure 32

Net exports of selected agricultural commodities by developing countries



Backgrounds (3)
Fisheries Management and Open Access

- Managements are enforced

  e.g., the Common Fisheries Policy (CFP) by EU and International Commission for the Conservation of Atlantic Tunas (ICCAT)

- However,

1. we still observe illegal, unreported and unregulated (IUU) fishing activities; (e.g., the plunder of bluefin tuna in the Mediterranean and East Atlantic, *WWF (2006)*: over-quota catch is 40% above the total quota set by ICCAT in 2004 and 2005.)
2. fishery resources in some areas are in fact open access because of the jurisdiction problem.

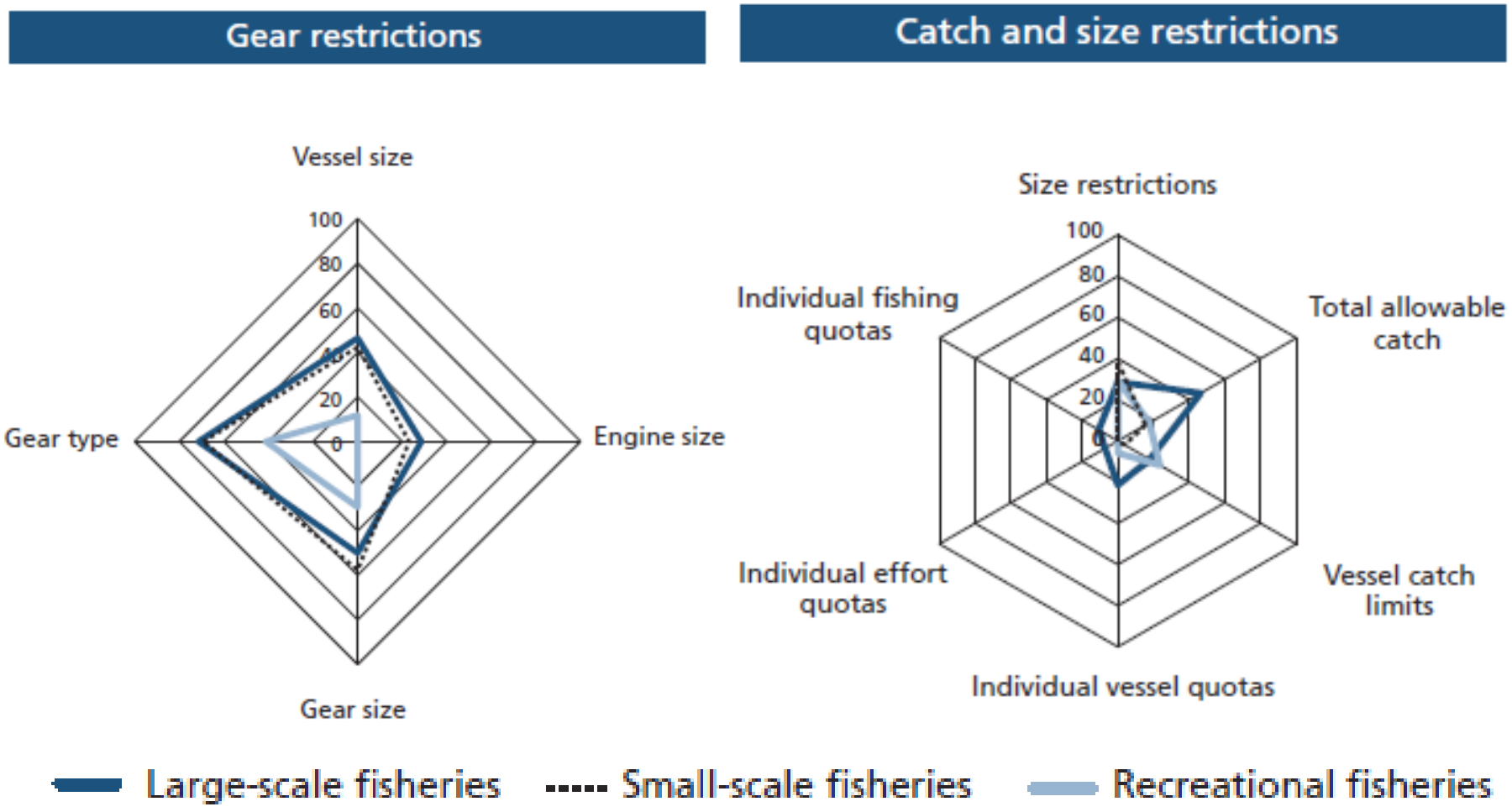
Backgrounds (4)
Technical Measures

- Technical measures are important and basic fisheries management, they are historically most widely implemented management tools.

- Regional fisheries management organizations (RFMOs) such as the International Commission for the Conservation of Atlantic Tunas (ICCAT) applies
  - restrictions against fishing quotas in member nations,
  - minimum allowable catch sizes,
  - time closures,
  - restriction and controls on fishing gears,
  - and protected areas, etc.

Figure 47

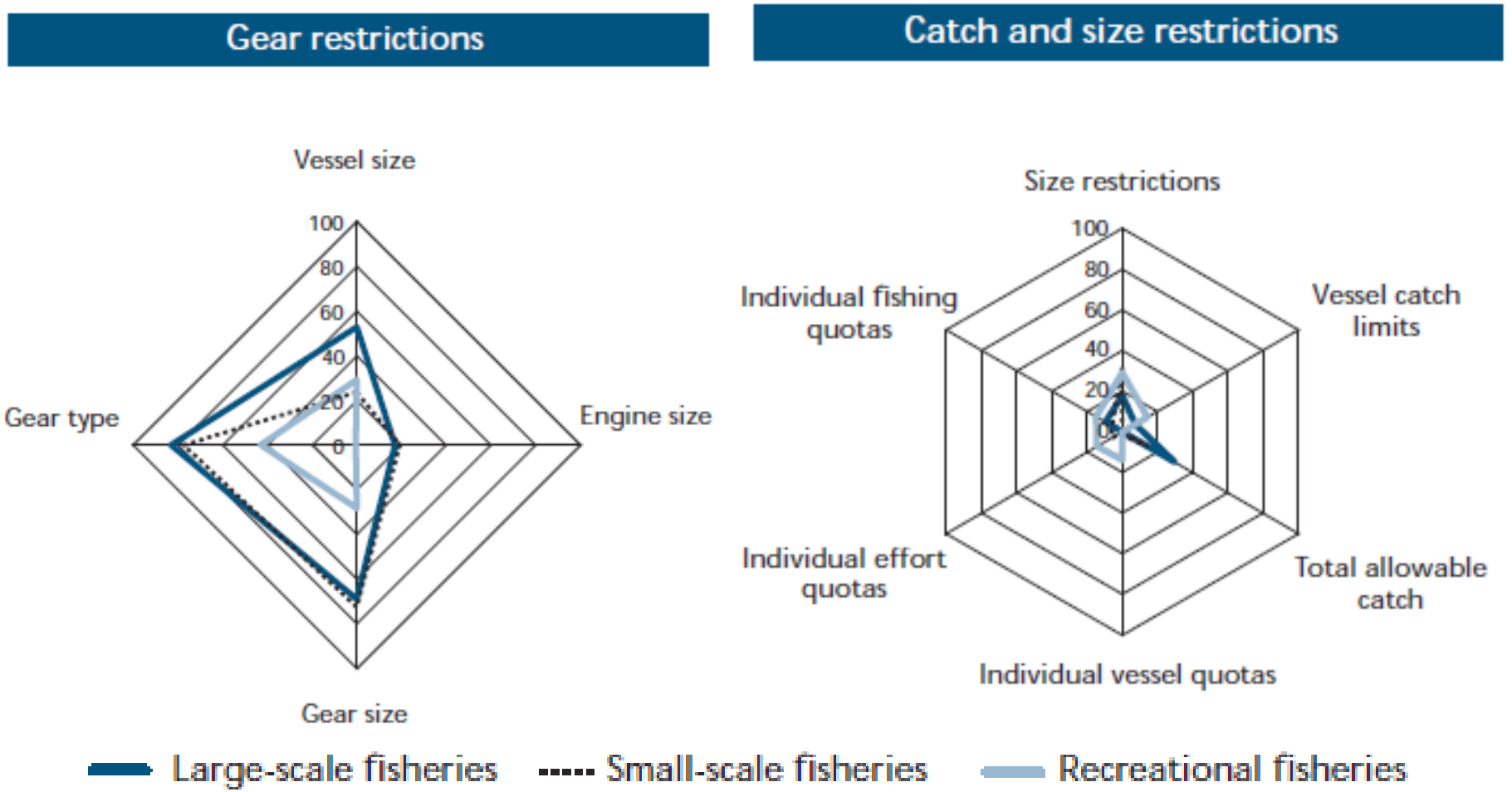
Technical measures for fisheries management in use in the Pacific Ocean countries (percentage of countries)



- FAO (2009) The State of World Fisheries and Aquaculture 2008, p.137

Figure 41

Technical measures for fisheries management in use in the Indian Ocean countries (percentage of countries)



- FAO (2007) The State of World Fisheries and Aquaculture 2006, p.128

Related Literatures (1)

- Patterns of trade and gains from trade

  Assumption: renewable resource is subject to <u>open access by residents of that country only</u>

- Focus: local resources such as forest

1. Basic model

   Brander and Taylor(1997, CJE; 1998, JIE)

2. With resource management

   Brander and Taylor(1997), Chichilnisky(1993, 1994), Emami and Johnston(2000), Hotte et al. (2000), Jinji (2007), and Copeland and Taylor (2009)

Related Literatures (2)

- Considerable and various papers about shared (transboundary) fishery resources
  - Focus is on strategic interactions between harvesting countries

1.*without trade*: fixed price, one sector model

e.g., Munro (1979), Levhari and Mirman (1980)

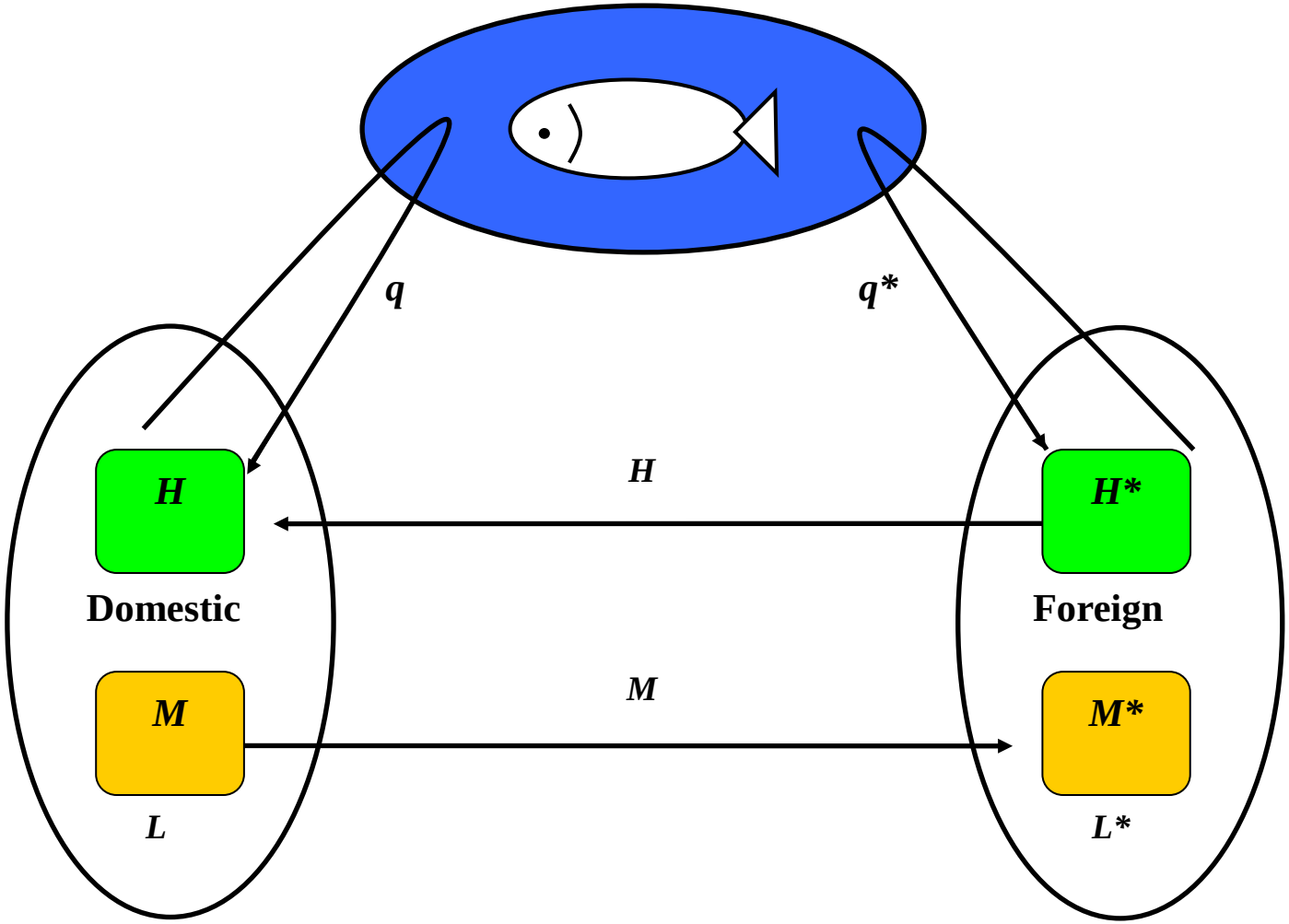
See, e.g., Munro and Scott (1985) and Clark (1990, 2006) for the development of this field.

2.*with trade*: Bulte and Damania (2005, CJE)

whether taxes (subsidies) on effort are strategic complements or substitutes

- Our contribution
  - Gains from trade under management of shared stock
  - Cooperative resource management under international trade

Basic Model



Main Results (1)

- Bilateral management
  - The resource exporting country gains from trade,

    whereas trade causes steady state utility to fall in the resource importing country,

    because the resource exporting country implements non-cooperative management

    when the demand for the harvest is not so high.
  - Under sufficiently high demand for the harvest,

    MSY can be attained after trade by what we call cooperative management and

    both countries are better off.

Main Results (2)

- Unilateral management
  - Under low demand for the harvest,
    trade benefits the resource importing country
    but may harm the resource exporting country
    although it implements strict management.

  - ✓ Low demand for the harvest ⟶ only one country produces the resource good.

Production

- Manufactures: $M_S = L_M$
- Harvest: $H_S = qSL_H$
- Input of labor: L_M , L_H
- Harvesting technology: *q*
- Shared renewable resource stock: *S*
- The unit labor requirement:

$$a_{LH}(S) = L_H / H_S = 1/(qS)$$

- Zero profit condition: $p = wa_{LH} = w/(qS)$
- The price of *M* is1 (numeraire)
- $w = 1$ if *M* is produced.

Demand

- The utility function: $u = h^{\beta} m^{1-\beta}$

  β, preference to the resource good, $0 < \beta < 1$

- Budget constraint: $ph + m = wL$

- Consumption: $H_D = w\beta L / p$

  $M_D = w(1-\beta)L$

Markets

- Market-clearing condition

$$H_D = \frac{w\beta L}{p} = w\beta L \frac{1}{wa_{LH}} = w\beta L \frac{qS}{w} = q\beta LS$$

$$H_S = qSL_H$$

$$H_D = H_S = q\beta LS$$

- Full employment condition

$$L_H + L_M = L$$

$$H_S a_{LH} + M = L \quad \text{(PPF)}$$

Basic Model: Autarkic Steady State (1)

- The dynamic function of resource stock at time *t* :

$$dS/dt = G(S) - H_S - H_S^*$$

- The growth function

$$G(S) = rS(1 - S/K)$$

- "Carrying capacity", *K* is the maximum possible size for the resource stock
- "Intrinsic" growth rate, *r*
- A steady state: $S_A = K(1 - q\beta L/r - q^*\beta L^*/r)$
- The steady state autarky prices:

$$p_A = 1/(qS_A), \quad p_A^* = 1/(q^*S_A)$$

Basic Model: Autarkic Steady State (2)

- A positive stock level requires $r > q\beta L + q^{*}\beta L^{*}$

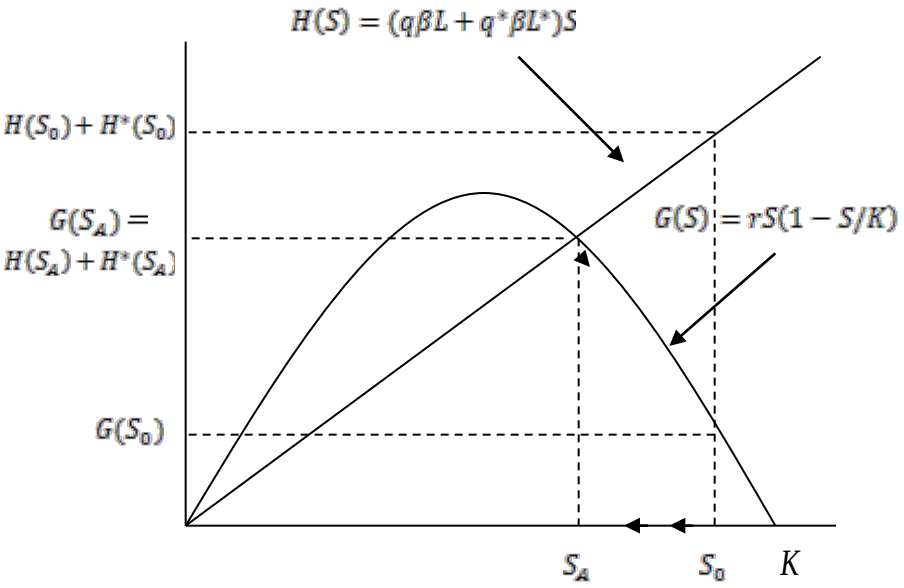


Figure 1. Transboundary Renewable resource dynamics

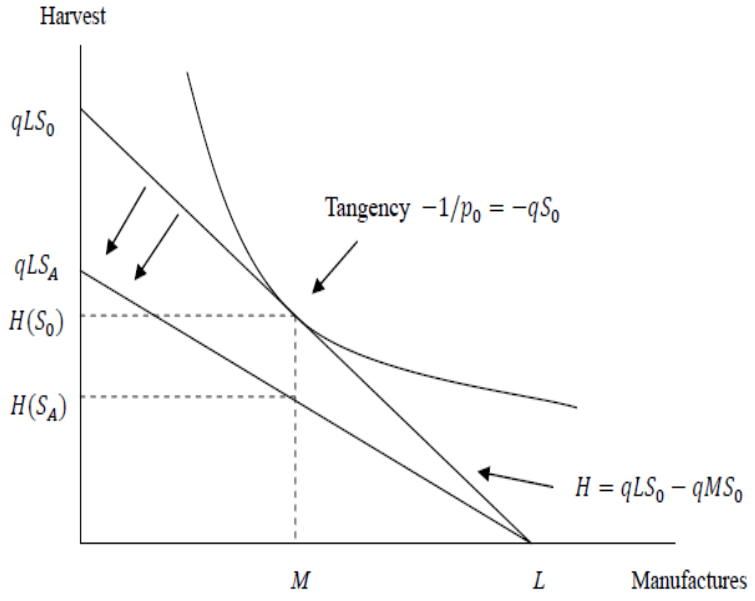


Figure 2. Temporary equilibrium dynamics in the domestic country

Steady State Patterns of Trade

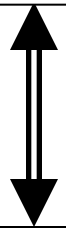
Without loss of generality, we assume

$$q < q^* \longrightarrow a_{LH} > a_{LH}^* \longrightarrow p_A > p_A^*$$

- The foreign country has a comparative advantage in producing *H*. ⟶ the foreign country exports *H*.
  - $q < q^*$ holds even after trade under the technical measures.

- Three patterns of production:
  - Domestic produces both *H* and *M,* Foreign specializes in *H.*
  - Domestic specializes in *M,* Foreign country specializes in *H.*
  - Domestic specializes in *M,* Foreign produces both *H* and *M.*
- $q=q^*$ must hold when both countries are diversified.

High demand on *H*



Low demand on *H*

Both countries produce H: Domestic country, H and M; Foreign country, H

- Conditions for this case:

$$[\beta L/(1-\beta)L^*] > (q^*/q)$$

$$w = 1 \qquad w^* > 1$$

- The post-trade resource stock:

$$S_{T3} = K(1 - q\beta L/r - q^*\beta L^*/r)$$

$$S_{T3} = S_A$$

If $S_{T3} \neq S_A$, the zero-profit condition cannot hold.

- Autarky: $p_A q S_A = 1$ and $p_A{}^* q^* S_A = 1 \longrightarrow p_A > p_A{}^*$
- Trade: $p_{T3} q S_{T3} = 1$ and $p_{T3} q^* S_{T3} = w^* > 1$

if $S_{T3} < S_A$, then $p_{T3} > p_A > p_A{}^* \longrightarrow H_S^W \neq H_D^W$

Result *without* resource management : Takarada et al. (2009)

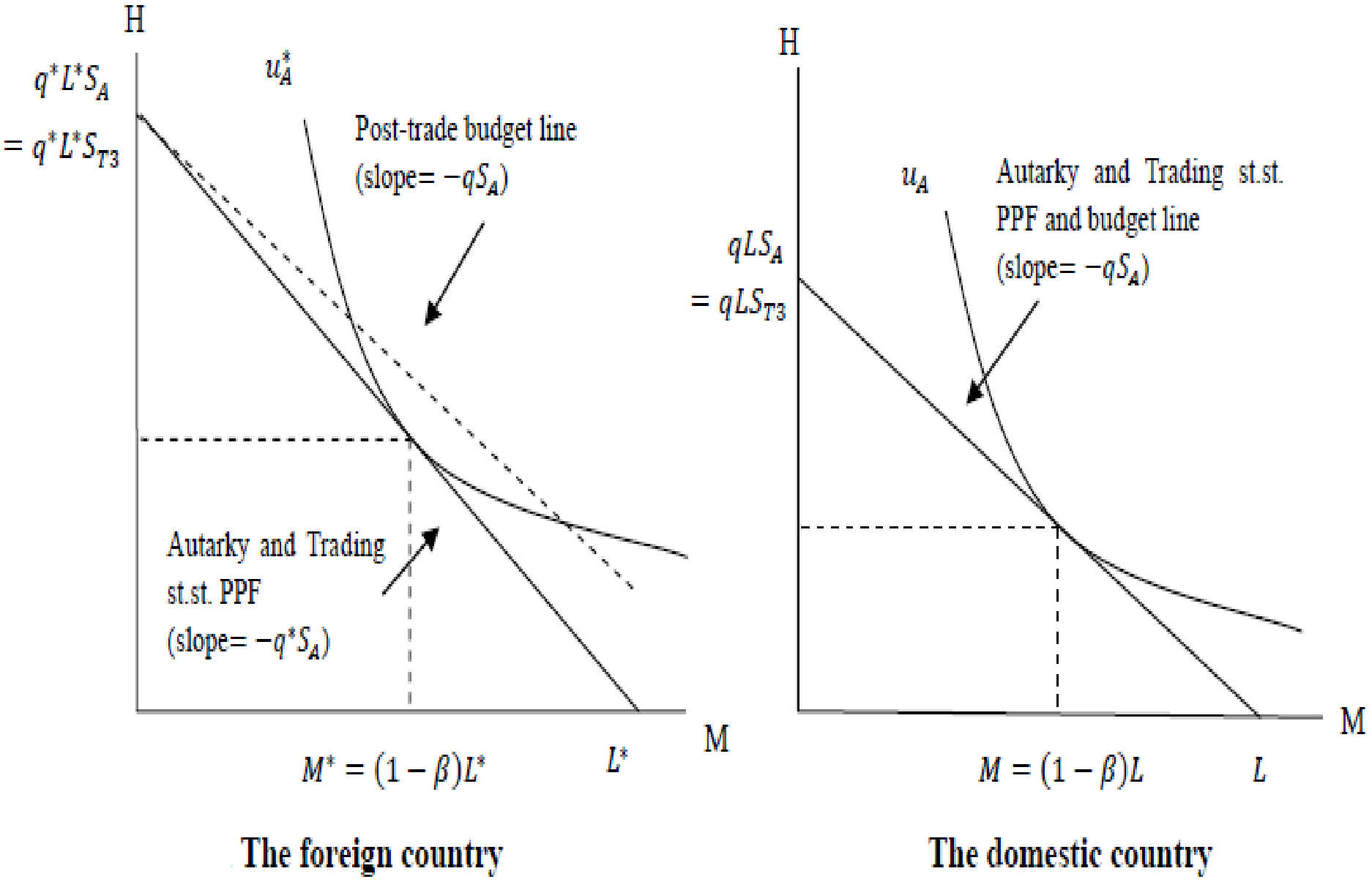
The trading steady state is diversified for the domestic country and specialized for the foreign country, if and only if $[\beta L/(1-\beta)L^*] > (q^*/q)$.

(i) The post-trade shared renewable resource stock is the same as autarky.

(ii) Trade does not change steady state utility in the domestic country.

(iii) Trade causes steady state utility to rise in the foreign country.

- A standard result in a Ricardian model



Domestic country, H and M; Foreign country, H

Transition to a steady state *without* resource management

Technical Measures

- Assumptions

  1. Changes in q and q^* are costless.

  ➢ Regulations on q improve social welfare.

  2. Production pattern remains the same even after implementation of resource management.

- The government's problem

  maximize the steady state utility, u, by setting the optimal harvesting technology, q.

  ➢ Technical measures are not the first-best policy.

Preliminary Analysis: Autarkic Steady State

- The foreign government's problem

$$\underset{q^* \geq 0}{Max}\, q^*(r - q\beta L - q^*\beta L^*) \longrightarrow q_A^* = \frac{r - q\beta L}{2\beta L^*}$$

➢ $u_A^* = L^*\{\beta q^* K(1 - q\beta L/r - q^*\beta L^*/r)\}^{\beta}(1-\beta)^{1-\beta}$

- Autarkic steady state:

$$S_A' = \{K(1 - q\beta L/r)\}/2, \quad r > q\beta L$$

$$p_A' = \frac{2}{qK(1 - q\beta L/r)}, \quad p_A^{*\prime} = \frac{4\beta L^*}{rK(1 - q\beta L/r)^2}$$

$$u_A' = \{(q\beta K/2)((1 - q\beta L/r)\}^{\beta}(1-\beta)^{1-\beta} L$$

$$u_A^{*\prime} = \{(rK/4)((1 - q\beta L/r)^2\}^{\beta}\{(1-\beta)L^*\}^{1-\beta}$$

Preliminary Analysis: Trading Steady State (1)

- Production pattern: <u>both countries produce *H*</u>

  Domestic country, *H* and *M*

  Foreign country, *H*

- Assumption $q < q^* \longrightarrow r > q\beta(2L^* + L)$

- The foreign government's problem after trade

$$\underset{q^* \geq 0}{Max}\, q^*(r - q\beta L - q^*\beta L^*)^\beta \longrightarrow q_1^* = \frac{r - q\beta L}{\beta(1+\beta)L^*}$$

- Necessary and sufficient condition

$$q\beta\{(\beta+1)L^* + L\} < r < \{q\beta L(\beta^2+1)\}/(1-\beta)$$

Preliminary Analysis: Trading Steady State (2)

- Harvesting technology

  $1 < q_1^* / q_A^* = 2/(1+\beta) < 2$, which only depends on β

- Stock

  $$S_{T1} = \{\beta K(1 - q\beta L/r\}/(1+\beta), \quad r > q\beta L \longrightarrow S_{T1} < S_A'$$

- Domestic welfare: $\partial u_A / \partial q^* < 0$

Preliminary Analysis: Proposition 1

Suppose that the *foreign country only* enforces technical measures.

The trading steady state is diversified for the domestic country and specialized for the foreign country, if and only if

$$q\beta\{(\beta+1)L^{*}+L\}<r<\{q\beta L(\beta^{2}+1)\}/(1-\beta).$$

(1) the foreign country implements weak resource management after trade;

(3) the post-trade shared stock is reduced by trade;

(4) the foreign country always gains from trade;

(5) the domestic country always suffers utility loss after trade.

- The change in the shared stock is consistent with the empirical evidence (McWhinnie 2009, *JEEM*).

Intuition of Proposition 1

- $q^*\uparrow$ has two opposite effects

  1. improvement of the efficiency in the resource sector
  2. decrease in the shared stock

- ➢ It is better for the foreign country to increase q^* under the conditions.
- ➢ Overexploitation becomes more sever

  ⟶ the price of *H* increases after trade

  ⟶ the domestic country is worse off by trade ($I = wL = L$)

- ◆ <u>Only the *domestic* country enforces the technical measures</u>

  ⟶ $u_a(\cdot) = u(\cdot)$ ⟶ no incentive to change *q*

  ⟶ effects of trade is the same without resource management

Implication of Proposition 1

- Technical measures by only the *foreign* country
  ⟶ the *domestic* country is worse off after trade
  - The resource importing country without resource management (the domestic country) has an incentive to change *q* after trade.
  - The resource importing country should also enforce the technical measures.

- Brander and Taylor (1997): local resources, only one country with resource management, and diversification in both countries
  - Sever overuse case: both countries benefit from trade.

Bilateral Resource Management: Autarkic Steady State

- Each country maximizes its welfare

$$\longrightarrow \quad q_a = r/3\beta L \ , \quad q_a^* = r/3\beta L^*$$

- Autarkic steady state

$$S_a = K/3$$

$$p_a = 9\beta L/rK, \quad p_a^* = 9\beta L^*/rK$$

$$u_a = (rK/9)^{\beta}\{(1-\beta)L\}^{1-\beta}$$

$$u_a^* = (rK/9)^{\beta}\{(1-\beta)L^*\}^{1-\beta}$$

Non-Cooperative Management under International Trade

- Production pattern: <u>both countries produce *H*</u>

  Domestic country, *H* and *M*

  Foreign country, *H*

- Suppose that the technical measures are enforced non-cooperatively.

  ⟶ Each country maximizes its own post-trade welfare.

$$\begin{cases} q = \dfrac{r - q^* \beta L^*}{2\beta L} \\ q^* = \dfrac{r - q\beta L}{\beta(1+\beta)L^*} \end{cases} \longrightarrow \begin{cases} q_n = \dfrac{r}{(1+2\beta)L} \\ q_n^* = \dfrac{r}{\beta(1+2\beta)L^*} \end{cases} \longrightarrow \begin{cases} q_a > q_n \\ q_a^* < q_n^* \end{cases} \longrightarrow S_n < S_a$$

- Assumption $q < q^* \longrightarrow q_n < q_n^* \longrightarrow \beta L^* < L$
- $0 < L_H < L \longrightarrow (\sqrt{5}-1)/2 < \beta < 1;\ r < 2q\beta L/(1-\beta) \longrightarrow H_S > 0$

Non-Cooperative Management: Lemma 1

Suppose that both countries implement resource management in autarky and non-cooperative resource management occurs after trade. The conditions for this case are $\beta L^* < L$ and $(\sqrt{5}-1)/2 < \beta < 1$.

(1) the *foreign* country implements weak resource management after trade, whereas the *domestic* country implements strict management after trade;

(2) the post-trade shared stock is reduced by trade;

(3) the *foreign* country always gains from trade;

(4) the *domestic* country always suffers utility loss after trade.

Intuition of Lemma 1

- $q^*\uparrow \longrightarrow$ shared stock $\downarrow$ even if $q\downarrow$
  $\longrightarrow$ price of $H\uparrow$
- Domestic income = $wL = L$ because w=1
  $\longrightarrow$ $u\downarrow$
  - Domestic country still suffer utility loss even if it implements the technical measures.
- $w^*\uparrow$ (>1) $\longrightarrow$ Foreign welfare improves

◆Cooperative management?

- Both countries can improve their welfare by making a marginal *decrease* in their post-trade harvesting technology severally.

Cooperative Resource Management (1)

- Foreign country has the bargaining power.

  ⟵ Foreign country is better off in the case of non-cooperative management.

- ➢ The foreign government's problem:

  maximize its own utility while keeping the domestic utility as same as autarky

$$\underset{q\ge 0, q^*\ge 0}{Max}\ \ln q^* + (\beta-1)\ln q + \beta\ln(r - q\beta L - q^*\beta L^*)$$

s.t. $q(r - q\beta L - q^*\beta L^*) = q_a(r - q_a\beta L - q_a^*\beta L^*)$

$$\longrightarrow\quad q_c = \frac{2r}{9\beta L},\quad q_c^* = \frac{5r}{18\beta L^*},\quad S_c = K/2$$

- Assumption $q < q^* \longrightarrow q_c < q_c^* \longrightarrow 4L^* < 5L$
- $0 < L_H < L \longrightarrow 5/9 < \beta < 1,\quad r < 2q\beta L/(1-\beta) \longrightarrow H_S > 0$

Cooperative Resource Management (2)

- Trading steady state

$$\begin{cases} q_c < q_n < q_a \\ q_c^* < q_a^* < q_n^* \\ S_n < S_a < S_c \end{cases}$$

  - Both countries implement most strict management.
  - Overexploitation mitigates: stock after trade recovers up to MSY.

Cooperative Management: Lemma 2

Suppose that both countries implement resource management in autarky and cooperative resource management occurs after trade. The conditions for this case are $4L^* < 5L$ and $5/9 < \beta < 1$.

(1) *both countries* implement strict resource management after trade;

(2) the post-trade shared stock recovers to MSY;

(3) the *foreign* country always gains from trade;

(4) the utility level of the *domestic* country remains the same as autarky.

Cooperation or Non-Cooperation

- Existence of overlapped area

$$(\sqrt{5}-1)/2 < \beta < 1, \quad L^*/L < \min\{5/4, 1/\beta\}$$

- Cooperation or non-cooperation?

$$\frac{u_n^*}{u_c^*} = \frac{4}{5\beta}\left(\frac{3\beta}{1+2\beta}\right)^{2\beta} \longrightarrow u_n^*/u_c^* = 1 \text{ when } \tilde{\beta}$$

  - Strictly decreasing under $\beta \in ((\sqrt{5}-1)/2, 1)$
  - $\lim_{\beta \to (\sqrt{5}-1)/2} \left(u_n^*/u_c^*\right) > 1$ and $\lim_{\beta \to 1} \left(u_n^*/u_c^*\right) < 1$

Cooperation or Non-Cooperation: Proposition 2

Suppose that both countries implement resource management in the trading steady state and the conditions $(\sqrt{5}-1)/2 < \beta < 1$, $L^*/L < \min\{5/4, 1/\beta\}$ hold.

The *foreign* country will chose <u>non-cooperative</u> resource management if $(\sqrt{5}-1)/2 < \beta \leq \tilde{\beta}$.

Otherwise, the *foreign* country will implement <u>cooperative</u> management.

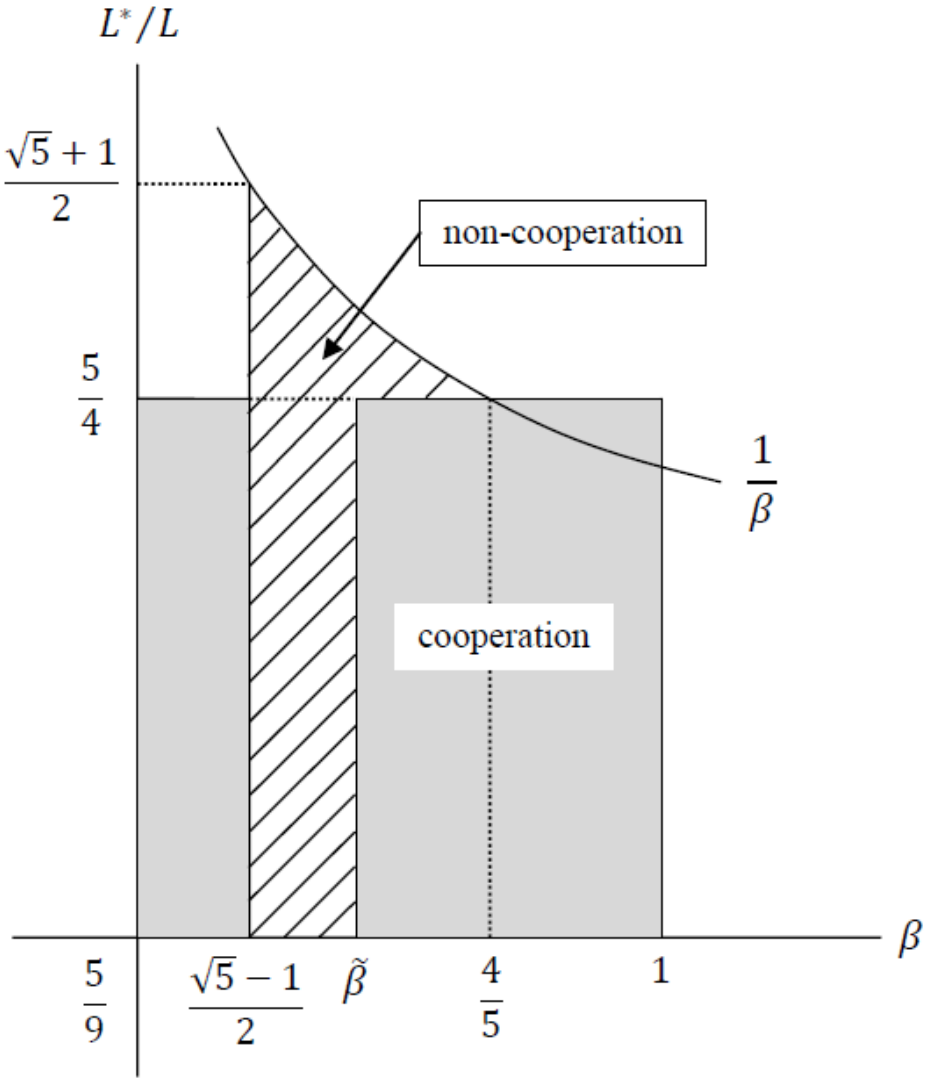


Figure 1 Cooperative and non-cooperative resource management

Note: Only a cooperative equilibrium exists under $5/9 < \beta < (\sqrt{5}-1)/2$.
Only a non-cooperative equilibrium exists under $L^*/L > 5/4$.

Intuition of Proposition 2

- When β is sufficiently large $(\beta > \tilde{\beta})$

  $\longrightarrow$ { the resource price is high enough
  { resource stock under cooperative is MSY

  - The foreign country gains much form cooperation.
  - Its production of *H* is larger than under non-cooperation.

- When β decreases $\longrightarrow$ the resource price $\downarrow$

  - Non-cooperation is beneficial: the foreign country maximizes its own welfare without any constraint;

  the domestic country implements strict management.

Implication of Proposition 2

- *Cooperative* management can be achieved without sanctions and side payments, when the demand for *H* is high.
  - The price effect is important.
  - Technical measures are effective for conservation of the stock under trade (MSY is attained).
  - ✓ Takarada et al. (2009): trade never improves the stock without resource management.
- However, *non-cooperative* equilibrium occurs when the demand for *H* is not so high.
  - Other policy instruments (e.g., tariffs, taxes, and output controls) are needed for conservation of the resource and improvement of world welfare.

Other patterns of production

- *H* is produced only by the foreign country

  - Domestic country specializes in *M,*
    Foreign country produces both *H* and *M*
  - Domestic country specializes in *M,*
    Foreign country specializes in *H*

  ⟶ The technical measures are implemented by the *foreign* country after trade.

  - Autarky: we assume that only the foreign country implements resource management to obtain explicit results.

Domestic country, *M*; Foreign country, *H* and *M*

Proposition 3.

Suppose that only the foreign country implements resource management in autarky and the trading steady state, and the domestic country specializes in manufactures and the foreign country diversifies after trade. The necessary and sufficient condition for this case is $\beta L < (1-\beta)L^*$.

(1) the *foreign* country implements strict resource management after trade;

(2) the resource stock recovers to MSY;

(3) the *domestic* country always gains from trade;

(4) the *foreign* country always suffers utility loss.

Result *without* Resource Management: Takarada et al. (2009)

The trading steady state is specialized for the domestic country and diversified for the foreign country, if and only if $[\beta L/(1-\beta)L^*]<1$.

(i) The post-trade shared renewable resource stock is reduced by trade.

(ii) Trade causes steady state utility to fall or rise in the domestic country depending on the condition.

(iii) Trade always causes steady state utility to fall in the foreign country.

Intuition and Implication of Proposition 3

- Intuition

➢ Although the resource stock recovers to MSY, the decline of the harvesting technology, q^*, still increases the resource price in terms of the foreign country.

- National income in foreign: $w^*L^* = L^*$ (w^*=1)
- The price of H falls in the domestic country and it gains from trade.

- Implication

➢ Other policy instruments are required to complement the technical measures because the resource exporting country (foreign) *never gains from trade* even if it enforces the optimal technical measures.

Domestic country, *M*; Foreign country, *H*

Proposition 4.

Suppose that only the foreign country implements resource management in autarky and the trading steady state, and both countries specialize after trade. The necessary and sufficient condition for this case is $\beta L \geq (1-\beta)L^*$ and $r \geq 2q\beta L/(1-\beta)$.

(1) the *foreign* country implements strict resource management after trade;

(2) the resource stock recovers to MSY;

(3) the *domestic* country always gains from trade;

(4) trade may benefit or harm the *foreign* country.

Result *without* Resource Management: Takarada et al. (2009)

The trading steady state is specialized for both the domestic and foreign country, if and only if $1 \leq [\beta L / (1-\beta) L^*] \leq (q^*/q)$.

(i) The post-trade shared renewable resource stock is reduced by trade.

(ii) Trade causes steady state utility to fall or rise in the domestic country depending on the parameters.

(iii) Trade causes steady state utility to rise or fall in the foreign country.

Intuition and Implication of Proposition 4

- Intuition
  - The foreign country benefits from trade if the increase of the wage rate covers the welfare loss caused by the rise of the foreign resource price.
  - The domestic country gains from trade because of the same reason as Proposition 3.

- Implication
  - *A win-win situation* may occur when the steady state is specialized for both countries under the technical measures.

Remarks

- A cooperative equilibrium will arise when the demand for *H* is sufficiently high.
- Technical measures are effective in the following sense although they are not the first-best policy.
  - Welfare: Cooperative management can arise.
  - Biological sense: trade can recover the shared stock to MSY.
- Other measures are required to complement the technical measures when the demand for *H* is small because the resource exporting country is unlikely to benefit from trade.

Possible Extension

- Resource management: output controls
- Dynamic analysis

Thank you for your attention!