Trade and Natural Capital

Brian Copeland
University of British Columbia

April 2013

Why Does it Matter?

Focus here will be on natural capital as an input into production (renewable resources, climate, water, etc.)

Without natural capital, there is a trade-off between income and environmental quality

With natural capital constraints:

- environmental degradation can lead to long run real income losses
- stringent environmental / conservation policy can be a source of comparative advantage
- lock-in effects can arise

Trends in environmental outcomes

- Lopez and Islam (2008) note a divergence between trends in environmental outcomes in urban areas vs rural environmental capital (also global pollutants)
- Evidence of technique effects (policy) offsetting scale effects for air pollution and to a somewhat lesser extent water pollution in urban areas as income rises
- However serious concerns about depletion of natural capital, especially but not exclusively in developing countries
- Trends in fisheries depletion are particularly alarming

Trends in fisheries

- According to FAO, proportion of fish stocks harvested beyond their maximum sustained yield (MSY) levels was 10% in 1970 and 30% in 1990's
- There have been major fishery collapses in high income countries, such as cod fishery off the east coast of Canada, white abalone off California, and others.
- Fish harvests now come (on average) from lower trophic levels than before
- A controversial study by Worm et al published in *Science* in 2006 projected that if current behaviour persists, all of the world's fisheries would collapse by 2048

Questions

- Is international trade exacerbating natural capital depletion?
- How does environmental / conservation policy affect the pattern of trade (and gains from trade)?
- How does the effectiveness of resource management respond to the trade regime?

Modelling Natural Capital

Let S denote a stock of natural capital

S naturally regenerates but is degraded by production in sector X

$$\frac{dS}{dt} = G(S) - X$$

where *G* is natural growth.

Consider a two good (X and Y) model and focus on two cases:

(1) S is a public input into Y production but not X production

- Cross-sectoral production externality

(2) S is a public input into X production but not Y production

- Fishery

Cross-sectoral production externalities

Natural capital is damaged by economic activity from outside the affected sector

Examples

- Industrial pollution damages fisheries
- Deforestation causes flooding and disrupts agriculture and other economic activity
- Tourism deterred by industrial pollution and wilderness degradation

A simple model

1. Two industries:

   Y (Clean)
   M (Pollutes)

2. Pollution from M degrades stock of environmental capital, S

3. The clean industry Y uses S as a free public input

4. Pollution is country-specific

5. Governments do nothing

6. Pollution does not harm consumers directly

Technology

$$M = L_M$$

$$Z = \lambda L_M$$

$$Y = S^{\alpha} L_Y$$

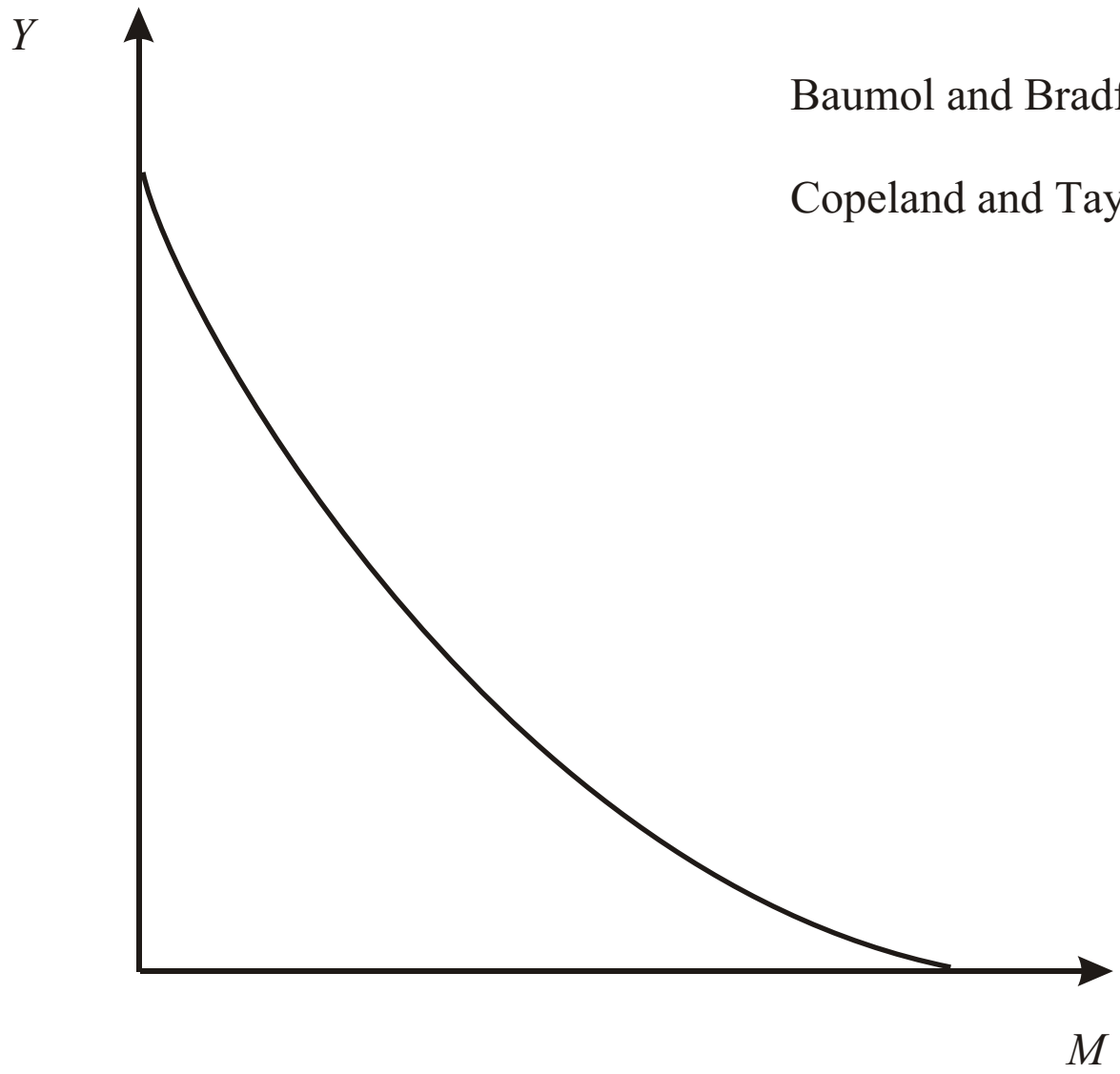
Natural Capital

$$\frac{dS}{dt} = G(S) - \gamma Z$$

Full Employment

$$L_Y + L_M = L$$

Markets clear at any point in time; adjustment to steady state is via evolution of S



Baumol and Bradford (1972)

Copeland and Taylor (1999)

Long Run Production frontier: Cross sectoral Externalities

Consider Two Identical Countries and Liberalize Trade

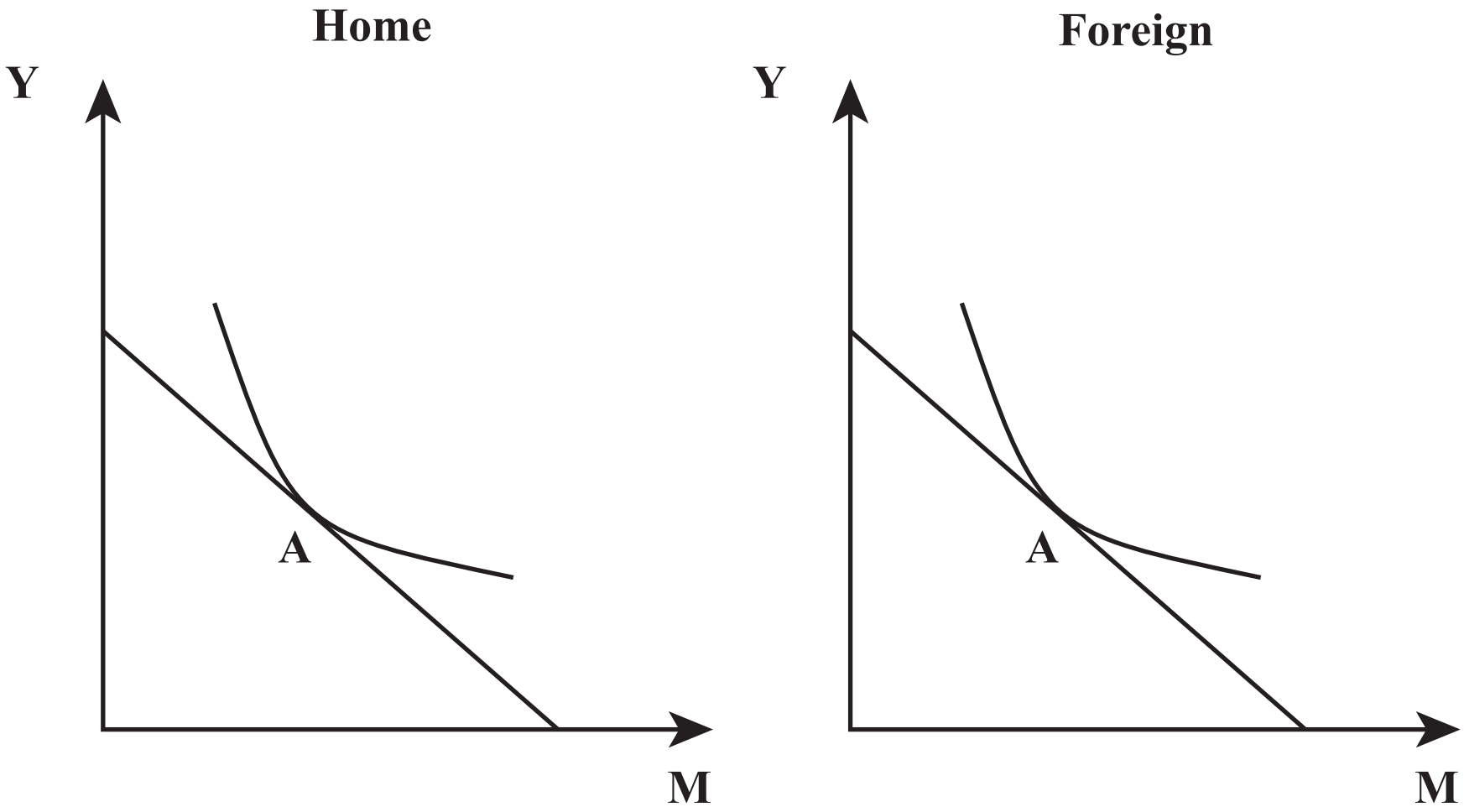
Autarky prices are the same and so one equilibrium is that there is no trade

But the no-trade equilibrium is unstable

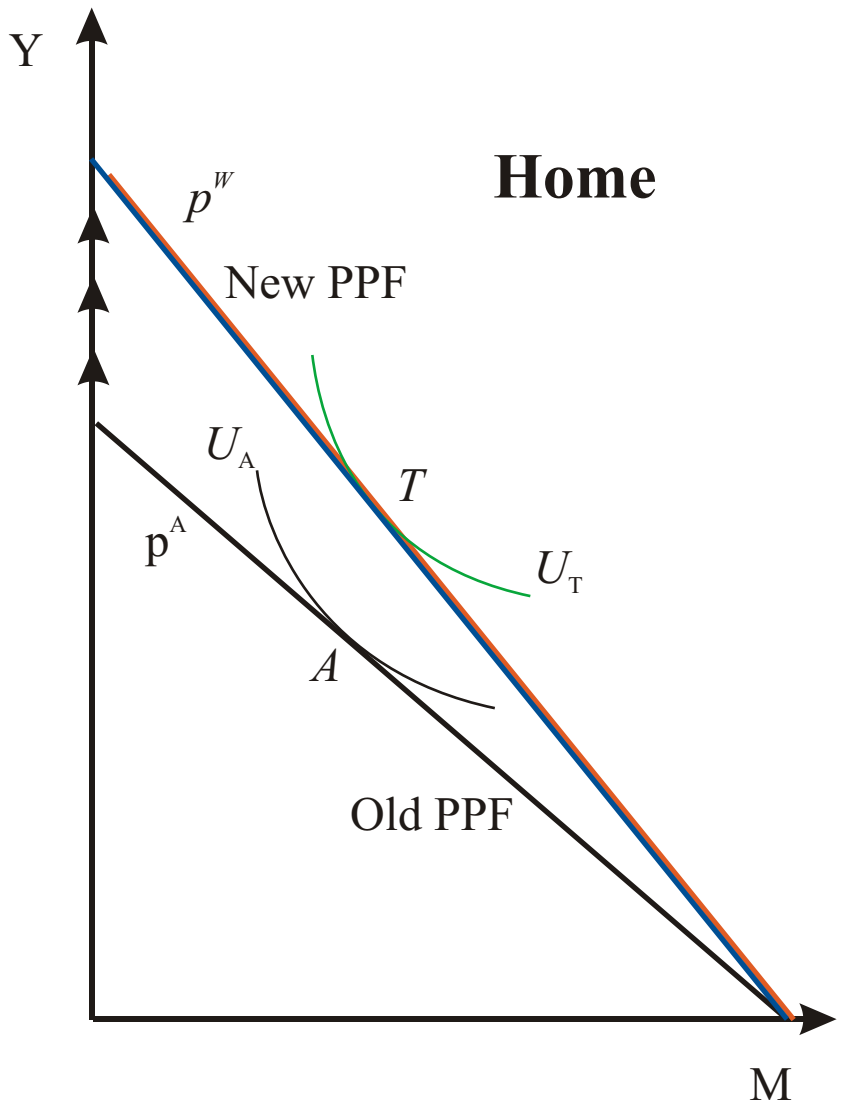
Three possible types of outcomes

- High demand for polluting good
- Intermediate demand for the polluting good
- Low demand for the polluting good

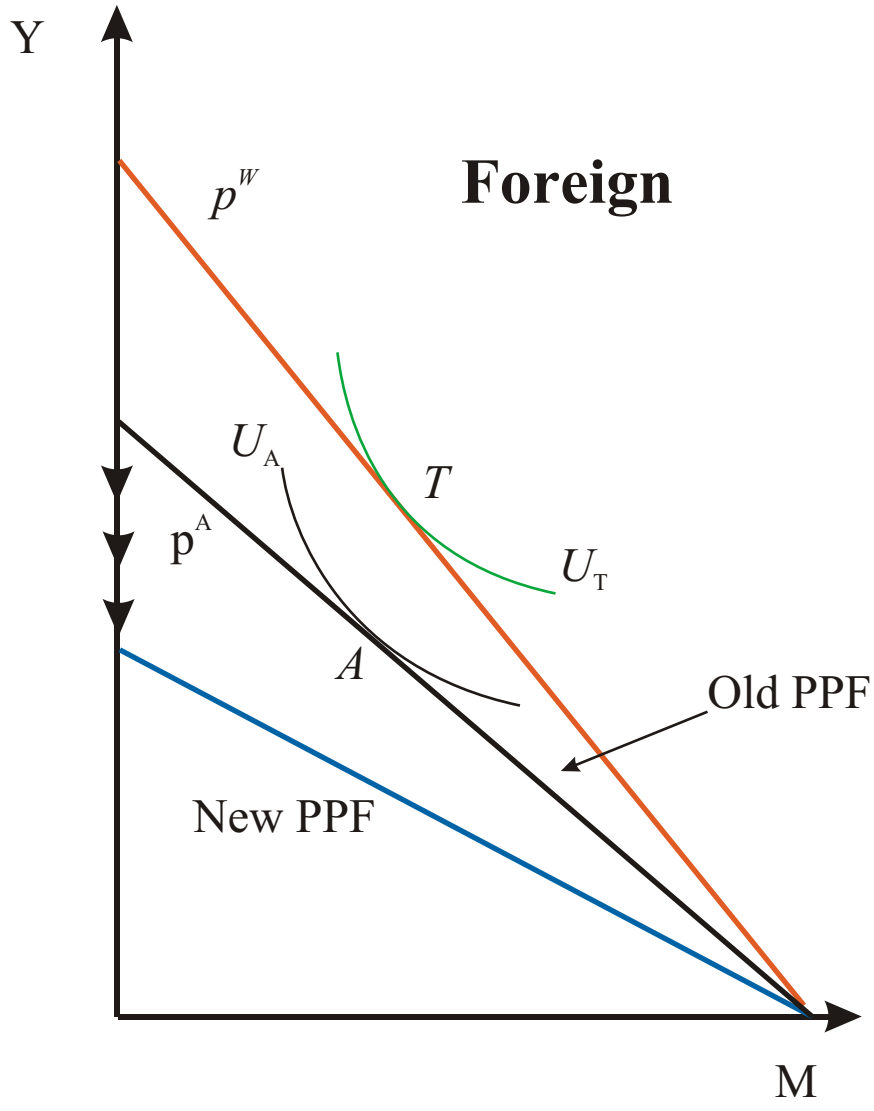
Autarky



Case 1: High demand for the Polluting Good: Both gain from trade



Production of clean good
expands at Home

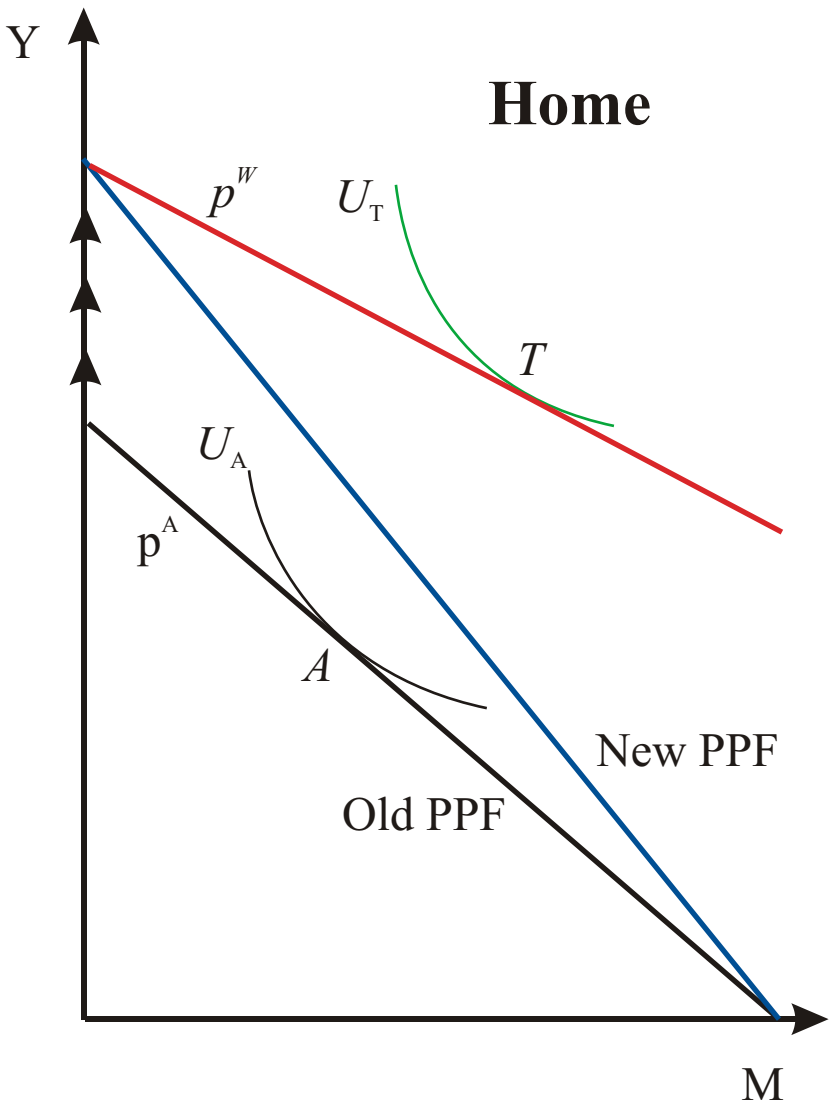


Production of polluting good
expands in Foreign

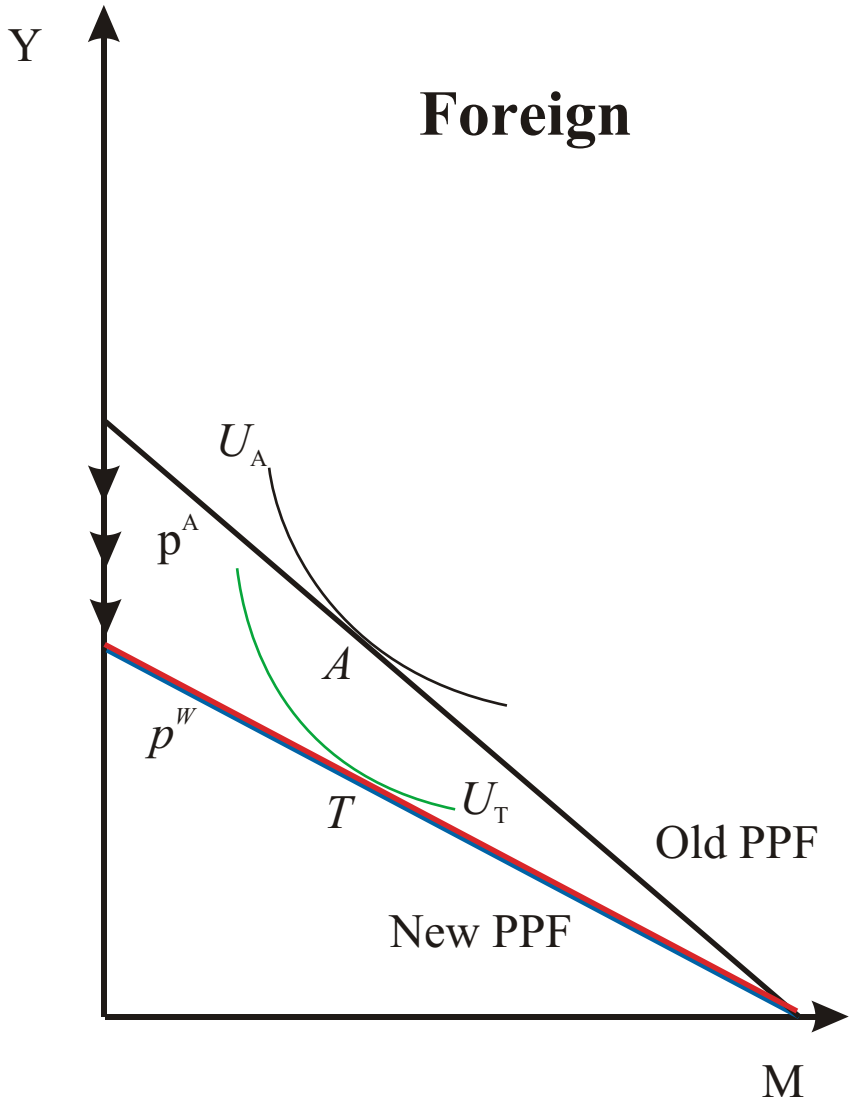
Case 1: High demand for the polluting good

- Foreign specializes in polluting good
- Home produces both goods, so world relative price of M is equal to slope of Home's new steady state Short Run Production Frontier (in order to ensure) diversification
- Both gain from trade
- Productivity in Y rises at Home as some dirty good production leaves for Foreign
- Foreign gains as this increased productivity lowers world relative price of its import good (Y).
- Trade improves welfare by allowing two incompatible industries to separate.
- Compare to Ethier (1982) model of external economies of scale.

Case 2: High demand for the Clean Good: Home gains; foreign loses



Production of clean good
expands at Home



Production of polluting good
expands in Foreign

Case 2: Low demand for the polluting good

- Home specializes in the clean good; foreign produces both clean and dirty good
- World relative price of M must be equal to slope of Foreign's new steady state Short Run Production Frontier (in order to ensure) diversification
- Home gains from trade - productivity rises as environmental capital replenished, and terms of trade improve during the adjustment.
- Foreign loses - degradation of its environmental capital lowers real income
- Also suffers a terms of trade loss.

Summary: Implications of trade liberalization in presence of cross-sectoral production externalites

- History matters; Lock-in effects
- Depletion of natural capital can create a comparative advantage in the industry causing environmental harm.
- Model predicts a strong pollution haven - type result. Degradation of natural capital magnifies effect of policy differences over time.

Renewable resources

Chichilnisky *AER* 1994
Brander and Taylor *Resource and Energy Economics* 1997
Karp, Sacheti, Zhao *International Economic Review* 2001
Copeland and Taylor, AER 2009

First consider a small open economy

Two goods: H (harvest good)

M (manufactured good)

Homothetic preferences U(H,M)

1 primary factor (labour) with endowment L

Resource stock with natural growth function

$$\frac{dS}{dt} = rS(1 - \frac{S}{K})$$

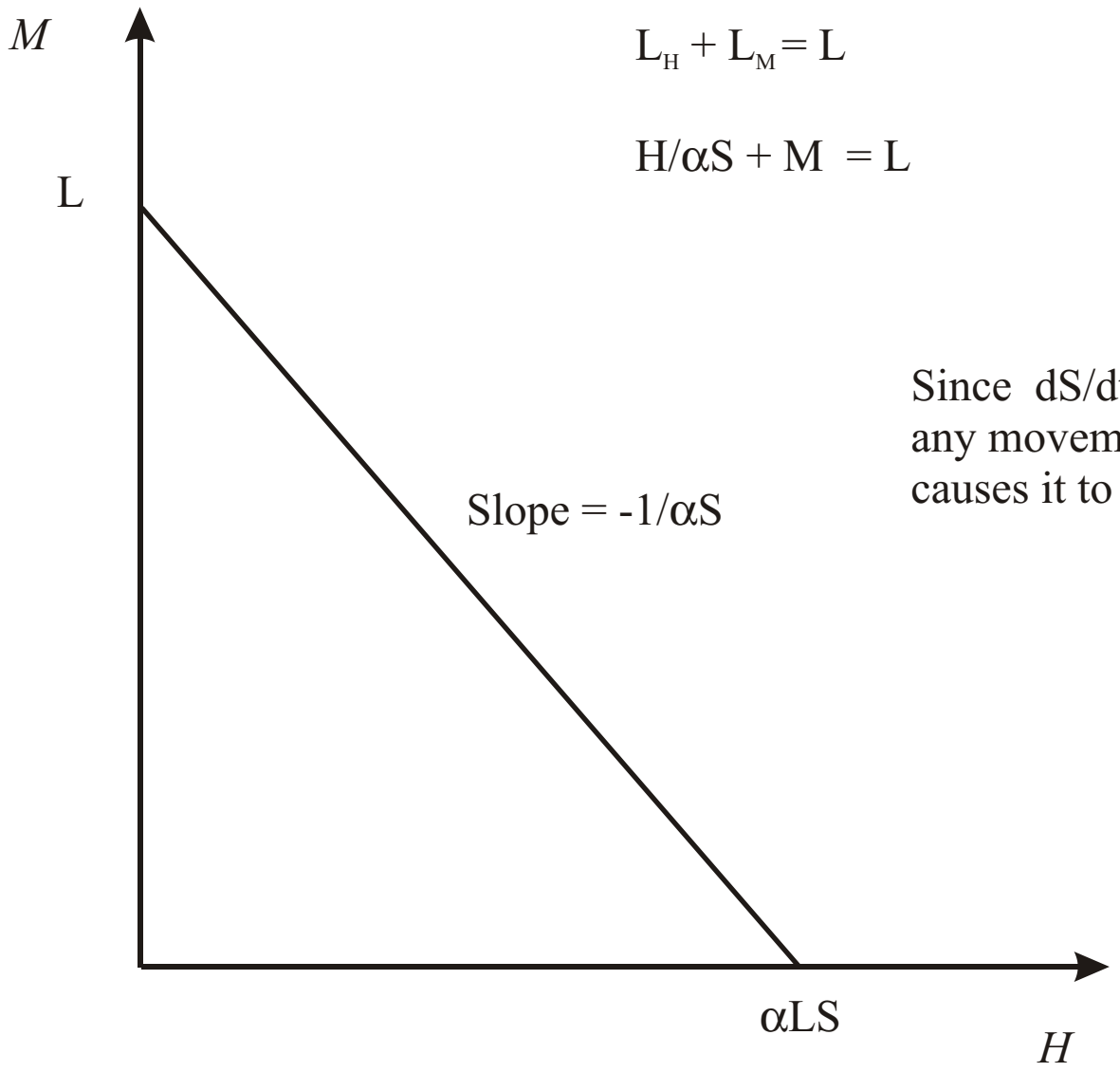
Technology

$$M = L_M$$

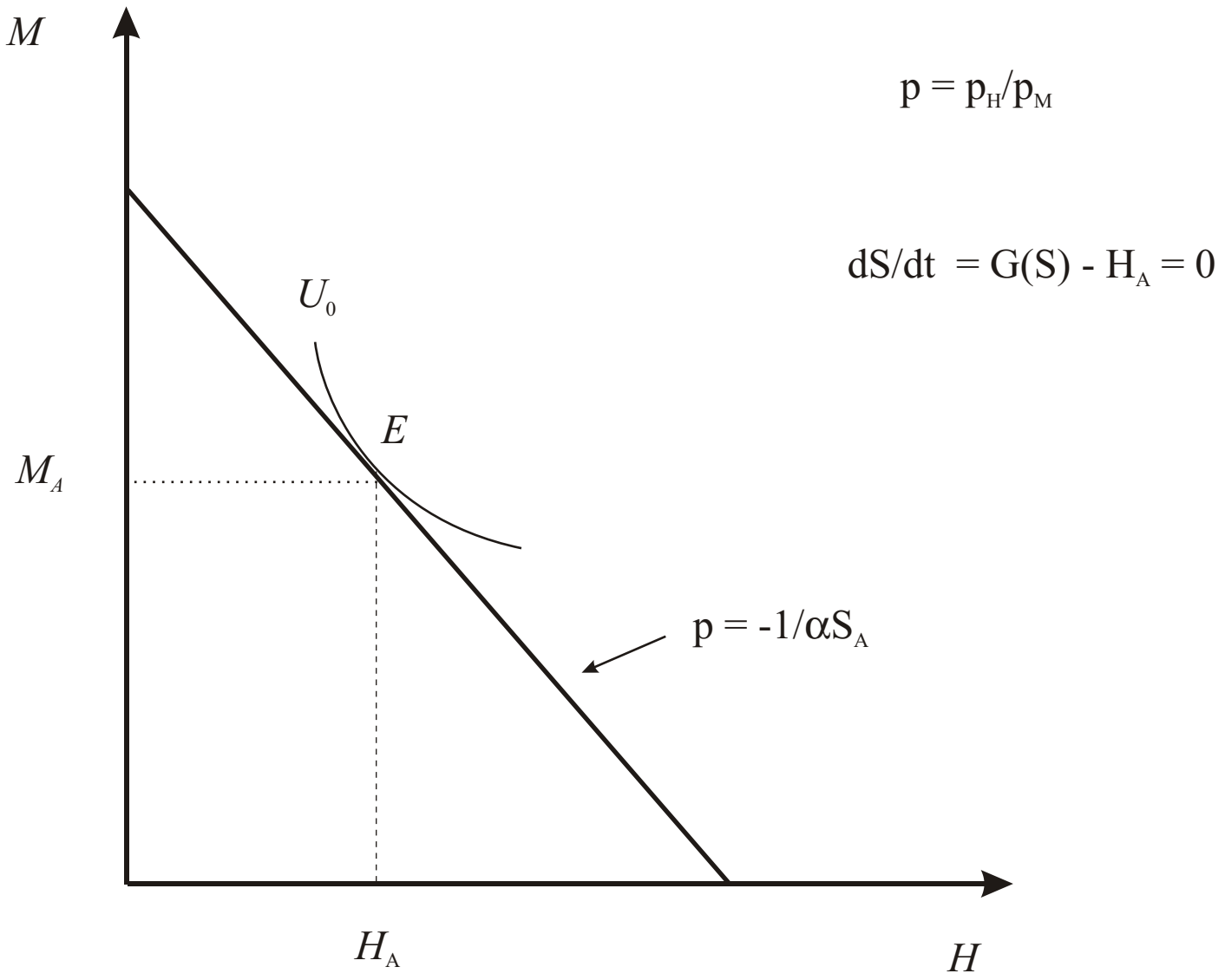
$$H = \alpha L_H S$$

Resource Stock Dynamics

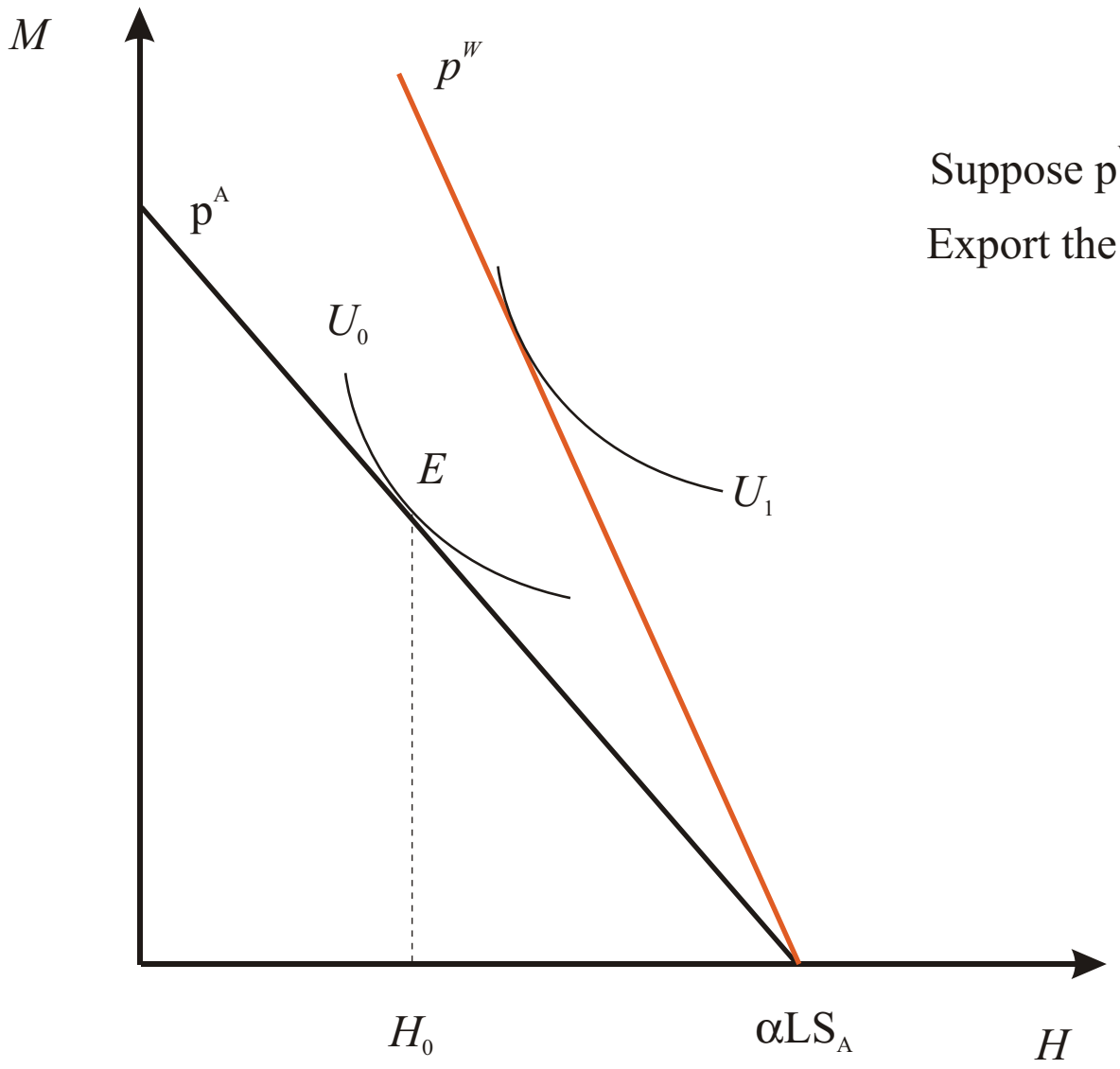
$$\frac{dS}{dt} = rS(1 - \frac{S}{K}) - H$$



Short Run Production Frontier



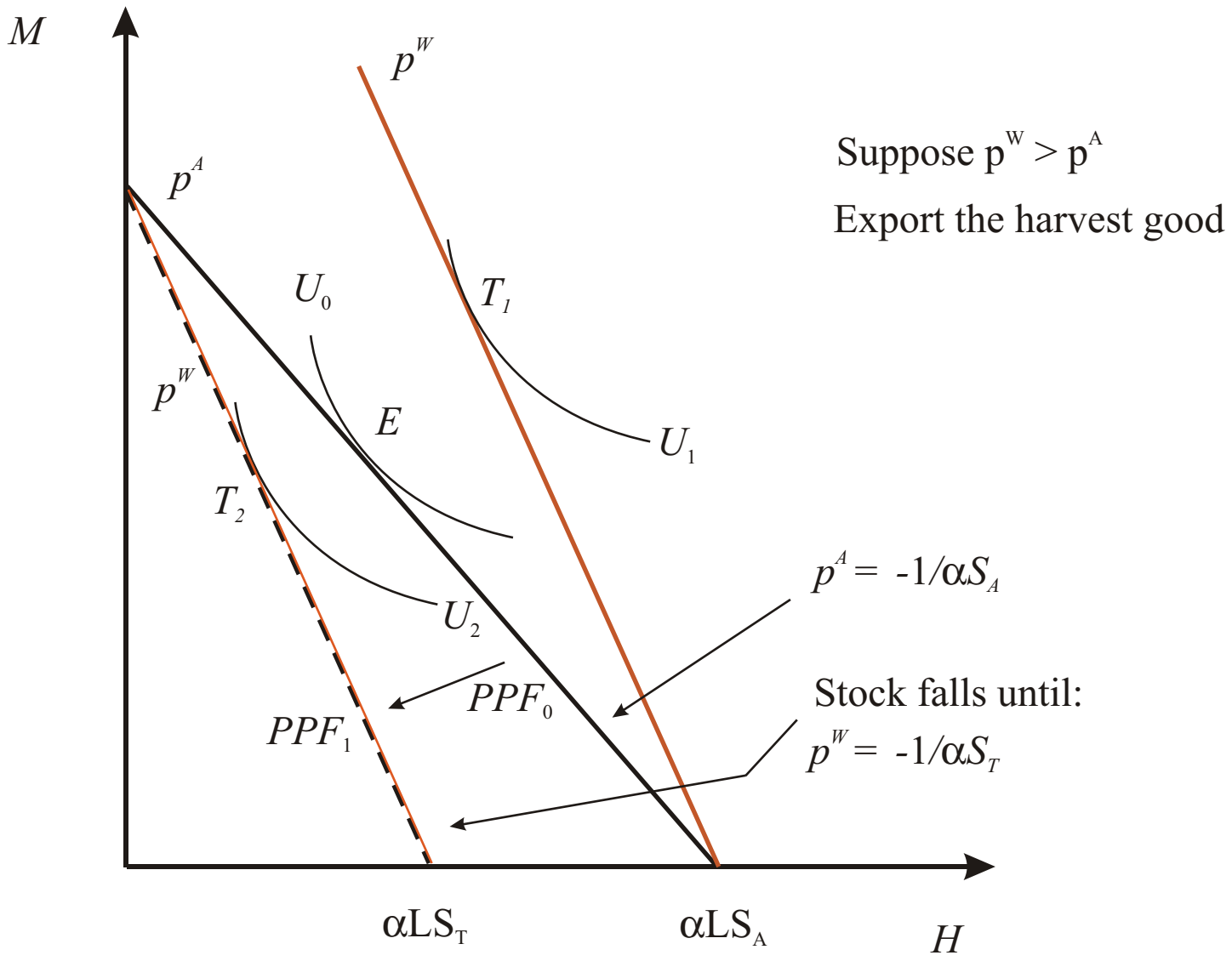
Steady State Autarky Equilibrium



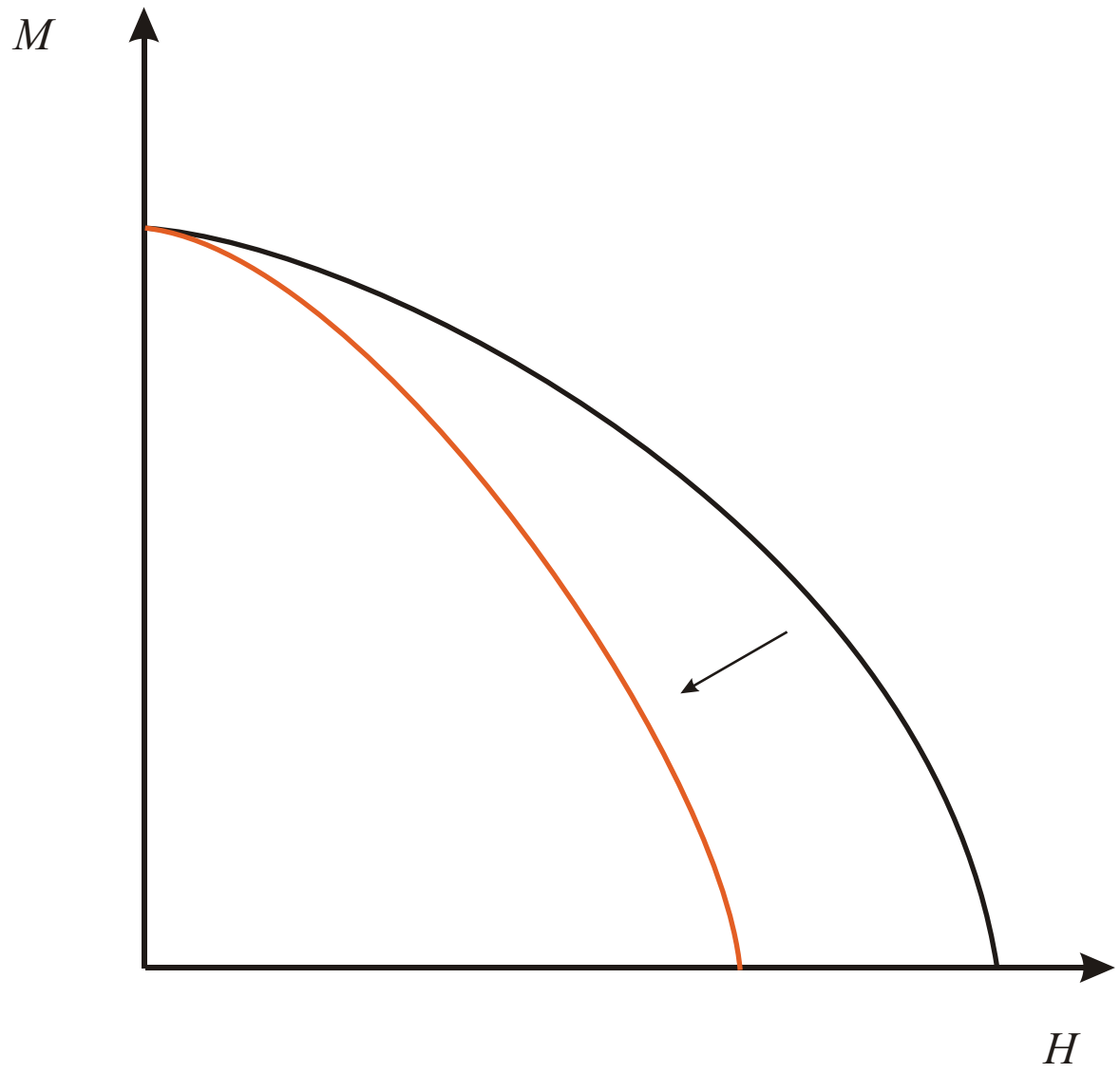
Suppose $p^W > p^A$

Export the harvest good

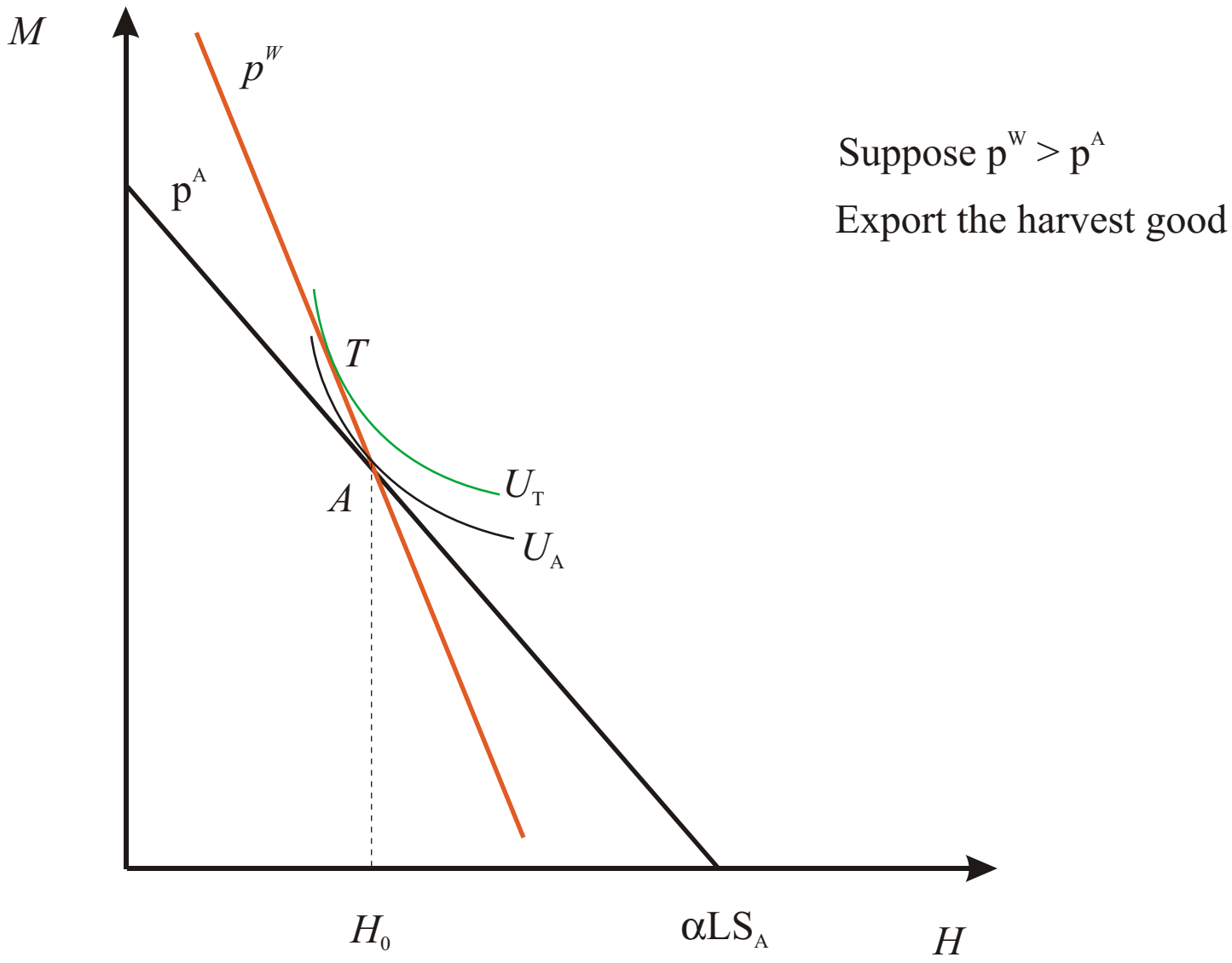
Short run gains from trade



Trade leads to fall in steady state real income



Generalizations: 1. Concave Short run production frontier (add additional primary factors)



Suppose $p^W > p^A$

Export the harvest good

Generalizations: 2. Management

Fish population dynamics with minimum viable stock size

$$\frac{dS_i}{dt} = r\left[S_i(t) - \underline{S}\right]\left[1 - \frac{S_i(t)}{K}\right] - H_i(t)$$

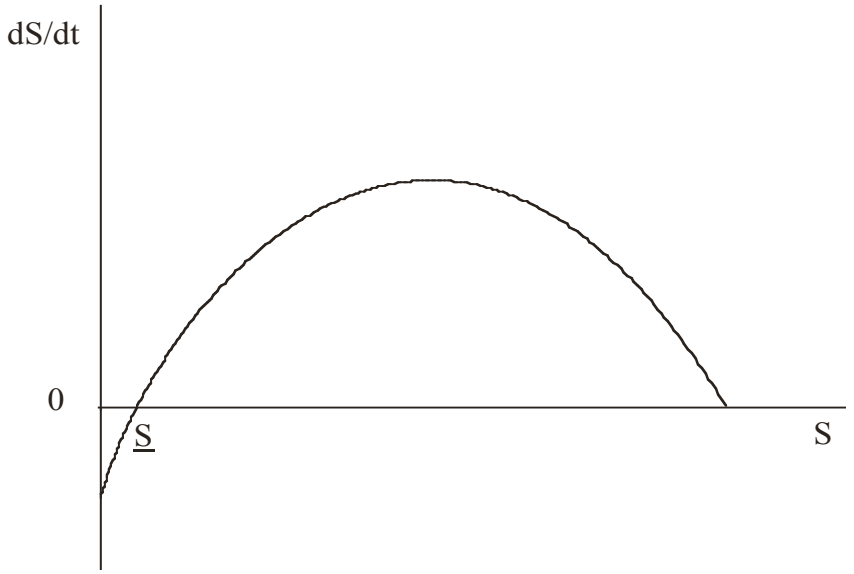
where:

r is the intrinsic growth rate of the stock,

$\underline{S}$ is the minimum viable population,

K is the environmental carrying capacity

H_i is the harvest level



Generalizations: 3. Extinction possibility and n countries

Serial Depletion

- Suppose cost of harvesting is not very sensitive to stock size
- Suppose there exists a steady state autarky equilibrium in a set of countries with a viable resource stock and positive harvest levels in each country
- Trade concentrates demand on the lowest cost producer
- Once the low cost producers are wiped out, demand switches to higher cost producers
- Trade liberalization can lead to a process of serial depletion that can ultimately lead to the collapse of fish stocks across many (and, in some cases, all) trading countries.
- Inelastic demand, low intrinsic growth rates, and low environmental carrying capacity, increase likelihood of trade-induced cumulative collapse.

Pattern of Trade

Does trade lead to a Pollution Haven - type result?

- Two countries, North and South
- North fully internalizes externalities. Assume discount rate approaches zero so manager maximizes sustained surplus from the resource
- South has open access
- What determines pattern of trade and effect of trade on real income?
- Chichilnisky (1994); Brander and Taylor (1997)

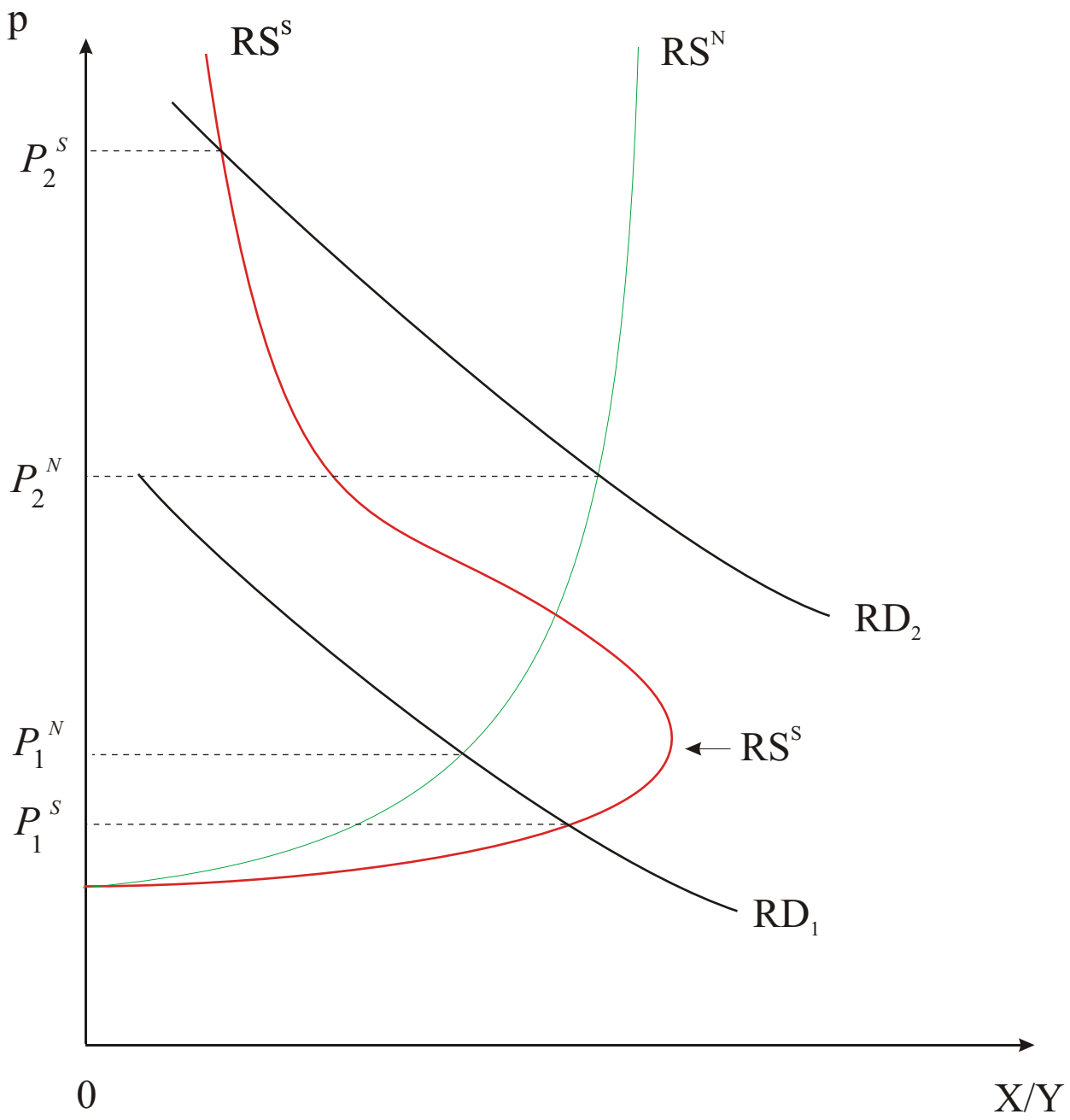


Figure 4. Trade and Renewable Resources

Two cases

1. Low demand for the renewable resource

- Conservation raises harvesting costs (tax or quota on harvesting)
- In this case, North's conservation shifts its relative supply curve inward (compared to South's)
- South has a comparative advantage in harvest good
- Trade puts increase pressure on South's resources
- North gains from trade; South loses (in long run).
- Note that if countries were identical and each had perfect regulation, there would be no trade
- Chichilnisky argues that such trade is unethical - North's only source of gains is South's lack of conservation policy

2. High demand for the renewable resource

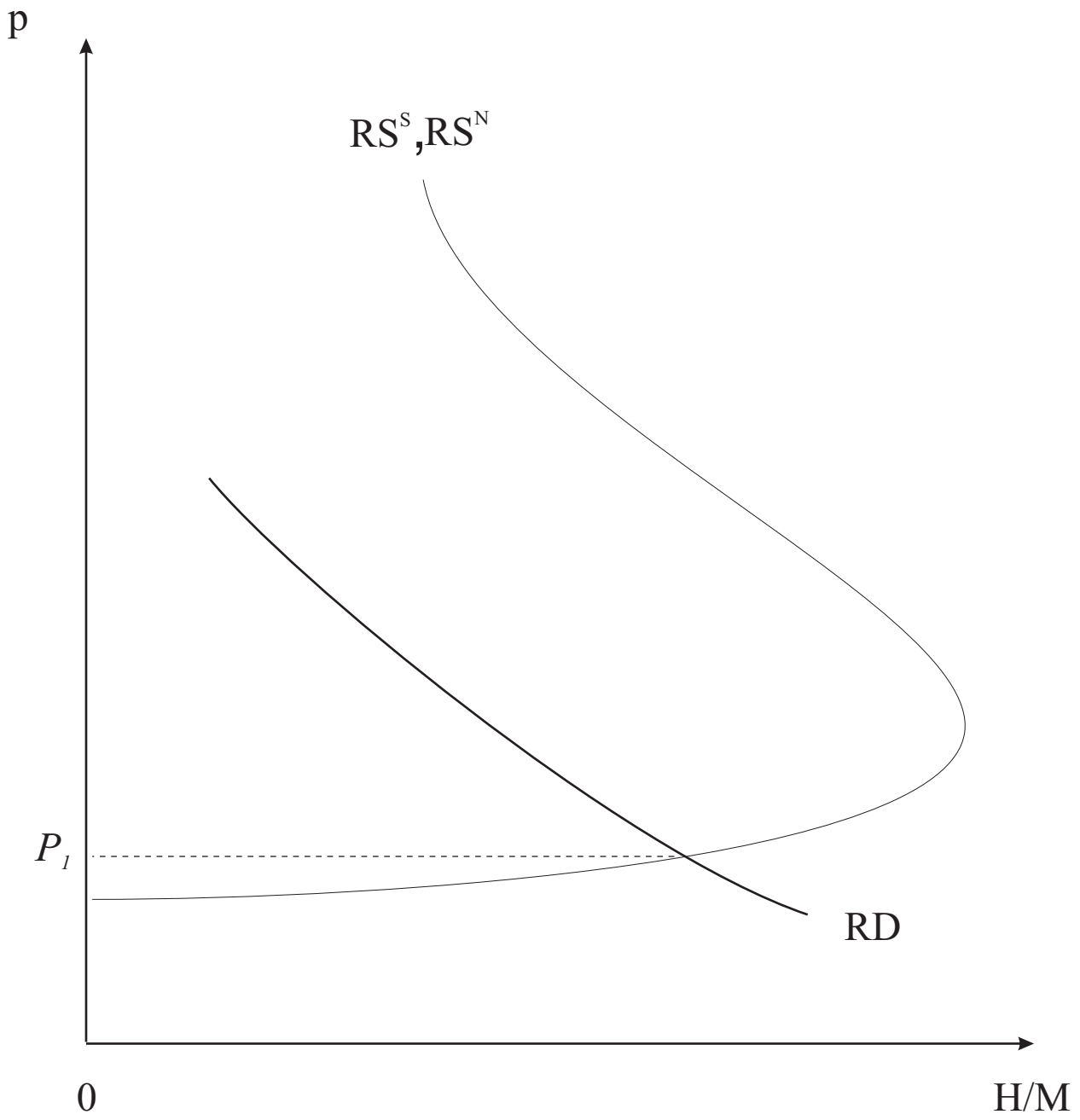
- Conservation raises harvesting costs (tax or quota on harvesting)
- But lack of conservation also leads to long run increases in costs via stock depletion
- The higher is demand, the more likely that the second effect offsets the first
- In this case North's conservation policy gives it a comparative advantage in the harvest good
- Trade takes pressure off South's resource
- Both gain from trade.

Introduction of Regulation in a Subset of Countries Can Lead to Increased Depletion in Other Countries

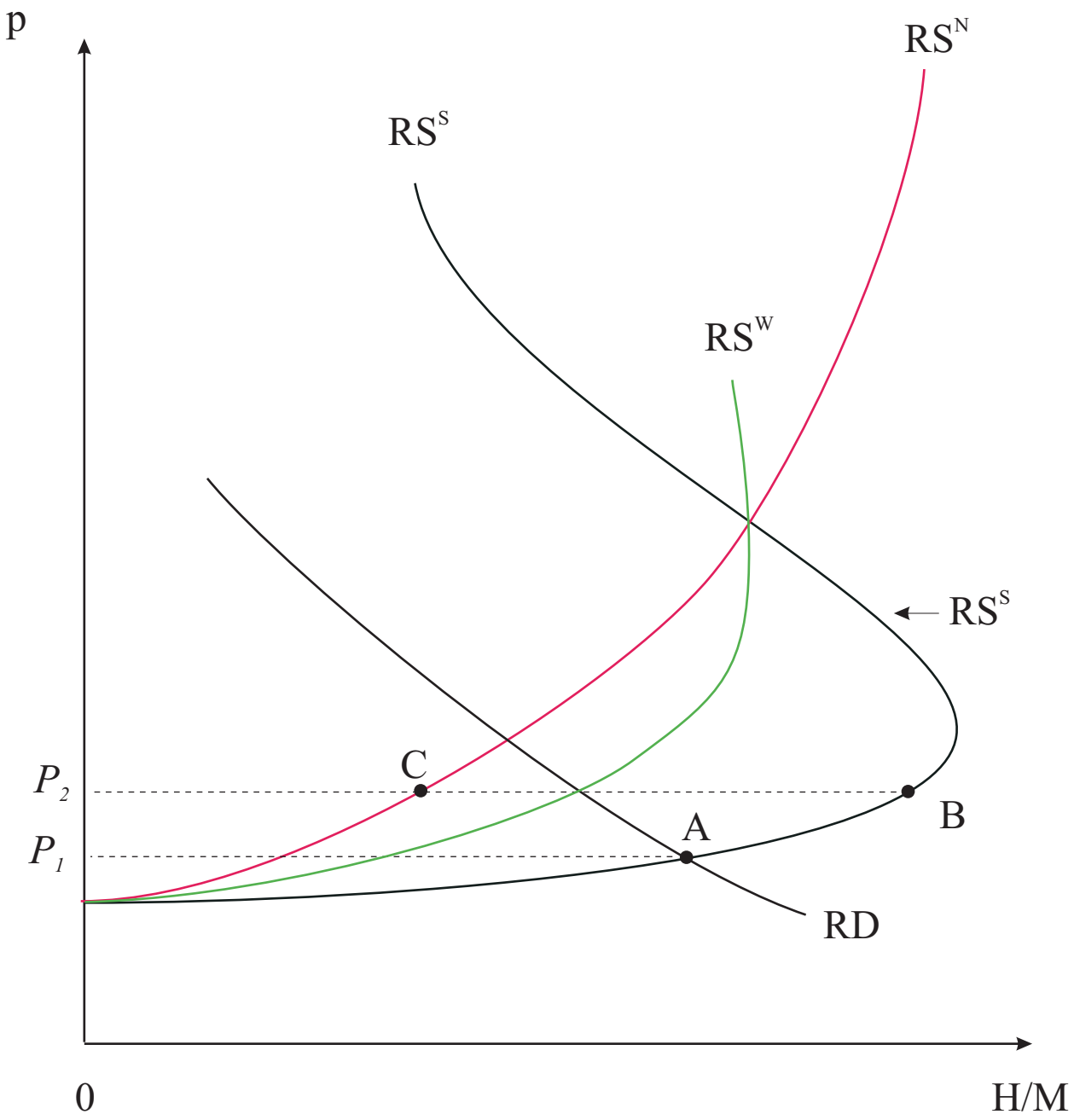
If goal is global conservation of fish stocks, then this is somewhat analogous to leakage

De Meza and Gould (JPE, 1992) considered this problem in the context of a closed economy with adjustment occurring via factor markets.

If the goal is to maximize overall global sustainability and if some countries are unable to internalize externalities, what is the optimal set of policies?



No regulation in either country



North's regulation leads to increased pressure on South's resource

How does openness to trade affect effectiveness of resource management?

Threshold models

- Francis (2001), Margolis and Shogren (2002), Bergeron (2002) building on Cohen and Weitzman (1976)

- Fixed cost of management. If trade increases the value of the resource, it is more likely to be managed well.

Poaching models

- Hotte, Long and Tian (2000). Manager spends resources to protect resource from encroachment by outsiders. If trade increases value of the resource, it is worth spending more protecting the resource, but pressure from poaching increases too.

Incentive constraints

- Copeland and Taylor (AER, 2009) focus on managing common property and explain heterogeneity both within and across countries in effectiveness of management as a function of observable parameters.
- Open economy renewable resource model combined with simple moral hazard model
- Manager restricts harvesting, but agents may cheat
- Agents caught cheating are excluded from the resource
- Manager must leave agents with some rents so that they have an incentive to avoid being excluded from resource
- Too much rent can create an incentive to cheat
- Similar to efficiency wage model

Heterogeneity in effectiveness of resource management

Three key factors determine whether or not resources will be effectively managed:

Enforcement power of the manager

- depends on monitoring technology, institutions, etc. relative to discount rates

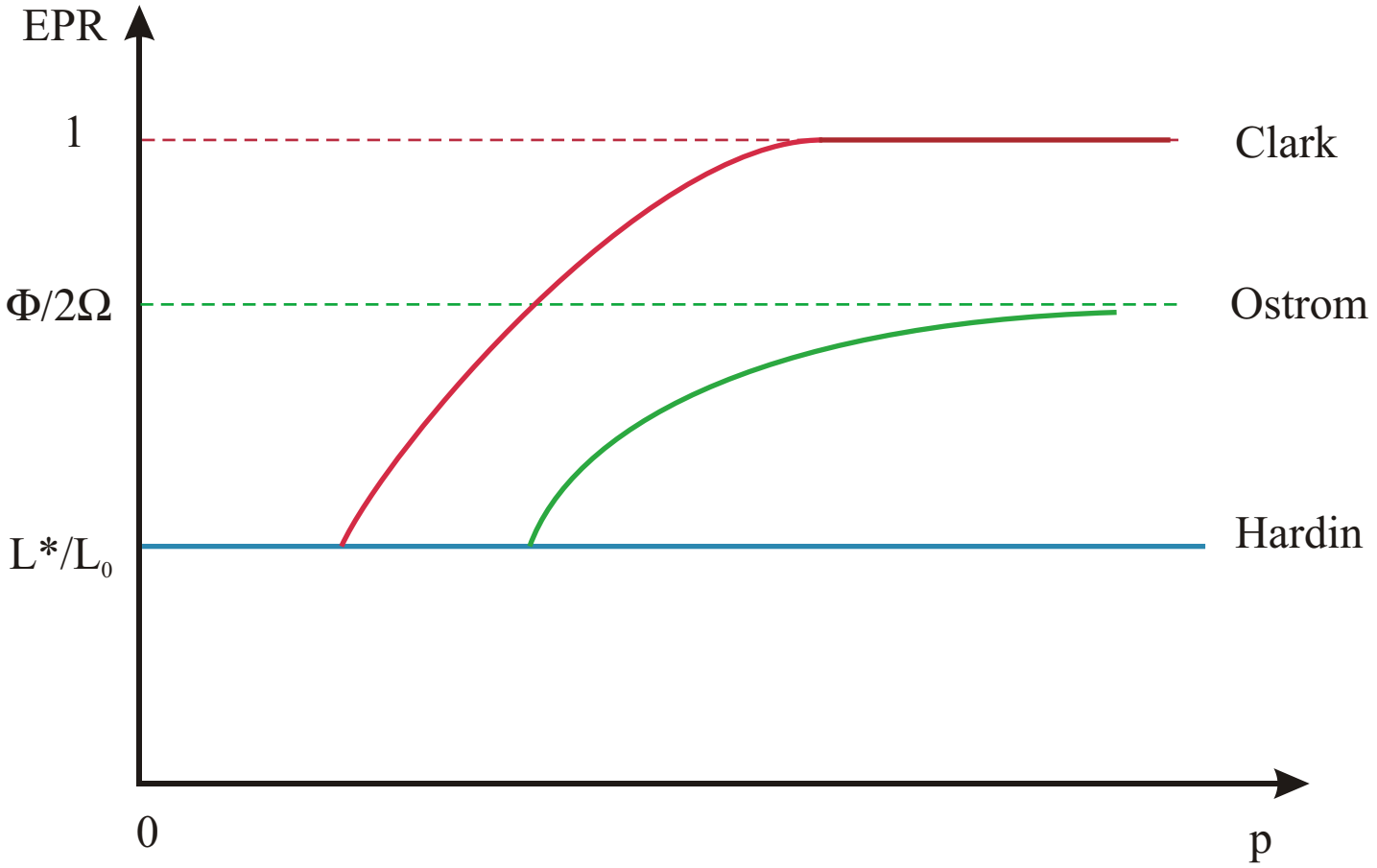
Harvesting capacity

- potential harvesting power relative to that needed to extinguish the resource
- depends on technology, number of people with rights to resource, and intrinsic growth rate of resource

Incentive to extinguish the resource

- measures the aggressiveness of the manager
- depends on manager's discount rate relative to growth rate of resource stock.

Heterogeneity Across Economies and Transitions



Definition: Effective property rights $EPR = L^*(p)/L^{Actual}(p)$

Trade liberalization

Conditional on exporting the resource, communities with

- high population,
- slow growing resources,
- inability to detect infractions,
- good harvesting technology

are likely to see a collapse of resource stocks as a result of trade.

Communities with

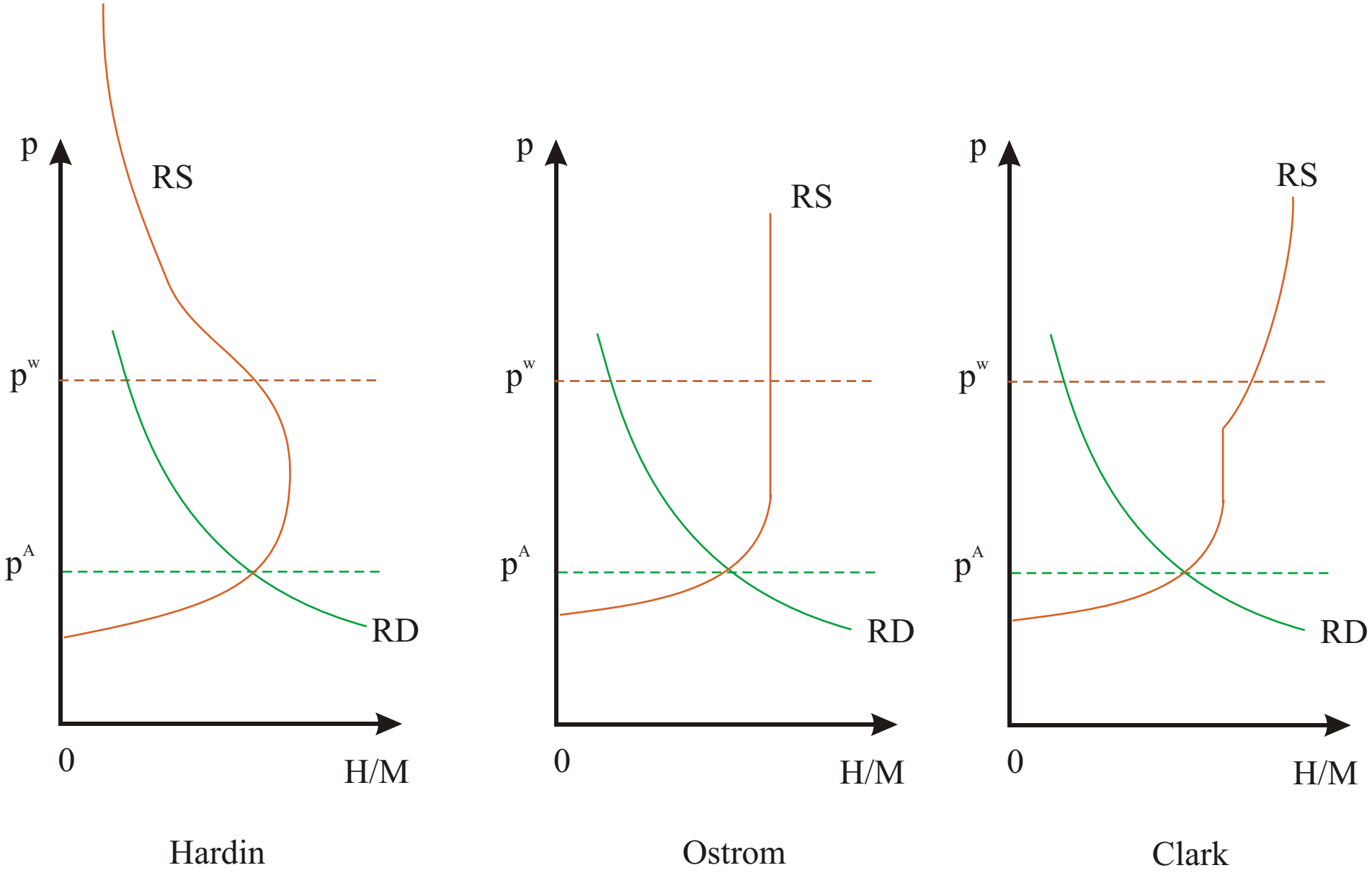
- low population density,
- fast growing resources,
- good monitoring ability,
- inferior harvesting technology

will be able to preserve their resource stocks and may see a real income gain from resource exporting opportunities.

Predictions differ from threshold model:

- Better harvesting technology, lower import prices for intermediate goods used in harvesting can lead to collapse of management regime.

Effects of Trade Liberalization on Resource Exporters



Empirical Evidence

Lopez (1997,2000) on Ghana and Cote d'Ivoire.

- Trade increased deforestation in Ghana but reduced it in Cote d'Ivoire.
- Pattern of trade is what mattered

Ferreira (2004)

- Cross country study of effect of openness on deforestation
- Openness leads to deforestation only in countries with weak property rights regimes
- Institutions matter

Examples of trade liberalization

Collapse of bison population in US in 1860s-1870s was exacerbated by export market (Taylor, 2011)

- Overcapacity
- little enforcement power

Opening of Estonian coastal fishery to exporting in 1990s contributed to rapid depletion of stocks (Vetemaa et al., 2006)

- Overcapacity
- little enforcement power

Fishery Examples: Heterogeneity within countries

The Geoduck and Abalone fisheries off the west coast of Canada were under pressure in the late 1970s from technological change and export markets. Individual quota systems were introduced for both

- The Abalone fishery collapsed (it is now illegal to harvest any abalone in BC). Abalone is available in shallow water in remote areas. Access is easy and difficult to monitor.

- The Geoduck fishery continues to generate rents. Geoducks do well in both shallow water and deep water (up to almost 100 metres). The fishery is also much more capital intensive. Boats, divers, water pressure hoses, air hoses, etc. are needed. Monitoring is therefore easier.

Conclusion

- Stringent environmental policy can be a source of comparative advantage
- Trade can exacerbate environmental problems by concentrating demand on vulnerable resource stocks
- Lock - in effects can exist
- Understanding interaction between environmental policy regime and trade regime can be critical in understanding long run outcomes.